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Chapter 1
Subbasin Overview

Mission Statement

"Restore sustainable and harvestable populations of salmon, steelhead, and other at-risk species through collaborative, economically sensitive efforts, combined resources, and wise resource management of the Yakima Basin."

– Yakima Subbasin Fish and Wildlife Planning Board

Chapter 1 describes the Yakima Subbasin and its place within the Columbia Plateau Province or eco-region as defined by the Northwest Power and Conservation Council (Council). The chapter begins with the Yakima Subbasin Fish and Wildlife Planning Board's (YSPB) preamble for the 2004 *Yakima Subbasin Plan* (YSP); summarizes the Yakima Subbasin's geological, climatic, biological, and hydrological characteristics; describes the human population and activities that occur in the subbasin; and gives an overview of its fish and wildlife resources.

1 The Purpose and Scope of the Yakima Subbasin Plan

The purpose of the YSP is to provide the Council with a coherent and measurable plan for allocating Bonneville Power Administration (BPA) fish and wildlife mitigation and restoration funds within the Yakima Basin. The plan is intended to provide guidance to BPA and the Council on the general locations and types of projects that would mitigate the impacts of the Federal Columbia River Power System (FCRPS) on basin fish and wildlife resources, and also to aid the Council in development of strategies for compliance with the Endangered Species Act (ESA) [1] in tributaries such as the Yakima River. The plan identifies short and long term non-regulatory strategies for restoring species habitat, and prioritizes those strategies relative to type and location within the basin. An objective of the prioritization is to identify early funding opportunities that provide basin-wide, and species-wide restoration results. The primary revenue source to implement plan strategies is BPA electric utility ratepayer funds which fund restoration actions through the enactment by Congress of the 1980 Pacific Northwest Electric Power Planning and Conservation Act (Power Act [P.L. 96-501]). Once adopted by the Council, the *Yakima Subbasin Plan,* along with the plans from the other subbasins within the Columbia system will become an amendment to the Columbia Basin 2000 Fish and Wildlife Program.

[1] The Endangered Species Act of 1973 was passed to provide for the conservation of species which are in danger of endangerment or extinction throughout all or a significant portion of their range and the conservation of the ecosystems on which they depend. "Species" is defined by the Act to mean a species, a subspecies, or, for vertebrates only, a distinct population.

1.1 The Role and Perspective of the Yakima Subbasin Fish and Wildlife Planning Board

Historically, the Yakama Nation (YN) and Washington Department of Fish and Wildlife (WDFW), as Co-managers of the Yakima Subbasin fish and wildlife resources, were the primary drafters of previous subbasin plans adopted into the Council's Fish and Wildlife Program. In order to achieve a subbasin plan that meets the requirements of the Power Act and also reflects local priorities, this subbasin plan relied on an ongoing high level of involvement by the Co-managers and direct participation by local. The YSPB was formed to prepare and deliver this plan by the end of May 2004.

The YSPB consists of elected representatives of the YN, Benton and Yakima Counties, and twelve cities, Benton City, Ellensburg, Granger, Kennewick, Prosser, Richland, Roslyn, Selah, Sunnyside, West Richland, Yakima, and Union Gap, within the basin. To integrate community values throughout the plan the YSPB has developed Mission (Chapter 1-3) and Vision statements with supporting principles (Chapter 4-3) that are consistent with and broaden the Council's vision as described in the Council's 2000 Fish and Wildlife Program. The Board's Vision statement emphasizes the protection and enhancement of local cultures, customs, and economies while restoring sustainable and harvestable fish and wildlife populations.

The Board considers the human community and its socio-economic activities as integral components of the basin ecosystem, and productive, sustainable, and harvestable fish and wildlife resources as integral components of an improved quality of life for the human community.

1.1.1 Strategies to Protect and Restore Fish and Wildlife Resources

The strategies identified within the YSP do not involve land use regulation, but instead rely on willing parties to voluntarily apply for grant funds, participate in BPA funded programs, or use BPA funding to supplement existing programs that benefit fish and wildlife resources. Strategies generally concentrate on either protection or restoration. Protection strategies are for habitat locations that are currently functioning at a high level, and are important to the overall life history of a focal species. These strategies include land or water rights purchases, transfers, easements, and exchanges. Restoration strategies are used for locations where conditions limit the productivity or abundance of a focal species or focal habitat. The intent of these strategies is to reverse the causes of those limiting conditions by, for example, opening up or reconnecting fragmented habitat areas, restoring riparian function, or returning seasonal flows to a more natural flow regime.

To accomplish the mission of this plan and the Power Act, continued funding is required to improve management of natural resources, to monitor and research the relationships between management actions and the health of the resource, and other actions that protect or restore natural resource functions that have been negatively impacted by the FCRPS and other actions in the basin.

1.1.2 The YSP as a "Balanced" Document

The contractually required purpose of the YSP is the protection and restoration of fish and wildlife. It is not an omnibus document that directly addresses other issues within the basin. The YSPB is aware of the narrow focus of the YSP, and intends to ensure that the plan will complement rather than conflict with other ongoing resource objectives within the basin. In addition, the implementation of the YSP can enhance the existing fabric of custom and culture, and economic objectives of the Yakima Basin.

1.1.3 Pre-settlement (Pre-1850) Conditions and Normative Flow

During early review of the draft YSP, it became apparent that there were a few key terms and concepts in the plan that raised concerns, especially the terms “pre-settlement” and “normative flow conditions”. These were perceived by some readers as plan objectives that would require the evacuation of all non-native humans from the basin and the destruction of all capital facilities that would impede a return to these conditions. This is not the intent of these terms and concepts.

The term “pre-settlement” (now pre-1850s) was used to identify a baseline describing the environmental conditions that sustained fish and wildlife in the basin prior to the major alterations of the basin ecosystem that began at the onset of increased settlement in the latter half of the 19th century. Identification of a baseline or benchmark against which to measure existing conditions is fundamental to the design, implementation, and monitoring of restoration and protection strategies identified in the plan.

The term “normative flow” in the YSP is not a goal but rather a benchmark that many of the objectives and strategies within the plan are directed towards, and that project action for flow improvement or water conservation should be measured against.

Given the existing institutional and legal constraints, a return to the pre-1850 flow regime is not likely to occur, though some improvements in flow can be made through the voluntary use of water rights transfers, purchases, trusts, conservation, changes in land use, etc. The YSPB also recognizes that modification of flows that could approach the functional equivalent of the pre-1850 flow regime (relative to restoring fish and wildlife in the basin) may be possible through flow management associated with new capital projects including additional off-stream water storage or other large infrastructure projects that allow irrigation water to be routed through the basin with less effect on in-stream resources.

Successful implementation of this plan will be ongoing, challenging, and long term. This will not be an easy or simplistic process. Fundamental changes to the current institutional, legal, and policy framework are beyond the scope of the YSP, and require a commitment by all parties to work together into the future. This commitment is articulated in the YSP Vision statement, “Decisions that continuously improve the river basin ecosystem are made in an open and cooperative process that respects different points of view and varied statutory responsibilities, and benefits current and future generations.”

2 Subbasin in Regional Context

The Council is responsible for implementing the Power Act of 1980 and the Fish and Wildlife Program mandated by the Act. For planning purposes, the Council divided the more than 60 subbasins of the Columbia River Basin south of the Canadian border into 11 eco-regions or provinces.

The 11 provinces (Figure 1-1), beginning at the mouth of the Columbia River and moving inland, are: Columbia Estuary; Lower Columbia; Columbia Gorge; Columbia Plateau; Columbia Cascade; Inter-Mountain; Mountain Columbia; Blue Mountain; Mountain Snake; Middle Snake; and Upper Snake. These 11 eco-regions include the entire Columbia River basin in the United

States, and together cover approximately 220,000 square miles in Washington, Oregon, Idaho, and Montana.

The provinces are made up of adjoining groups of ecologically related subbasins, each province distinguished by similar geology, hydrology, and climate. Because physical patterns relate to biological population patterns, fish and wildlife populations within a province are also likely to share life history and other characteristics (NPCC 2000).

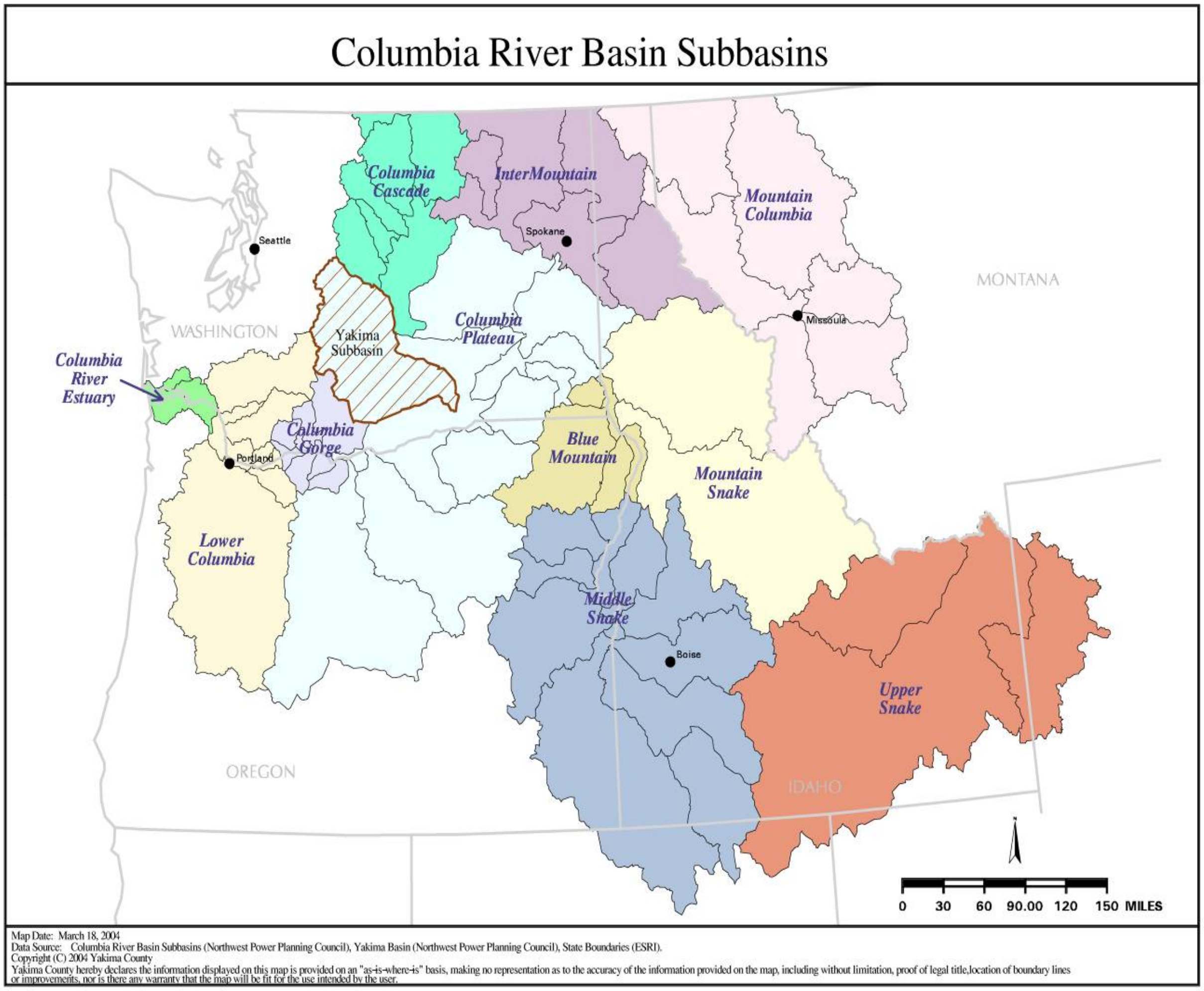

Figure 1-1. Columbia River Basin ecologically based provinces and Yakima Subbasin

The Yakima Subbasin is in the Columbia Plateau Province. The Yakima Subbasin, along with other subbasins in the 11 Columbia Basin provinces, will develop its own Management Plan with a vision, biological objectives, and strategies. The Council's intent is to adopt each subbasin Management Plan into the 2000 Fish and Wildlife Program during its 2004-2005 amendment process. The Management Plans will then guide development of the Columbia Basin Fish and

Wildlife Program and the selection of projects at the subbasin level. The plans will be periodically updated.

