FINAL DRAFT SHORELINE INVENTORY, ANALYSIS, AND CHARACTERIZATION REPORT
GRANT COUNTY SMP UPDATE

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Prepared for

Grant County, Coulee City, City of Electric City, City of Grand Coulee, City of Soap Lake, Town of Krupp, and Town of Wilson Creek

Prepared by

Anchor QEA, LLC
8033 West Grandridge Boulevard, Suite A
Kennewick, Washington 99336

Prepared with assistance from

Oneza & Associates

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LIST OF ACRONYMS AND ABBREVIATIONS

%	percent
°C	degrees Celsius
°F	degrees Fahrenheit
Anchor QEA	Anchor QEA, LLC
BP	before present
BLM	U.S. Bureau of Land Management
CBP	Columbia Basin Project
CBWA	Columbia Basin Wildlife Area
cfs	cubic feet per second
CMZ	Channel Migration Zone
Coalition	Grant County, Coulee City, Electric City, City of Grand Coulee, City of Soap Lake, Krupp and Wilson Creek
County	Grant County
CRB	Columbia River Basin
DAHP	Department of Archaeology and Historic Preservation
DDE	dichloro-diphenyl-dichloroethene
DEM	digital elevation model
DNR	Washington State Department of Natural Resources
DOR	Washington State Department of Revenue
Ecology	Washington Department of Ecology
FCRPS	Federal Columbia River Power System
FEMA	Federal Emergency Management Agency
FERC	Federal Energy Regulatory Commission
ft	feet
GWMA	Ground Water Management Area
HPA	Hydraulic Project Approval
km	kilometer
MAF	million acre feet
mg/L	milligrams per liter
NEHRP	National Earthquake Hazards Reduction Program

NEPA	National Environmental Policy Act
NPS	National Parks Service
NRCS	Natural Resources Conservation Services
NWI	National Wetlands Inventory
NWRS	National Wildlife Refuge System
OHWM	ordinary high water mark
ORV	off-road vehicle
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
ppm	parts per million
PUD	Grant County Public Utilities District
RCW	Revised Code of Washington
RM	river mile
SEPA	State Environmental Policy Act
SMA	Shoreline Management Act
SMP	Shoreline Master Program
spp.	species
UGA	urban growth areas
USBR	U.S. Bureau of Reclamation
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WAC	Washington Administrative Code
WRCC	Western Regional Climate Center

1 INTRODUCTION

1.1 Background and Purpose

Grant County (County) received grant funding from Washington State Department of Ecology (Ecology) for the County, Town of Coulee City, City of Electric City, City of Grand Coulee, City of Soap Lake, and the Towns of Krupp and Wilson Creek (Coalition) to update existing (Grant County and Soap Lake) or develop new (all others) Shoreline Master Programs (SMPs). A primary purpose of this effort is to develop SMPs that comply with Chapter 90.58 Revised Code of Washington (RCW), the Shoreline Management Act (SMA), and Ecology's 2003 Shoreline Master Program Guidelines (Chapter 173-26 Washington Administrative Code [WAC]).

The Inventory, Analysis, and Characterization Report is the foundational step for the Coalition's comprehensive SMP updates. The inventory, analysis, and characterization process includes a discussion of the setting and ecosystem-wide processes that influence ecological functions within the County, city, and town shorelines. Also addressed are alterations based on existing land use patterns and future potential development within the shoreline jurisdiction areas. The report also includes an accompanying map folio.

The guidelines require the Coalition members to demonstrate that SMPs will result in "no net loss" to shoreline ecological functions during implementation. This report will serve to describe the existing baseline conditions of shoreline ecological function. An associated Shoreline Restoration and Protection Plan and Cumulative Impacts Analysis will follow development of the draft code. The cumulative impacts analysis will demonstrate that future development under the proposed SMP will result in no net loss of shoreline ecological function. The restoration measures described in the Shoreline Restoration and Protection Plan could be implemented to improve shoreline ecological functions beyond existing conditions.

1.2 Regulatory Overview

Counties, cities, and towns develop or update local SMPs to be in compliance with Washington State's SMA (RCW 90.58), and consistent with WAC 173-26, Ecology's guidelines. The State's SMA addresses concerns about the effects of unregulated

development on shorelines. The SMP update process indicates the joint state/local nature of the SMA program as local governments develop SMPs in close coordination with Ecology, informed by local opportunities and constraints, and consistent with state law and guidelines.

1.3 Report Organization

The report is organized in the following sections:

- Grant County Overview provides a discussion of the SMP update setting1.
- Shoreline Jurisdiction reviews the data and analysis used to determine the shoreline jurisdiction waterbodies and extents of the SMA shoreline jurisdiction.
- Shoreline Inventory, Analysis, and Characterization describes the ecosystem processes and the level to which they are currently impaired or altered. The processes most critical to ecological function are described for each of the following ecosystem types: the Columbia River, streams, and lakes. Also includes a review of the reach characterization methods and references the Reach Inventory, Analysis, and Characterization tables provided in Appendices B to H.
- Critical Areas and Other Regulations describes the existing applicable regulations for each Coalition member
- Public Access identifies existing public access goals and policies for each Coalition member, along with other potentially applicable local, state and federal public access goals and policies, and other considerations for specific geographic areas within the County
- Cultural Resources provides an overview of cultural and historic resources within the County
- Land Capacity Analysis identifies developable lands and associated residential unit and commercial area available for specific geographic areas within the County, cities, and towns.

[1] Note that the Grant County overview primarily focuses on lands outside incorporated cities and towns. Specific details on shorelands within the County and participating cities and towns are addressed