Eventually, each of the 11 provinces will have its own vision, biological objectives, and strategies consistent with those adopted for its subbasins. The biological objectives at the province scale would then guide development of the program at the subbasin scale.

2.1 Columbia Plateau Province

The Columbia Plateau Province (Plateau) is the largest of the ecological provinces and extends over an area of approximately 45,275 square miles. It is defined as the Columbia River and associated watersheds between The Dalles and Wanapum dams on the Columbia River and Ice Harbor on the Snake River. This area includes much of southeast and south-central Washington, north central and northeast Oregon, and a small portion of Idaho east of Moscow. The Plateau is divide into 10 subbasins: Deschutes; John Day; Columbia Lower Middle; Umatilla; Walla Walla; Tucannon; Snake Lower; Palouse; Crab; and Yakima.

The Cascade Mountains form the western border of the Plateau through Oregon and Washington, while the Palouse region along the Washington/Oregon border and Blue Mountains form the eastern edge. The southern border is marked by the divides that separate the upper Deschutes and John Day drainages from the Oregon High Desert and drainages to the south, while the northern border is formed by the Wenatchee Mountains and the divides that separate Crab Creek and Palouse River from the drainages in the Inter-Mountain Province.

The principal rock of the Columbia Plateau is a series of basalt flows, interspersed with sedimentary layers, called the Columbia River Basalt Group. The hydrology of the Plateau is complex; surface water includes numerous small tributaries draining to mainstem rivers, while underlying the region is the Columbia Plateau aquifer system, localized in some areas by series of groundwater subbasins. Temperatures and precipitation vary widely, usually depending on elevation, with cooler and wetter climates in the mountainous areas at the Plateaus' western, eastern, and northern boundaries, and warmer and drier climates in the lower areas that make up most of the province. The mountainous regions are predominantly coniferous forests, while the arid regions are characterized by sagebrush steppe and grassland. Many of the same fish and wildlife species are found in each of the 10 Plateau subbasins.

The native people of the Plateau included the Yakama, Wanapum, Palouse, Cayuse, Umatilla, Walla Walla, Nez Perce, Tenino, John Day (Dock-Spus), and Wyam. Today the Plateau province is home to three tribal confederations and parts of four Indian reservations. Most of the Yakama reservation is located within the southwest portion of the Yakima Subbasin, while the Warm Springs and Umatilla reservations of Oregon are located within the Deschutes and Umatilla Subbasins, respectively. The northwest tip of the Nez Perce reservation in Idaho is located in the Palouse Subbasin. Significant urban centers within the Province include Tri-Cities (Pasco, Richland, and Kennewick), Walla Walla, Pullman, and Yakima, Washington; Moscow, Idaho; and Bend, Redmond, Pendleton, and Umatilla, Oregon.

Columbia Plateau is an important agricultural and grazing area and is a major source of hydroelectric power. Four major hydroelectric dams are located in the Plateau province: McNary and John Day dams downstream of the Snake-Columbia confluence, and Priest Rapids and Wanapum dams upstream of the Yakima-Columbia confluence. Downstream of the province on the mainstem Columbia are two more dams, The Dalles and Bonneville, which must be traversed by anadromous fish migrating to and from the province's 10 subbasins.

3 Subbasin Description

3.1 Topographic and Physio-Geographic Environment

The Yakima River Basin encompasses an area of just over 6,100 square miles in south central Washington (Figure 1-2).

It is bordered on the west by the crest of the Cascade Mountains, on the north by the Wenatchee Mountains, on the east by the breaks of the Columbia River, and on the south by the Simcoe Mountains and the Horse Heaven Hills. The major geologic actions affecting the formation of the Yakima basin have been volcanoes and lava flows, glaciation, and uplifting (Haring 2001).

The Yakima River basin is interrupted by a number of east-west tending anticlinal ridges, which form a series of intervening valleys: Kittitas, Wenas, upper Yakima, and lower Yakima. From north to south, the anticlinal ridges include Manastash, Umtanum, Yakima, Ahtanum, and Toppenish Ridges as well as Rattlesnake Hills. The elevations of these ridges vary from 1,000-3,000 feet above the valley floors. The Yakima River cuts through these ridges along the Ellensburg Canyon at Selah Gap and at Union Gap.

A multitude of landforms are found in the basin. The Cascade Mountains run along the western portion of the basin with elevations exceeding 8,000 feet above mean sea level. Portions of the mountainous area were glaciated, leaving glaciated peaks and deep valleys. Moving east and south from the crest of the Cascades, elevation decreases, and broad valleys and lowlands open up. This area of the basin is part of the Columbia Plateau. The lowest elevation in the basin is 340 feet at the confluence of the Yakima and Columbia Rivers at Richland. Precipitation is also highly variable across the basin, ranging from approximately 7 inches per year in the eastern portion of the basin, to over 140 inches per year along the western border near the crest of the Cascade Mountains. Total runoff from the basin averages approximately 3.4 million acre/feet per year, ranging from a low of 1.5 to a high of 5.6 million acre/feet.

The basin contains a variety of aquatic habitats; the large mainstem of the Yakima River; medium-size rivers such as the upper Yakima, Cle Elum, and Naches; and many smaller tributaries, such as the Little Naches River, Satus, Ahtanum, and Taneum creeks, and the headwaters above the basin's reservoirs.

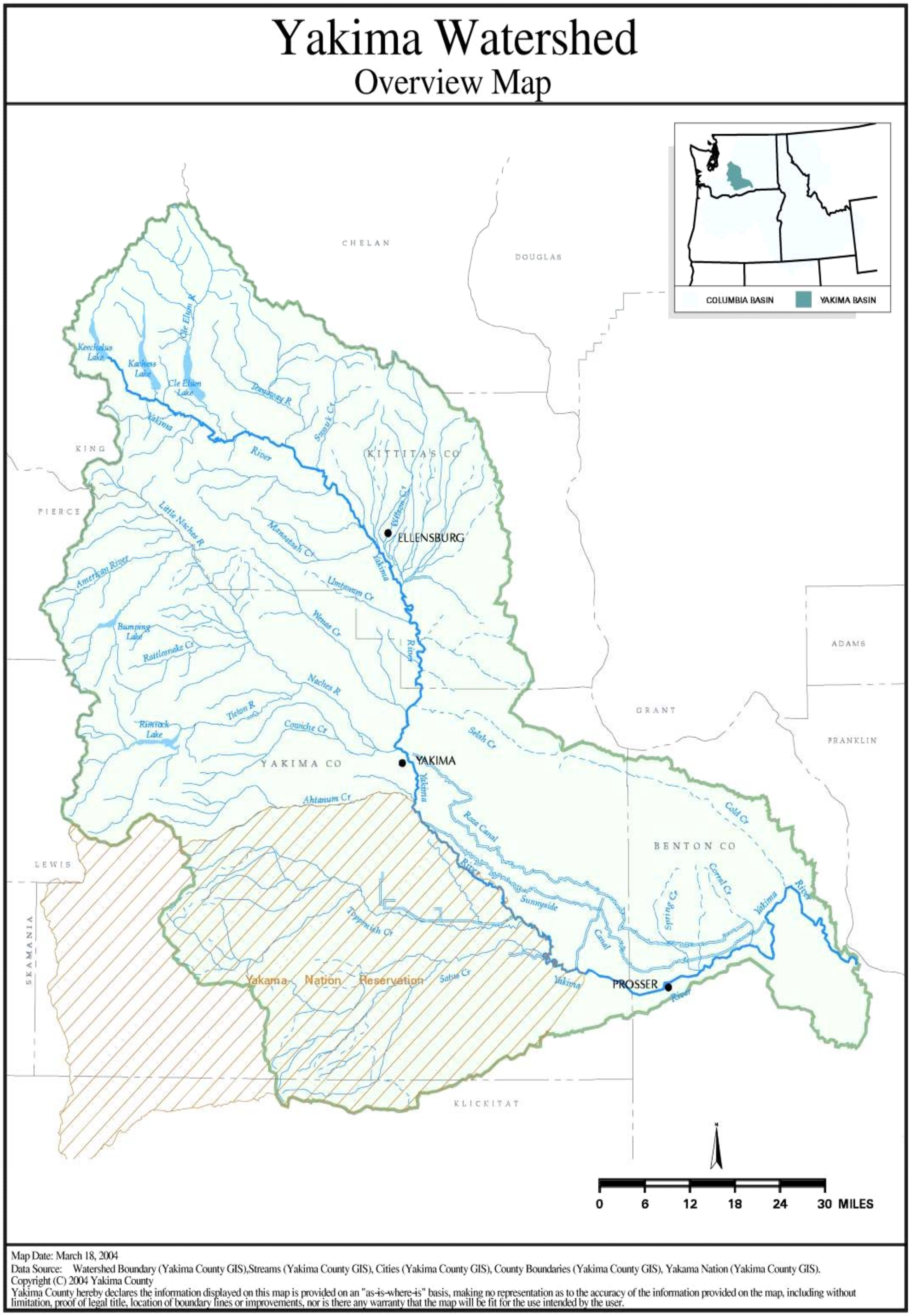

Figure 1-2. Yakima Subbasin overview map

3.1.1 Geology

The Yakima River Subbasin consists of two very different physiographic and geologic regions; the Cascade Mountains occupy roughly the western third of the subbasin, while the Columbia Plateau extends from the Cascade foothills to the eastern border of the subbasin. The mountains consist of continental formations of Eocene-age sandstone, shale and some coal layers, and pre-Miocene volcanic, intrusive, and metamorphic formations. Tertiary and quaternary age andesite and dacitic lavas, tuff, and mudflows form a broad north-south arch along the western edge of the subbasin (TCWRA 2003). The upper mainstem Yakima and Naches rivers and several tributaries occupy valleys excavated by glaciers. Lowlands typical of landforms associated with the Columbia Plateau are found along the lower half of the Yakima River (TCWRA 2003).

The principal rock of the Columbia Plateau is a series of basalt flows of Tertiary age that cover older rock and reach the western edge of the Cascade Mountains. The majority of these basalt flows, interspersed with sedimentary layers are called the Columbia River Basalt Group. The thickness of the Columbia River Basalt Group within the lower and middle Yakima River basin ranges from 9,000 to 12,000 feet, increasing in thickness along a west to east gradient (TCWRA 2003). The basalt plateau of the eastern basin was subsequently folded and faulted into a series of west-east trending anticlinal ridges and synclinal valleys, called the Yakima Fold Belt, that extend from the Cascades to the broad plains of the Columbia River. The antecedent Yakima River incised canyons and water gaps through the ridges and deposited gravels, eroded from uplifting mountains and ridges in the valleys.

Outflow from glaciers along the Cascade crest into the Yakima and Naches valleys delivered large volumes of glacial outwash to the alluvial basins, resulting in partial filling of Cle Elum, Kittitas, and upper and lower Yakima valleys with sand, gravel, and silt. Glaciation created many lakes. Backwaters from the Ice-age Lake Missoula flood left thick silt deposits in the lower valley from Union Gap to Richland. Extensive portions of the eastern and southeastern subbasin are mantled by loess, a wind-deposited silt derived from outwash deposits.

3.1.2 Climate

The climate of the Yakima Subbasin ranges from cool and moist in the mountains to warm and dry in the valleys. Annual precipitation near the Cascade crest ranges from 80 inches to 140 inches, lower elevations in the eastern part of the subbasin receive 10 inches or less. Summer temperatures average 55º F in the mountains and 82º F in the valleys. In the summer, air from the interior of the continent usually results in high temperatures. Winter temperatures are fairly moderate. The Selkirk Mountains in Idaho and the Rocky Mountains in British Columbia shield the area from the very cold continental air masses that sweep down from Canada into the Great Plains. The predominantly westerly winds in the winter allow the area to benefit from the coastal maritime influence. Average maximum winter temperatures range from 25º to 40º F, while average minimum winter temperatures range from 15º to 25ºF. Minimum temperatures of -20º to -25º F have been recorded in most areas.

A sharp precipitation gradient in the subbasin falls off in a generally southeasterly direction. Orographic cooling of moist maritime air passing over the Cascades results in heavy precipitation on the windward slope and near the crest, and a rain shadow to the east. In a distance of 10 miles, annual precipitation falls from 100 inches or more at the crest of the Cascades to 48 inches at Bumping Lake and to 26 inches at Rimrock Dam. Within the next 15–

20 miles, precipitation decreases to 8-10 inches on the valley floor. Virtually all of the streams in the subbasin originate at higher elevations where annual precipitation is 30 inches or more.

The rainy season in the valleys occurs during November through January when about half the annual precipitation occurs. Snowfall in the valleys ranges from 20 to 25 inches and from 75 inches at 2,500 feet to over 500 inches at the summit of the Cascades. This mountain snow pack provides most of the water for irrigated agriculture and streamflow.

3.1.3 Land Ownership and Use

Private ownership totals 32 percent or over 1.2 million acres of the 4 million acres in the Yakima Subbasin. The single largest landowner is the U.S government with 1.5 million acres or 38 percent of the land area. Most of the federal land is within the Wenatchee National Forest. Other large federal land holding include the U.S. Army Yakima Training (YTC) Center, the Hanford Nuclear Reservation, and Bureau of Land Management lands (BLM). Other public ownership (state, county, and local governments) total over 400,000 acres. The YN Reservation covers 1,573 square miles (1,371,918 acres) in southern Yakima County and a smaller part of Klickitat County (Figure 1-3 and Table 1-1). The YN and its members have over 880,000 acres held in trust; only a small portion is deeded land.

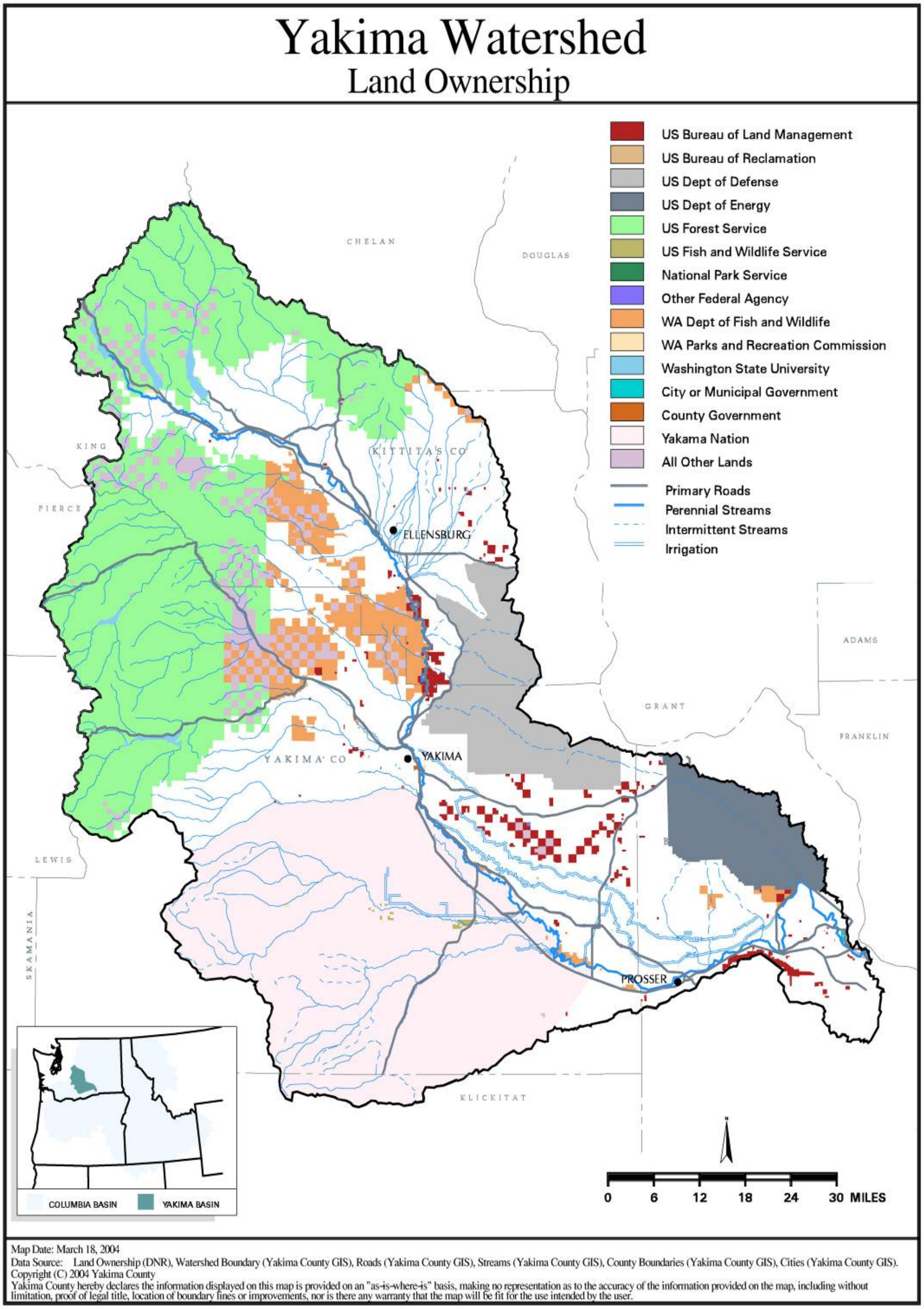

Figure 1-3. Land ownership and jurisdiction in the Yakima Subbasin

3.1.4 Human Population

About one half of the Yakima Subbasin is within and occupies most of Yakima County. The upper part of the subbasin lies in Kittitas County and occupies most of that county. The southeastern portion of the subbasin occupies part of Benton County and the southern part of the subbasin extends slightly into Klickitat County.

The Yakama Reservation occupies 1,384 sq. mi. of the Yakima Subbasin and about 40percent of Yakima County. The entire subbasin lies within areas either ceded to the United States by the YN or areas reserved for the use of the YN. The number of both enrolled tribal members on the reservation and non-members on the reservation grew between 1990 and 2000 (U.S. Census).

The basin's population is projected to increase about 45percent by 2020, according to the Yakima River Basin Watershed Management Plan (TCWRA 2003). While overall human population density is increasing in the basin (see Table 1-2), of potentially greater ecological concern is where human populations are most likely to be located.

Table 1-1. Land ownership in the Yakima Subbasin in hectares and acres

Owner	Hectares	Acres
Private	504,560	1,246,818
Unknown	67,803	167,548
US Forest Service	361,179	892,509
National Park Service	197	487
US Fish & Wildlife Service	835	2,063
Bureau of Land Management	19,786	48,893
Department of Energy	64,788	160,098
Department of Defense	80,571	199,099
Bureau of Reclamation	60	148
Washington Dept. of Fish & Wildlife	63,418	156,712
Washington State Parks	417	1,030
Washington Dept. of Natural Resources	82,184	203,085
University	233	576
County	253	625
City	222	549
Yakama Nation	360,077	889,786
Other	60	148
Total Hectares/Acres	**1,606,645**	**3,970,180**

As can be seen in Table 1-3, most of the population growth is anticipated in and around the city of Yakima; downstream along the Yakima River in communities situated in the mid-Yakima floodplain; and further east along the lower Yakima as far as the confluence with the Columbia River. (Most of the population growth is projected for the Yakima Subbasin's Lower Assessment Unit and its Mid-Yakima Floodplain Assessment Unit. Assessment units are discussed in Environmental Conditions, Chapter 2.) See Figure 1-4 for city locations.

Projected population growth in the subbasin will continue to put pressure on fish and wildlife habitat through the conversion of habitat to housing, roads, commercial development, and related infrastructure. In addition, increasing numbers of people using fish and wildlife habitat areas for recreational purposes means more disturbance of fish and wildlife species. The impacts of population growth can be ameliorated and/or mitigated through careful zoning or by purchase of critical habitat or restoration of deteriorated habitat areas so that development does not adversely impact important habitat areas.

It is especially important that population growth in the subbasin not be allowed to further impact critical habitat areas such as floodplains/riparian areas, wetlands, and shrub steppe. These habitats all lie in close proximity to existing growth areas. Without careful planning, critical habitat will be further impacted by human development.

Table 1-2. Population, trends, and densities in the Yakima Subbasin, 1990-2020

Counties, Yakima Basin	1990 Population in Yakima Basin	2000 Population in Yakima Basin	2020 Projected Population in Yakima Basin	Square miles in Yakima Basin	People/square miles in Yakima Basin		
					1990	2000	2020
Kittitas	26,725	32,493	42,242	1,928	13.86	16.85	21.91
Yakima	188,823	208,681	308,685	3,466	54.48	60.21	89.06
Benton	53,323	52,616	74,567	685	77.85	76.81	108.86
Yakima Basin	268,871	293,790	425,494	6,079*	43.7	47.8	69.2

*An additional 66 sq. mi. of the basin are in Klickitat County. Source: U.S. Census Bureau 1990, 2000; Yakima River Basin Watershed Management Plan (TCWRA 2003).

Table 1-3. Population of larger towns and cities in the Yakima Subbasin, 1990-2020

Cities	1990 Population	2000 Population	2020 Projected Population	% Change 2000-2020
Ellensburg	12,361	14,401	17,827	24%
Selah	5,113	8,406	12,982	54%
Yakima	54,827	86,239	132,867	54%
Union Gap	3,210	6,821	10,534	54%
Wapato	3,795	5,963	8,439	42%
Toppenish	7,419	8,310	12,633	52%
Zillah	1,911	2,475	4,293	73%
Granger	2,053	2,307	3,564	54%
Sunnyside	1,1238	14,446	22,309	54%
Grandview	7,169	9,253	16,215	75%
Prosser	4,476	5,125	6,596	29%
Benton City	1,806	2,616	5,248	101%
West Richland	3,962	7,789	13,308	71%
Richland w/in basin	16,158	19,339	26,183	35%

*In 2000, about 90,000 people lived in unincorporated areas in the basin, and by 2020 that number is expected to increase about 30percent. Adapted from Table 2-2 in the Yakima River Basin Watershed Management Plan (TCWRA 2003).

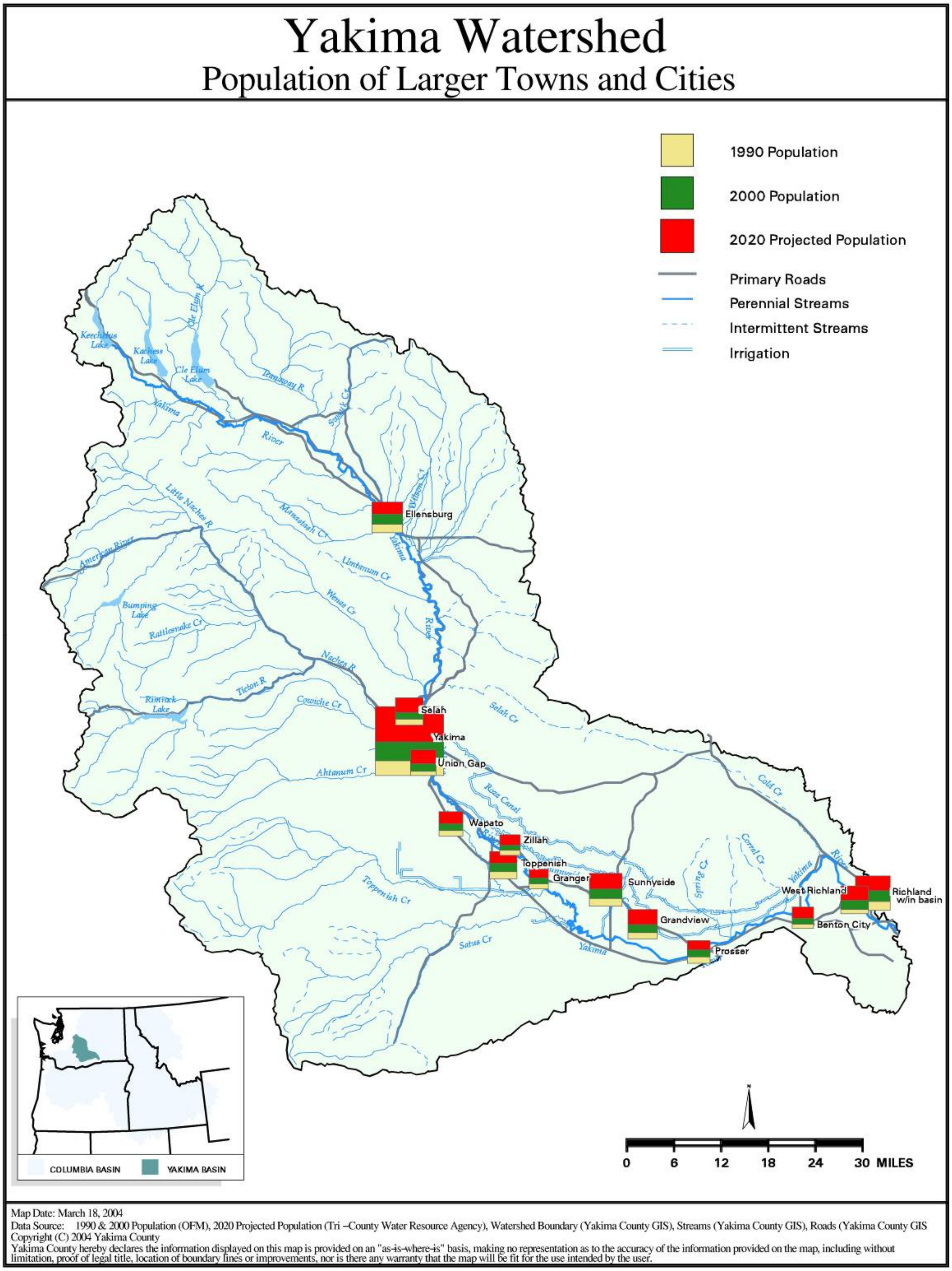

Figure 1-4. Location of the Yakima Subbasin's larger towns and cities

3.2 Socio-Economic-Demographics

Demographic characteristics vary considerably between the three counties in the Subbasin. White persons comprise 91.8 percent of the population of Benton County, 86.2 percent of Kittitas County, and 65.6 percent of Yakima County. Black or African Americans comprise 1 percent of Yakima County, .8 percent of Kittitas County, and .7 percent of Benton County. Persons of Asian, Native Hawaiian and Pacific Islands heritage comprise 1.1 percent of the population in Yakima County, 2.3 percent of Kittitas County, and 2.3 percent of Benton County. Those that identify themselves as Hispanics comprise 35.9 percent of Yakima County, 5percent of Kittitas County, and 12.5 percent of Benton County.

Almost 32 percent speak a language other than English at home in Yakima County, compared to 7.7 percent in Kittitas County, and 14.2 percent in Benton County. Over 87 percent of the adult population in Kittitas County have graduated from High School, compared to 85.1 percent in Benton County, and 68.7 percent in Yakima County. Of the adult population in Yakima County, 15.3 percent of the adult population have a Bachelor's degree or higher, compared to 26.2 percent in Kittitas County and 26.3 percent in Benton County.

Both Yakima and Kittitas Counties have median household incomes considerably below the $45,776 median annual income figure for all households in Washington State. Yakima County's is $34,828. Kittitas County's is $32,546. At $47,044, Benton County's is slightly higher than the state median.

A diverse economy has developed within the Yakima Subbasin, providing many opportunities for employment and income. Service is the largest employment sector, with over 30 percent of all employment, trade accounts for nearly 20 percent, government 15 percent, agriculture 10 percent, manufacturing 9 percent, construction 6 percent, financial and related services 4 percent, natural resources 3 percent, and transportation and communications 2 percent.

3.2.1 Land Uses

Nearly 40 percent of the basin is forested, another 40 percent is rangeland, 15 percent cropland, and the remaining acreage includes other land uses and water bodies. The predominant types of land use in the Yakima Subbasin include grazing (2,900 square miles), timber harvesting (2,200 square miles), irrigated agriculture (1,000 square miles), and urbanization (50 square miles).

The 2,900 square miles of rangelands are primarily used and managed for grazing, military training, wildlife habitat, and tribal cultural activities. The 2,200 square miles of forested areas in the northern and western portions of the basin are primarily used and managed for timber harvest, water quality, fish and wildlife habitat, grazing, tribal cultural activities, and recreation. About one-fourth of the forested area is designated as wilderness. The 1,000 square miles of irrigated agriculture includes pasture, orchards, grapes, hops, and field crops. Diverse recreational activities, including hunting, fishing, and camping, occur across much of the subbasin. Major urban areas include the cities of Yakima and Richland (see Table 1-3).

3.2.2 Transportation

Since Euro-American development began in the subbasin during the 1860s, an extensive transportation net has been constructed. This includes an expansive series of highways and secondary roads, a forest road system, and railroad lines.

Within the basin road and railroad construction in sensitive riparian and floodplain areas has severely altered channel structure and function and reduced habitat quality and quantity within the Yakima Subbasin, particularly in the heavily developed lowland areas (the mainstem Yakima in the vicinity of the cities of Ellensburg and Yakima, and much of Satus Creek). Road development has also substantially modified channel structure in the Naches and Little Naches Rivers, and the critical upper Yakima spring chinook spawning and rearing area extending from Easton Dam to the Teanaway River confluence. The narrowing and straightening of natural channels for roads, dikes, land uses, and road embankments has increased stream velocities substantially, inhibited the establishment of vegetation, and increased fine sediment delivered to streams. Roads through floodplains have played the dominant role in disconnecting and segmenting alluvial floodplains and process, simplifying tributary channels, and eliminating off-channel habitat.

There is an extensive network of forest roads throughout the basin and new construction into remote areas continues on private lands (particularly in the upper subbasin). This increasing density of roads contributes to high stream temperatures by increasing runoff and decreasing water storage potential. In addition, the development and poor locating of roads, railroads, and powerline corridors has increased instability and erosion in hill slopes and stream banks, confined and straightened the channels, degraded or destroyed riparian habitat, compacted soils, elevated peak flows in headwater streams, and increased weed infestations, sediment, and pollutant levels in streams.

3.2.3 Mining

With one major exception, mining is a relatively minor land use in the Yakima Subbasin. However, floodplain gravel mining remains an extensive and intensive activity in the Yakima Subbasin. About two-thirds of the floodplain mining in Washington State has occurred along the Yakima River or the lower reaches of two of its tributaries, the Cle Elum and Naches rivers. Selah pit and surrounding pits comprise the largest complex in the state at more than 230 acres in 1986 (Collins 1997). From the late 1880s to 1960, significant coal mining occurred in the Cle Elum-Roslyn area. Gold mining in the Swauk Creek drainage was significant during the late 1800s and continues at a much reduced level. Scattered mining claims have been filed in the Naches and Cle Elum drainages.

3.2.4 Timber Production

Approximately 2,200 square miles of the western and northern portions of the subbasin are devoted to timber production. Species harvested include ponderosa pine, Douglas fir, western larch, white fir, and lodgepole pine. Large timberland landowners include the U.S. Forest Service (USFS), Yakama Nation, American Forest Resources, Boise-Cascade, and Plum Creek. The largest timber-processing mill is located in the City of Yakima. This mill, formally owned by Boise Cascade, was recently acquired by Yakima Resources. The Yakama Nation recently opened a mill in White Swan for the processing of timber located on the YN lands. A smaller mill owned by Layman Lumber Company is located in Naches. Trucks mainly transport timber from the forest to the mill.

3.2.5 Agriculture

Irrigated agriculture occupies approximately 1,000 square miles of the Yakima Subbasin. Important crops include apples, hops, grapes, cherries, mint, forage crops, dairy products, and beef cattle. The subbasin ranks as one of the top producers nationally for apples, hops, cherries, and mint. Of the total acreage in the subbasin, forage crops occupy almost 40 percent of the acreage, while fruits occupy almost 30 percent, hops approximately 12 percent, grains over 10 percent, and vegetables over 7 percent.

Cattle are grazed on much of the 2,900 square miles of the subbasin designated as rangeland.

3.2.6 Urban/Suburban

Less than 60 square miles (1 percent) of the 6,150 square miles of the Yakima Basin has been converted to urban/suburban development. Significant urban areas include Cle Elum, Ellensburg, Selah, Yakima/Union Gap, Toppenish, Sunnyside, Grandview, Prosser, and the Tri-Cities. Though a minor part of the total basin, this area of urban/suburban development and its associated features, such as roads, railroads, and dikes and levees, has an impact on fish and wildlife habitats that is significant and disproportionate to its relative size.

3.2.7 Recreation

The Yakima Basin offers many recreational opportunities associated with natural resources, including hunting, fishing, camping, hiking, wildlife viewing, and boating. The forested and shrub/steppe habitats offer hunting for several species during prescribed seasons, including deer, elk, cougar, bear, and grouse. Permits for bighorn sheep and mountain goat are highly sought-after. The agricultural areas provide hunting for pheasants and quail, while the shrub/steppe offer chukars. Numerous wetlands and ponds attract waterfowl hunters, primarily in the lower Yakima valley.

Fishing prospects abound in the Yakima Basin. The Yakima River from Cle Elum to Roza Dam is a highly regarded catch and release trout stream. Fishermen come from all over the world to face the challenge of catching rainbow trout up to 24 inches in length. Many other streams and tributaries offer fishing for rainbow, eastern brook, and cutthroat trout. The Lower Yakima River and many ponds in the lower Yakima valley provide fishing for introduced warm-water species, including small and large mouth bass, bluegill, and catfish. In recent years, the Yakima River has provided fishing opportunities for spring, fall chinook, and coho.

Boating and fishing often go together, and the Yakima Basin offers many areas where these two activities can be enjoyed. The reservoirs owned by the Bureau of Reclamation (USBR) offer excellent boating opportunities. Many people prefer to enjoy a slightly faster pace on the Yakima River; the Yakima Canyon stretch is a popular area for small watercraft. For those who like a really fast pace, there is the white-water rafting experience on the Tieton River during September and October.

Hiking is a popular activity supported by numerous trails in the Basin. The western margin of the Basin contains a segment of the Pacific Crest Trail. The forested region contains an extensive network of trails traversed by thousands of hikers each summer. At lower elevations, there are hiking trails on land owned by the WDFW that provide spectacular spring hikes when the wild flowers are blooming. The John Wayne Trail in Kittitas County offers the opportunity to hike from the Cascade Mountains to the Columbia River.

There are many camping areas associated with hiking trails. Camping is allowed on lands owned by the USFS, WDFW, Department of Natural Resources (DNR), and the BLM. In addition, two state parks are located in the Basin, Yakima Sportsman State Park and Lake Easton State Park.

While precise economic figures exist for recreational activities in the Yakima Basin are not available, the beneficial revenue impact from this activity is considerable. For the state of Washington as a whole, fish and wildlife generate approximately $2 billion in economic benefits annually. Of this figure, over $1 billion is generated by non-consumptive wildlife viewing and other related activities. Hunting and fishing account for slightly less than $1 billion annually. Boating, hiking, and camping not related to fish and wildlife generate additional economic activity.

3.3 Hydrology

3.3.1 Surface Water

The Yakima River originates at the outlet of Lake Keechelus and runs for 214 miles in a southeasterly direction to its confluence with the Columbia River at Richland. With its tributaries, the Yakima River drains about 6,150 square miles or 4 million acres. The headwaters of the Yakima Subbasin originate in the high Cascade Mountains, with numerous tributaries draining subalpine regions within the Snoqualmie National Forest and the Alpine Lakes, Norse Peak, and William O. Douglas Wilderness areas. Major tributaries include the Kachess, Cle Elum and Teanaway rivers in the northern part of the subbasin. The Swauk, Teneum, Umtanum, Manastash, and Wenas creeks drain into the upper and middle Yakima River. The Naches River in the west is formed by the confluence of the Bumping and Little Naches Rivers at RM 44.6. Tributaries of the Naches include the Tieton River and Rattlesnake and Cowiche creeks. Ahtanum, Toppenish, and Satus creeks join the Yakima in the lower subbasin from the west.

Six major reservoirs are located in the subbasin and form the storage component of the federal Yakima Project, managed by the USBR. These six reservoirs and their storage capacities are: Keechelus Lake (157,800 acre feet); Kachess Lake (239,000 acre feet); Cle Elum Lake (436,900 acre feet); Rimrock Lake (198,000 acre feet); Bumping Lake (33,700 acre feet); and Clear Lake (5,300 acre feet). Total storage capacity of all reservoirs is approximately 1.07 million acre/feet. With the exception of Rimrock and Clear Lake, all reservoirs were natural lakes, formed during the period of glaciation, prior to the construction of dams near their respective outlets. The non-federal Wenas Dam is located on Wenas Creek at RM 14.7 and stores irrigation water for use in the lower Wenas Valley. The construction and operation of irrigation reservoirs altered the natural, seasonal hydrograph of all downstream reaches (Eitemiller et al. 2000).

3.3.2 Groundwater

The Columbia River basalts of the Columbia Plateau provide a locally important aquifer system including interbeds and overlying sediments. The overlying alluvial aquifers are highly permeable and are heterogeneous and anisotropic, due to their deposition within the fluvial environment where the processes of cut and fill alluviation by the Yakima River and tributaries occurred. The rocks of the Cascade Mountains store and transmit little water via aquifer systems, and the majority of runoff occurs as overland flow.

In both the Columbia Cascade and Columbia Plateau provinces, recent glacial activity and the network of tributary and main channel flow deposited large amounts of lacustrine and fluvial material in the valleys. This geologic template produced a series of groundwater basins separated by natural knick points (e.g., Selah and Union Gaps) and longer canyons (e.g., Yakima Canyon) (Kinnison and Sceva 1963). The Yakima River cuts through four large groundwater subbasins (Rosyln, Kittitas, upper Yakima, and lower Yakima). This geological setting influences the hydrologic cycle.

Historically, the hydrologic cycle in each basin was characterized by extensive exchange between the surface, hyporheic (shallow groundwater made up of down-welling surface water) and groundwater zones (Kinnison and Sceva 1963; Ring and Watson 1999). This exchange would have occurred mainly in flood plains functioning as hydrologic buffers, distributing the energy of peak flows and moving cool, spring melt water out onto the flood plains. This inundation would annually recharge the shallow, surficial aquifers; a process that would occur potentially well into summer because of extensive and long-lasting snow pack in the Cascades (Ring and Watson 1999).

Groundwater recharge of this nature would have provided a source of groundwater that would have maintained base flow and cooler thermal refugia as summer progressed and air temperatures increased. Groundwater recharge would also have maintained warmer winter temperatures, preventing or reducing the risk of anchor ice (Ring and Watson 1999). Bansak (1998) quantified this process in a similar alluvial valley of the unregulated Middle Fork Flathead River in Montana.

Reaches associated with alluvial flood plains have been shown to be centers of biological productivity and ecological diversity in gravel bed rivers (Stanford and Ward 1988; Independent Scientific Group 1996). In the Yakima basin, bedrock constrictions between alluvial subbasins control the exchange of water between streams and the aquifer system. Under pre-development conditions, vast alluvial flood plains were connected to complex webs of braids and distributary channels. These large hydrological buffers spread and diminished peak flows, promoting infiltration of cold water into the underlying gravels providing natural water storage. Side channels and sloughs provided a large area of edge habitat and a variety of thermal and velocity regimes. For salmon and steelhead, these side channel complexes increased productivity, carrying capacity, and life history diversity by providing suitable habitat for all freshwater life stages in close physical proximity.

At a large spatial scale, each of the Yakima groundwater subbasins is conceptualized as being down-welling, or losing surface water to the hyporheic and groundwater systems at the upstream end, and upwelling, or gaining surface water from the groundwater and hyporheic systems at the downstream end, as described for other rivers (e.g., by Stanford and Ward 1988; Tockner and Schiemer 1997). The hyporheic zone extended the functional width of the alluvial flood plain and hosted a microbe- and invertebrate-based food web that augmented the food base of the ecosystem. As snowmelt-generated runoff receded through the summer, cool groundwater discharge made up an increasing proportion of streamflow. Much of this groundwater upwelled from the gravel into complex channel networks upstream of bedrock constrictions.

This upwelling is driven by the decreasing size of the sedimentary aquifers causing groundwater to move back into the river, tributaries, and irrigation drains. Annual inundation and recharge also maintained the connectivity and flow of backwater, or spring brook, habitats. These habitats are critical for successful completion of the life-history cycles of numerous fish species and other biota (e.g., Morgan and Hinojosa 1996; Tockner and Schiemer 1997). Historic maps and photographs indicate that these types of habitats were much more abundant prior to anthropogenic alteration of the flood plain (Archive, USBR Yakima Office; M. Uebelacker, CWU, pers. comm).

Five distinct channel provinces are very apparent along the altitudinal gradient from source to mouth; 1) high gradient, largely constrained headwaters, 2) expansive anastomosed or braided alluvial flood plains, 3) constrained canyons, 4) meandering with expansive flood plains containing oxbows, and 5) deltaic flood plain at the confluence with the Columbia River.

3.3.3 Water Quality

Washington Department of Ecology has rated the Yakima River from the confluence with the Cle Elum River (RM 185.6) to the mouth as having Class A, or "excellent" water quality (for detailed description, see Water Quality Standards for Surface Waters of the State of Washington, Chapter 173-201A), while the American, Bumping, upper Naches and upper Yakima rivers were classified as AA or "exceptional".

However, there are some specific water quality parameters that do not conform to this classification. For example, the Washington Department of Ecology (Ecology) placed 72 stream and river segments throughout the Yakima basin on the 303(d) list of threatened and impaired water bodies (DOE 1996, candidate list for 1998, Federal Clean Water Act 1977). Of these segments, 83% were cited as exceeding temperature standards. Specifically, temperatures exceeded 70º F in Yakima River and tributaries from the Columbia River confluence to the Cle Elum River and 61º F in the upper Yakima, American, and Bumping rivers.

Furthermore, standards set for DDT and DDT byproducts (including, in most cases, PCBs and other pesticides and herbicides such as endosulfan, parathion, endrin, aldrin and dieldrin) were exceeded in 15 percent of the listed reaches. Six of these nine sites were located below the city of Yakima and four of the nine were located in the Yakima River proper, ranging in distribution from Cle Elum to Horn Rapids. The site with greatest contamination was Horn Rapids. In essence, longitudinal linkage within the river has led to a downstream increase in contamination, with specific point sources entering from Snipes, Spring, Sulphur, Wide Hollow, and Cherry creeks, and Granger and Moxee drains (however, both Snipes and Spring creeks have been removed from DOE's draft 1998 303 (d) list.

Instream flows were cited as exceeding standards set by the Washington State in 8 of the 72 reaches, including the Yakima River near Toppenish and Horn Rapids; Cowiche, Wenas, Big, Taneum and Manastash creeks; and the Teanaway River.

Because of these listings, DOE conducted a study to determine total maximum daily load (TMDL) criteria in the lower Yakima Basin (Joy and Patterson 1997). Because the link between total suspended sediment (TSS), turbidity and concentration of DDT had previously been established (Rinella et al. 1992), turbidity standards were limited to an increase of only 5 NTUs (Nephelometric Turbidity Unit) between the confluence of the Naches and Yakima rivers and Benton City (139 miles). As discussed above, this standard was based on the Washington's "A" classification for this river segment. Furthermore, recommendations were made to limit tributary and drainage return concentrations to 25 NTUs (56 mg/L TSS). If implemented, this will require a 70percent TSS reduction in the major drainage returns (Joy and Patterson 1997). Of particular concern are the high concentrations of DDT (and its breakdown products DDE and DDD) in fish tissue, which are among the highest concentrations recorded in the United States (Rinella et al. 1993). Subsequently, in 1993, the Department of Health (DOH) recommended that people eat fewer bottom feeding fish (Joy and Patterson 1997; DOH 1993). This advisory is still in effect.

The effect of DDT, dieldrin, and other pesticide contamination on river ecology is less certain. However, whole fish sampled by DOE in 1990, 1992, and 1995 found that nearly all concentrations exceeded 200 to 270 µg/kg—levels that exceed guidelines to protect wildlife populations from chronic carcinogenic risk (Joy and Patterson 1997; similar to results from earlier studies reported in Johnson et al. 1986). Furthermore, several studies have documented the presence of physical abnormalities on fish collected from agricultural drains and the lower Yakima River (e.g., Cuffney et al. 1997, Walsh et al 1977).

A sediment budget also was constructed for the lower Yakima, because of the link between TSS and DDT (Joy and Patterson 1997). Results indicated that in 1995, inputs from tributary and irrigation returns contributed a significant quantity of the sediment load for the river. For example, Moxee Drain contributed 35 tons/day in the latter part of the irrigation season, while the Naches River contributed only 27 tons/day, even though discharge in the Naches was 14 times greater than Moxee Drain. TSS concentration in Sulphur, Spring, and Snipes creeks, Granger Drain, and combined load from the Yakama Reservation was 110, 46, 60, and 75 tons/day, respectively. These values are within the range of other studies (Fast et al. 1991). Also apparent from this analysis was the huge influx of TSS during the early part of the growing season relative to the period from July through October in reaches spanning the Naches confluence to Parker and Parker to Kiona.

For example, mean TSS load (tons/day) from March-October was 2.4 times greater than mean load calculated from July-October from the Naches to Parker. Similar trends were apparent in the Parker to Kiona reach. Apparently, this is mainly a function of high TSS load (94 tons/day) carried by the Naches River during spring runoff (March to July) relative to July to October (27 tons/day), although increased TSS load in Yakama reservation tributaries and drains contributed to this as well. The high TSS load from the Naches is believed to be due to logging activities and sediment releases from the reservoirs (Joy and Patterson 1997). However, further studies are necessary to distinguish the importance of these sources versus other variables, such as the influence of the "flip-flop" flow regime.

The lower reach generated 67 percent of the total TSS load carried from March to October and 92 percent from July to October. This indicates that the lower Yakima reach is obtaining >90 percent of the TSS load during July to October from sources within this reach. Of these sources, gauged drains in project areas contributed 213 tons/day, while Yakama reservation returns cumulatively accounted for 75 tons/day, ungauged drains in project areas for 43 tons/day, and unknown sources for 55 tons/day. Finally, as flows decreased from July through October, sedimentation became prevalent. Sedimentation in the upper reach accounted for 23 percent of the total TSS load (32 tons/day), while the lower basin was characterized by a 43 percent sedimentation rate (153 tons/day).

Numerous studies have cited temperature in the lower Yakima River, particularly below Prosser, as a serious barrier to migration and to completion of salmonid life histories (Lilga 1998; SOAC 1999; CAG 1997; Vaccaro 1988; Pearsons et al. 1996; USBR 1999). This is particularly true during the irrigation season, when temperatures are often stressful or lethal to salmonids (Lilga 1998; Lichatowich and Mobrand 1995; Lichatowich et al. 1995; Fast et al. 1991).

Lilga (1998) also examined the utility of using increased in-stream flows to decrease temperature in the lower river. She found that there was no relationship between mean daily summer stream temperature and flow, and that about 70 percent of the variation in water temperature was explained by air temperature. Several variables thought to influence in-stream temperatures were not measured as part of this study. These included subsurface flow from surficial aquifers, withdrawals, surface flow from tributaries and irrigation returns, channel morphology, variation in water velocity, upstream temperature conditions, solar insulation and topographic and riparian shading effects (1998). Because of these uncertainties, Lilga concluded that a numerical model needed to be implemented before an accurate assessment could be made of the relationship between in-stream flows and temperature.

In a similar study, Vaccaro (1988) analyzed the effect of four different management scenarios on in-stream temperatures for the 1981 irrigation season. Scenarios ranged from estimated natural conditions (e.g., no storage, diversion or return flows) to various reductions in irrigation withdrawal and return flows (e.g., 50 percent reduction in all canals and 50 percent reduction in the major canals), hypothetically derived from increased irrigation efficiency.

Interestingly, simulated natural conditions yielded higher in-stream temperatures in August compared to any of the regulated scenarios. This is almost certainly a direct effect of hypolimnetic releases from four of the five storage reservoirs (all but Rimrock) (see also Vaccaro 1988). Natural surface releases would have been relatively warmer as stratification occurred in the lakes as summer progressed. Vaccaro also found that although August temperatures were warmer, mean temperatures throughout the irrigation season were lower at Prosser and Kiona. Although many potential sources of error were noted, not included was the potential effect of groundwater inflow and the interaction between historical spring flooding and inundation of the alluvial aquifer with cool, spring-melt water, as previously discussed (Ward 1985a,b; Bansak 1998; Ring and Watson 1999).

An analysis of the lower basin in August 1997 using digital aerial thermography indicated that there are numerous sources of cooler water entering the system from many spring brooks and some tributaries. Influx of relatively cooler ground water likely was much greater prior to regulation—potentially providing thermal refugia for biota, including outmigrating smolts and returning adult salmon (Ring and Watson 1999). Ring and Watson (1999) concluded that the natural ability of the alluvial floodplains to moderate in-stream temperatures has been seriously compromised because of the change in the natural flow regime, as discussed earlier, and because of the significant alteration and disconnection of the flood plain.

3.3.4 Irrigation Development

Euro-American irrigation development in the Yakima Subbasin began in the 1860s when early ranchers diverted streams to irrigate gardens and hay fields. During the 1870s and 80s, more ditches were dug from a number of streams, including Ahtanum Creek, Naches River, Manastash Creek, Taneum Creek, and Yakima River mainstem. After the railroad was completed from Yakima (then North Yakima) across the Cascade Mountains to the Puget Sound region, irrigation acreage in the subbasin steadily increased as local farmers reacted to the new market. Several sizable canals were constructed in the late 1800s, including the Sunnyside Canal. By 1905 about 137,000 acres were under irrigation in the subbasin.

In 1904 the newly created USBR began surveys and investigations in the subbasin for the purpose of planning and constructing additional irrigation facilities, including storage reservoirs. Between 1910 and 1935, six storage reservoirs were built with a combined capacity of 1.07 million acre/feet: Bumping, Clear Lake, Keechelus, Kachess, Cle Elum, and Tieton. In addition, six major federal irrigation districts or divisions were constructed: Yakima/Tieton, Sunnyside, Kittitas, Wapato, Roza, and Kennewick. Several smaller districts also receive irrigation water from the Yakima Project. Currently, about 500,000 acres are under irrigation in the subbasin.

All of the storage reservoirs are located in the headwaters of the upper basin within the Cascade Mountains. The majority of the water sustaining the agricultural industry is transported to the lower basin during periods of the summer and early fall when the river would otherwise be approaching base flow. Six low-head diversion dams are located on the mainstem of the Yakima, including Easton at river mile (RM) 146, Roza (RM 128), Wapato (RM 107), Sunnyside (RM 104), Prosser (RM 47) and Horn Rapids (RM 4). The Naches River, the largest tributary to the Yakima River, has two large diversion dams, Wapatox (RM 17) and Naches Cowiche (RM 4). Diversion dams are shown in Chapter 2 Fish Habitat Conditions. Each of these diversion dams maintains screening structures that were installed in order to prevent upstream migration of adults or downstream entrainment by juvenile salmonids into the irrigation systems. Groundwater recharge occurs via precipitation and from the application of irrigation water, the latter of which increases recharge over pre-irrigation times by about a factor of 10 (T.Ring, YN, pers. comm.). Kinnison and Sceva (1963) noted that water table elevations rose substantially during the onset of irrigation in the first half of the century. Because of this, drains often were cut to reduce high water tables and prevent the development of alkaline soils. Thus, the pattern of ground water recharge has been substantially altered with post-irrigation recharge following the seasonal patterns of irrigation. Historically, recharge would have occurred mainly in the winter and spring when evapotranspiration was low and precipitation was high. The result has been a reduction in the frequency, magnitude, and duration of flood plain inundation because of reservoir storage. Thus, recharge of cold, spring-melt water into the aquifer systems has been replaced by recharge of warmer water derived from irrigation later in the spring and summer.

The diversions at Sunnyside and Wapato typically divert one half of the entire river flow during the irrigation season, from May to October, while Prosser diverts 40 m 3/s most of the year, both for irrigation and power production. Because of regulation and withdrawals for irrigation, the Yakima River experiences periods of both dewatering and elevated flows relative to the historic discharge regime (Parker and Storey 1916; Vaccaro 1988; Conservation Advisory Group [CAG] 1997[2]). For example, at Union Gap and Parker, regulation has reduced annual discharge (mean based on data from 1926-77) from 134 m 3/s to 108 m 3/s at Union Gap and 65 m 3/s at Parker (Vaccaro 1988). Declines of this magnitude would significantly affect the processes of cut and fill avulsion that historically maintained habitat heterogeneity. Furthermore, the average annual 7-day minimum mean discharge at Parker for the same time period was 3.7 m 3/s (Vaccaro 1988). Vaccaro (1988) estimated that composite error of historic discharge estimates was 12 percent relative to the 21 percent change in discharge by regulation at Union Gap and the 52 percent change at Parker. At present, legislation calls for flows below Sunnyside and Prosser to range from 8.5 to 17 m 3/s, depending on the estimated supply of water.

3.3.5 Reservoir Operations

The Bureau of Reclamation owns and operates six reservoirs (Bumping, Rimrock, Kachess, Keechelus, Cle Elum) located in the headwaters of the Yakima Basin as part of the Yakima Reclamation Project, with a combined storage capacity of 1.07 million acre/feet. These reservoirs exert a fundamental influence on the floodplains and riparian zones located downstream. This influence is the result of reservoir operations that have significantly altered the historic river hydrograph. In general, flows are lower in the fall, winter, and spring, and higher in the summer and early fall, than they would be without the reservoirs. Most importantly, the reservoirs significantly reduce flood flows during flood events. The reduction of flood flows has significant hydrological and biological implications, including the lowering of biodiversity and bioproduction. As the 2002 USBR's Interim Operating Plan (IOP) noted, reservoir operations have caused: "Truncation of flood peaks by capture in reservoirs reduces the frequency, duration, magnitude, and spatial extent of floodplain inundation. This decreases the size of the regulatory floodplain, thus project operations have indirectly allowed commercial and residential development of floodplains. By reducing recharge from over bank flow and increasing irrigation induced recharge, which has different timing and location, project

[2] The Conservation Advisory Group (CAG) is charged with developing recommendations to the Secretary of the Department of the Interior regarding a market-based process to facilitate the voluntary sale or lease of water.

operations have altered the quantity, quality, and timing of groundwater discharge to the river and floodplain spring brook habitats" (USBR 2002).

Much of the remaining floodplain has been compromised with respect to ecological function and biological productivity. The CAG took note of the compromised current conditions of salmonid habitat: "Today production of anadromous fish is severely restrained because of problems associated with degraded habitat, (e.g., loss of wetlands, backwater areas, side channels, and connectivity of the river channel and floodplains)" (USBR 1999).

3.3.6 Floodplains and Flood Control

Historically, the valley floodplains played a pivotal role in anadromous fish production in the Yakima Basin: "Flood plains likely are hotspots of regional biodiversity and bioproduction because the soils are enriched by flooding, and the fringing wetlands and riparian forests characterize complex habitat mosaics in which many species can co-exist, including great numbers of migrants" (Snyder and Stanford 2001). Most species of wildlife use floodplain habitats during at least some portion of their life history. The riverine environment provides habitat for many resident and anadromous species of fish, including salmon and steelhead. "The riparian area is where aquatic and terrestrial ecosystems interact and is essential to both fish and wildlife. Streamside plants shade the water, help moderate water temperature, and promote streambank stability as well as providing the organic nutrient load in the aquatic ecosystem. These plants are the source of large instream woody debris that provide refuge and food sources (Norman, et al. 1998).

The historic floodplains were a complex mosaic of channels, side channels, spring brooks, riparian forests, ground water/surface water interaction, and abundant species of fish and wildlife. Snyder and Stanford (2001) summarized the function of natural floodplains as "key structures that appear to organize the occurrence of biota within the river corridor. Organization of river biota revolves around the shifting mosaic of floodplain habitats above and below ground that is created and maintained by flood-driven cut and fill alluviation and associated ground and surface water interactions."

The USBR's IOP described current floodplain conditions as follows: "Floodplain isolation and channel simplification, combined with inversion and truncation of the natural hydrograph, have dramatically reduced river floodplain interactions and degraded the aquatic environment. The floodplain is isolated from the river by diking, channelization, wetland draining, gravel mining, and highway and railroad building. Many of these same activities have eliminated or isolated vast areas of side channels and sloughs. River operations for irrigation and flood control alter the natural hydrograph by impounding spring freshets, substantially increasing summer flow, and decreasing winter flow. A common effect of these developments is a sharp reduction in the frequency with which spring floods recharge the alluvial floodplain aquifer system. Water temperatures in the lower river are therefore higher in summer, and the number and extent of thermal refugia are reduced" (USBR 2002).

Much of the remaining floodplain has been compromised with respect to ecological function and biological productivity. The CAG took note of the compromised current conditions of salmonid habitat: "Today production of anadromous fish is severely

restrained because of problems associated with degraded habitat, (i.e. loss of wetlands, backwater areas, side channels, and connectivity of the river channel and floodplains, etc.)" (USBR 1999).

As important as floods are to bioproduction and properly functioning riverine ecosystems, they can cause damage to man-built structures and features, as well as pose a threat to human safety. Extensive efforts have been undertaken in the subbasin to protect man-built structures, prompted by urban development and periodic floods. As a result of the 1933 flood, still the highest Yakima River flow level on record, an extensive federal levee system around the City of Yakima was constructed in 1947-48 by the Corps of Engineers (KCM 1998). This levee system extends approximately 25,000 feet along the right bank and almost 11,000 feet along the left bank between Selah Gap and the old Moxee bridge (KCM 1998). Other agencies have constructed levees downstream of SR 24.

Extensive dikes/levees have been constructed along the lower Naches River and along the Yakima River near Ellensburg and Selah. The construction of highways and railroads can function as de facto dikes/levees and have the same impact on floodplain functions productivity. Highway/railroad dikes impinge on the floodplain along the Naches and Little Naches rivers, along the Yakima River between Easton and Ellensburg, and along the Yakima River in the lower Yakima valley between Union Gap and Zillah.

3.3.7 Hydroelectric Development in the Yakima Subbasin

Three small federal hydroelectric projects are located on the Yakima and Naches rivers: the Roza and Chandler power plants and the Naches Drop project on Wapatox Canal. In 1999 the Roza and Chandler power plants contributed about 130.4 million-kilowatt hours to the Columbia River Federal Power System.

Wapatox Power Plant is located on the Naches River (RM 9.7) and was formerly owned by PacifiCorps. This facility was recently purchased by the BOR for the purpose of returning the majority of the water (up to 450 cfs) previously used for power generation to instream flows in the Naches River.

Chandler Powerplant (RM 35.8) uses water diverted down the Chandler Power Canal (diversion capacity is 1500 cfs) at Prosser Dam (RM 47.1) to operate pumps to convey irrigation water across the Yakima River into the Kennewick Main Canal. The residual capacity remaining from irrigation needs, including when the pumps are not run for irrigation is diverted to power production. Power production is subordinated to various flows throughout the year. In the spring, the subordination target is 1,000 cfs over Prosser Dam through the end of June. During the remainder of the irrigation season, the subordination target is 450 cfs or the YRBWEP Title XII target flow, whichever is higher. Prior to the winter of 1998-1999, the subordination target was 450 cfs through the non-irrigation season. Since that time, winter targets have been negotiated annually.

Roza Powerplant is located along Roza Canal northeast of the city of Yakima. Water is diverted into the canal at Roza Dam (RM 127.9) about 10 miles north of the city and returns to the river below the power plant (RM 113.3). The power plant has 11,250 kilowatt (kW) of capacity. Some of the power from the Roza Powerplant is used to operate Roza Irrigation District's pumping plants.

When power is being generated, there is a minimum flow target of 400 cfs below the dam. Power generation is terminated when the 400 cfs target cannot be met with the plant operating. This is usually only an issue during "flip-flop”.

In addition, both Yakima-Tieton Irrigation District and Wapato Irrigation Project have power-generating turbines installed in their respective irrigation distribution systems. Both districts use a portion of the power generated for pumping irrigation water within their districts and sell surplus power, Wapato Irrigation District sells to BPA and Yakima-Tieton to Pacific Power.

3.4 Terrestrial and Wildlife Resources

3.4.1 Vegetation

As would be expected in an area of highly varied landforms and precipitation, vegetation across the basin is a mix of forest, grassland (shrub/steppe), and cropland. In general, the western third of the basin is forested with a mixture of species, such as grand fir, Douglas fir, lodgepole pine, ponderosa pine, and Western larch (A full list of all common and scientific names are provided in Appendix D). Along the eastern edge of the forested zone, where precipitation has decreased, a band of Oregon white oak is found, intermingled with ponderosa pine and Douglas fir. As precipitation and elevation decrease, the forested areas meld into shrub/steppe, which occupies the eastern two-thirds of the basin. The shrub/steppe areas of the valley floors have been converted to cropland.

Shrub-steppe is the predominant native habitat type from approximately Ellensburg to Pasco. Conversion to cropland and grazing, however, have left only about 5 percent of the historical shrub-steppe habitat in relatively undisturbed condition, according to estimates by the Washington Natural Heritage Program.

While undisturbed shrub-steppe habitat is very rare, moderately disturbed shrub-steppe communities are fairly common, being affected to various degrees by grazing, exotic plant infestations, and other disturbances. About 26 percent of the relatively undisturbed shrub-steppe habitat is dominated by native grasses and sagebrush, with an intact cryptogam crust (a thin layer of moss and lichen that indicates an undisturbed community), and contains mostly native shrubs (e.g., big sagebrush and bitterbrush) with a predominantly native grass understory. This habitat type, while damaged by grazing, off-road vehicle use, and other disturbances, still provides cover, food, and nesting habitat for many species of wildlife. These moderately disturbed shrub-steppe areas are particularly important during winter months when nearby and adjacent cultivated fields provide no vegetative cover for wildlife.

3.4.2 Rare Plant Communities

The Yakima Subbasin contains 67 rare plants and 52 rare or high-quality plant communities. Approximately 8 percent of the rare plant communities are associated with grassland habitat, 28 percent with shrub steppe habitat, 56 percent with upland forest habitat, and 8 percent with riparian habitat. For a detailed list of known rare plant occurrences and rare plant communities in the subbasin, see Appendix B

3.4.3 Wildlife

A large variety of wildlife species are associated with the Yakima Subbasin because of its diverse vegetative and geologic features. Using IBIS (2003) and regional information, 390 wildlife species have been identified to currently occur within the Yakima Subbasin (See Figure 1-5, Appendix E).

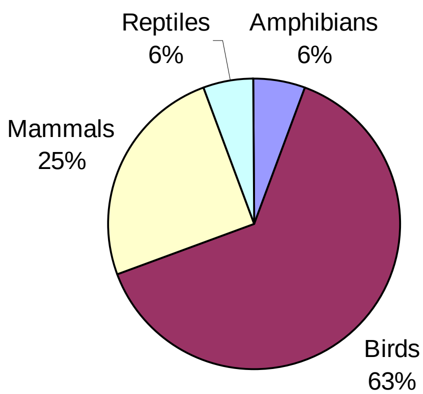

Figure 1-5. Species richness of the Yakima Subbasin, Washington (IBIS 2003)

The subbasin supports 22 reptiles such as the western rattlesnake and 23 amphibians such as the Cascades frog. Little is known, however, of the distribution, abundance, and life histories of reptiles and amphibians in the Yakima Subbasin. For example, species associated with western Washington may actually occur in the northwestern portions of the subbasin (e.g., Northwestern salamander, Pacific giant salamander, red-legged frog).

Passerine birds, raptors, waterfowl, and uplands birds are found in various habitats across the subbasin and account for 247 of the subbasin wildlife species. Some bird species, such as the ring-necked pheasant, California quail, black-billed magpie, American crow, common raven, western meadow lark, horned lark, and American kestrel are year-round residents, while others, including the rough-leg hawk, snow bunting, and varied thrush are migratory, and are only present during the winter. Many other migrant species of birds are present in the Basin during the spring and summer nesting season, including osprey, turkey vulture, common nighthawk, long-billed curlew, and common poor-will. The subbasin is an important nesting area for many neo-tropical species, including western and eastern king bird, evening grosbeak, lazuli bunting, and spotted towhee.

In addition to providing habitat for those species that are permanent or seasonal residents, the Basin is an important component of the migratory route for many species that traverse the Basin during the spring and fall migratory period. A considerable number of passerine species pass through the Basin on their travels to and from nesting areas in Canada and Alaska, including several species of warblers, flycatchers, and finches. Species of shorebirds also pass through the Basin during the spring and fall migration period.

The Yakima Basin is a component of the Pacific Flyway. Waterfowl pass through the Basin on their north/south migrations during the spring and fall, respectively. Similar to the connection established by anadromous fish between the Basin and distant geographic areas, migratory waterfowl bind the Basin to areas as distant and diverse as artic nesting areas and wintering areas in northern Mexico. Regionally, waterfowl routinely transit from other wintering areas, such as the Columbia Basin and the Umatilla National Wildlife Refuge.

The Yakima Subbasin supports a significant population of waterfowl during the spring and summer nesting season as well as during the winter period. The Basin produces a significant portion of all wood ducks hatched in the state, as well as mallards, Canada geese, and other duck species. While wintering populations of waterfowl in the Basin have decreased over the past 30 years, the Basin still plays host to many thousands of duck and geese each winter, including mallards, Canada geese, green-wing teal, northern pintail, and other species. Wintering waterfowl are concentrated in the Lower Yakima Basin on the Toppenish creek and the Yakima River floodplain below the city of Granger. From these concentration areas, waterfowl feed in many agricultural areas throughout the Lower Yakima Valley.

Ninety-eight large and small mammals are found in the subbasin. Loss of habitat has drastically reduced numbers of one small mammal, the western gray squirrel, and this species is now a Washington State threatened species. Several species of big game inhabit the Yakima Basin, including black bear, black-tailed deer, mule deer, Rocky Mountain elk, bighorn sheep, mountain goats, and cougar. Bighorn sheep were reintroduced over 40 years ago and inhabit the canyons and ridges between Selah/Naches and Ellensburg. A small number of mountain goats are found at high elevations along the western fringe of the subbasin. In recent years, wolverine sightings have been reported in the upper portions of the subbasin, as have unconfirmed sightings of gray wolves and grizzly bears (NPPC 2001).

3.4.4 Federal and State-listed Species

Populations of bald eagles in Washington were listed as “Threatened” under the ESA in 1978. At the same time, bald eagle populations in the remainder of the lower 48 states were listed as “Endangered” (USFWS 1986). Because of increases in bald eagle populations across the United States, the USFWS reclassified the species from “Endangered” to “Threatened” throughout the lower 48 states in 1995. In 1999 the USFWS proposed removing the bald eagle from the ESA list. A decision is pending.

Certain species have needed federal and/or state protection due to the loss of suitable habitat. Appendix E, Table E2 lists those birds, mammals, and reptiles that have been afforded federal and/or state protection designations. Only a few focal wildlife species are discussed in detail in the remainder of this document. See the discussion of focal habitats and representative focal wildlife species and the reasons for their selection in Chapter 2.

3.4.5 Washington State Department of Fish and Wildlife

State Game Species

In the Yakima Subbasin a total of 23 fish (J. Easterbrook, WDFW, pers. comm. 5/4/04) and 44 wildlife species are available for regulated harvest (IBIS 2003). A detailed list of game species in the Yakima Subbasin is provided in Appendix E; Table E4.

Priority Habitats and Species (PHS)

PHS fulfills one of the most fundamental responsibilities of the WDFW; to provide comprehensive information on important fish, wildlife, and habitat resources in Washington. Initiated in 1989, the PHS Program was identified as the agency's highest priority. Today, the PHS Program serves as the backbone of WDFW's proactive approach to the conservation of fish and wildlife. PHS provides the information necessary to incorporate the needs of fish and wildlife in land use planning. The PHS program addresses three central questions:

- Which species and habitat types are priorities for management and conservation?
- Where are these habitats and species located?
- What should be done to protect these resources when land use decisions are made?

3.4.6 Other Wildlife Programs

Partners in Flight

Partners in Flight (PIF) is a coordinated effort by government, non-profit, and scientific entities to address avian conservation issues across international borders. PIF’s goals are to focus resources on the improvement of monitoring and inventory, research, management, and education programs involving birds and their habitats. The PIF strategy is to stimulate cooperative public and private sector efforts in North America and the Neotropics to meet these goals. Inclusion on the PIF list indicates significant conservation concern. See Appendix E, Table E3 for full list.

Habitat Evaluation Procedure (HEP)

Certain wildlife species were used to conduct wildlife habitat loss assessments associated with the construction and inundation of federal hydroelectric projects on the Lower Snake and Columbia Rivers. HEP is an established methodology to measure the quality and quantity of habitat change (USFWS 1981). These species are included in Appendix E, Table E5.

3.5 Aquatic/Fish Resources

Anadromous fish act as a thread, linking the Yakima Subbasin to other portions of the Columbia Basin; indeed, linking it to far-flung areas of the North Pacific. Salmon and steelhead exit the subbasin, move down through the lower Columbia River downstream of the Tri-Cities, and enter the Pacific Ocean at Astoria, Oregon. From the mouth of the Columbia River, most salmon and steelhead turn north. A lesser number, primarily coho, turn south as they enter salt water and move down the coast of Oregon and northern California. Salmon and steelhead produced in the Yakima Subbasin influence fish and wildlife species, and people, over many thousands of square miles. As they travel along their extended migration route, they enter the ecosystems of the areas they travel through, feeding on the resources available in those areas, and being eaten in turn.

People over these many miles are impacted by Yakima Subbasin fish, from the Native American fishers dipping their traditional nets along the Columbia River, to fishing boats off the coast of British Columbia and southeast Alaska, to high seas fishing boats on the North Pacific. All are tied to the Yakima Subbasin by the salmon and steelhead emanating from the river.

Yakima Subbasin fall chinook that are considered to be part of a larger, regional population (metapopulation) which includes the fall chinook in the Hanford Reach of the Columbia River, located just upstream of the mouth of the Yakima River. Yakima Subbasin steelhead are grouped with steelhead from the Umatilla, John Day, and Deschutes Rivers in a Mid-Columbia River Evolutionary significant unit (ESU). Native coho, sockeye and summer chinook have been extirpated from the Yakima Subbasin. Efforts by the YN have led to a reintroduced coho population. Planning is also underway for a reintroduced sockeye population. These coho are now spawning in the Yakima River near Yakima, in the lower Naches River, in Cowiche, Wide Hollow, and Ahtanum Creeks. The YN places a high priority on reintroducing sockeye, and planning is currently underway,

The efforts to restore populations of salmon and steelhead in the Yakima Subbasin are not isolated. Salmon and steelhead restoration programs are underway in the Wenatchee, Walla Walla, and Umatilla Subbasins as well.

3.5.1 Fish Resources

The Yakima subbasin supports at least 48 species of anadromous, resident native, and exotic fish. Table 1-4 shows the distribution of fish species in the Yakima subbasin. Anadromous species include spring and fall chinook, coho, and summer steelhead.

Table 1-4. Species distribution in the Yakima River Mainstem and associated tributaries Shaded cells indicate species is rare (relatively few captures reported). Distance is from river mouth (km)

Species	0 to 44	45 to 68	69 to 161	162 to 180	181 to 305
W. brook lamprey			X	X	X
Unidentified lamprey			X		X
Pacific lamprey	X	X	X	X	
Coho salmon	X	X	X	X	X
Spring chinook salmon	X	X	X	X	X
Fall chinook salmon	X	X	X	X	
Sockeye salmon	X	X	X	X	X
Summer steelhead	X	X	X	X	X
Bull trout		X		X	X
Lake trout			X	X	X
Brook trout				X	X
Rainbow trout	X	X	X	X	X
Cutthroat trout				X	X
Brown trout	X	X	X	X	X
Mountain whitefish	X	X	X	X	X
Pygmy whitefish					X
Chiselmouth	X	X	X	X	X
Common carp	X	X	X	X	X
Goldfish	X	X			
Peamouth	X	X	X		
Northern pikeminnow	X	X	X	X	X
Longnose dace	X	X	X	X	X
Speckled dace	X	X	X	X	X
Leopard dace	X	X	X		
Umatilla dace (subspecies)	X	X	X		
Unidentified dace	X	X	X	X	X

Species	0 to 44	45 to 68	69 to 161	162 to 180	181 to 305
Redside shiner	X	X	X	X	X
Bridgelip sucker	X	X	X	X	X
Largescale sucker	X	X	X	X	X
Mountain sucker			X	X	X
Unidentified sucker	X	X	X	X	X
Brown bullhead	X	X	X	X	
Channel catfish	X	X	X		
Three-spine stickleback	X	X	X	X	X
Pumpkinseed	X	X	X	X	X
Bluegill	X	X			X
Smallmouth bass	X	X	X	X	X
Largemouth bass	X	X	X	X	X
Black crappie	X	X			
White crappie	X				
Yellow perch	X	X	X	X	X
Walleye	X	X	X		
Mottled sculpin			X	X	X
Torrent sculpin			X	X	X
Piute sculpin			X	X	X
Shorthead sculpin			X		X
Prickly sculpin	X				
Unidentified sculpin	X	X	X	X	X
Burbot		X			X
White sturgeon	X	X			
Mosquitofish	X				
Sandroller	X		X		

Mouth (Tri-cities) = River m 0; Kiona (Benton City) = RM 27; Prosser = RM 42; Yakima = RM 100;Roza Dam = RM 111; Keechelus Dam = RM 189. Source: WDFW Ecological Interactions Team 1998

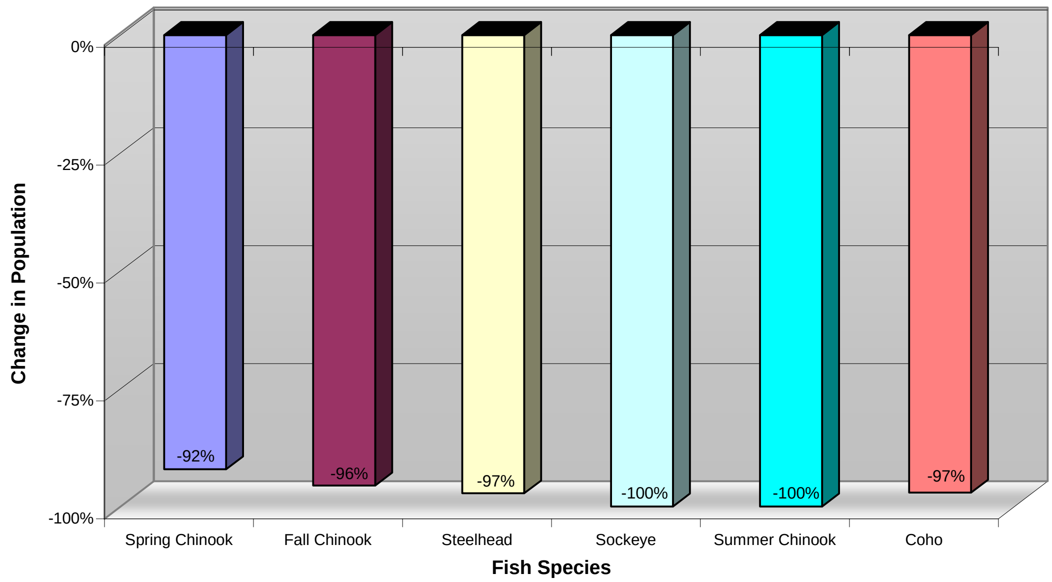

Figure 1-6. Change in abundance of selected salmonid species expressed as a percentage of populations circa 1850 (NPPC 2001). Sockeye, summer chinook, and coho were extirpated but coho have been reintroduced. Bull trout is a focal species but historical abundance estimate are unavailable and therefore are not included in this figure. See discussion in Chapter 2 related to bull trout for more information.

In March 25, 1995 (64 FR 14517) the National Marine Fisheries Service listed summer steelhead in the Mid-Columbia ESU, which includes the Yakima Subbasin, as threatened under the ESA. Endemic coho stocks were extirpated by 1980 although naturalized production resulting from hatchery releases have been documented since 1989. Endemic summer chinook were last observed in the early 1970s and are now considered extirpated. Sockeye were historically abundant, but were extirpated following the completion of impassible storage dams below all natural rearing lakes in the late teens and early 1920s. Pacific Lamprey are a U.S. Fish and Wildlife Service category 2 candidate species, and in the Yakima Basin, have become very rare.

Historically, 500,000-900,000 adult salmon and steelhead returned to the Yakima Subbasin annually. This total was comprised of spring, summer, and fall chinook, coho, sockeye, and steelhead. Summer chinook, sockeye, and native coho are extinct in the subbasin. Coho currently found in the subbasin are the result of reintroduction efforts by the YN. The number of returning adults is greatly reduced from historic levels. Over the last ten years, returns of spring chinook have varied from a low of 645 to highs of 25,000. Fall chinook returns average 2,000 to 4,000, while coho runs have been in the 1,000 to 2,000 range (Figure 1-6).

The distribution of anadromous fish in the basin is modified significantly compared to the pre-1850s. In recent times spring chinook use the mainstem Yakima River for migration, rearing, and holding, while spawning occurs in the upper Yakima between Keechelus Dam and Ellensburg, with the most significant spawning taking place between Easton and the confluence with the Teanaway River. Spawning also occurs in the Cle Elum River below Cle Elum Dam, and in the Teanaway River. Some spring chinook spawn in the Yakima River below Roza Dam in the East Selah area. In the Naches drainage, spring chinook spawn in the Little Naches River, Bumping River, American River, Rattlesnake Creek, and the mainstem Naches from the Little Naches down to Horseshoe Bend. Most fall chinook spawn in the mainstem Yakima River downstream of Prosser Dam, while some spawn upstream between Prosser Dam and Sunnyside Dam. A small population also spawns in Marion Drain on the WIP. More than half of the returning steelhead spawn on the Yakama Reservation in Satus and Toppenish Creeks. Approximately a third of the population spawn in the Naches drainage, with scattered spawning in the upper Yakima River and tributaries. Coho spawn in the mainstem Yakima River below Roza Dam, in the Naches drainage, and in several tributaries, including Cowiche and Ahtanum creeks.

Two species of fish in the subbasin have been listed pursuant to the Endangered Species Act of 1973; the steelhead Mid-Columbia ESU and bull trout. In early 1999, the National Oceanic and Atmospheric Administration-Fisheries (NOAA Fisheries) published a Federal Register Notice (64 FR 14517) listing the Mid-Columbia steelhead ESU as “Threatened” pursuant to the ESA of 1973, with an effective date of 24 May 1999. An earlier Federal Register Notice (63 FR 31647) was published on 10 June 1998 also listing Bull trout in the Columbia Basin as “Threatened”, effective 10 July 1998. Only a few focal fish species are discussed in detail in the remainder of this document. See the discussion of focal fish species and the reasons for their selection in Chapter 2.

4 Description Of Chapters 2, 3, and 4

As can be seen from the description in Chapter 1 above, the Yakima Subbasin is a complex geographic area, with a wide range of habitat types that are produced by elevation changes from less than 400 feet above sea level to over 8,000 feet above sea level. Precipitation patterns are like-wise highly variable across the basin. As a result, the subbasin has a rich diversity of biological resources. Layered on top of this geographic and biological diversity is an equally diverse human community, with its associated complex pattern of development and land use activities.

The remainder of this document is divided into several chapters. References, definitions, and appendices are included as well.

4.1 Chapter 2

Chapter 2 is the Assessment. It contains an extensive discussion of the various habitat types in the Yakima Subbasin, associated fish and wildlife species, habitat assessment methods, and focal species. This chapter contains maps, charts, graphs, and other visual material to assist the reader in understanding the geographic extent of habitat types in the Yakima Subbasin, the complex nature of habitat and species relationships, and the life history of various species. Key findings are presented in this chapter.

4.2 Chapter 3

Chapter 3 is the Inventory. This chapter contains an inventory of fish and wildlife protection, restoration, and artificial production projects and programs that have been or are being implemented in the Yakima Subbasin. This inventory includes projects or programs dating back to 1999. The inventory is designed to provide the reader information on individual projects or programs regarding the funding source, the project name, the implementing agency, and the status of the project.

4.3 Chapter 4

Chapter 4 is the Management Plan. It contains the proposed Management Plan for the Yakima Basin. The Management Plan integrates the Vision for the Yakima Basin with the Assessment and Inventory. The Management Plan is designed as a draft amendment to the Columbia Basin Fish and Wildlife Program, and to be reviewed and approved by the Northwest Power and Conservation Council. The structure of the Management Plan reflects the division of the basin into Assessment Units for the purpose of analysis and contains key findings and key uncertainties as well as biological objectives.

Following Chapter 4 is a section that contains references cited in the body of the document, as well as definitions of selected technical terms. Appendices are provided in an electronic format.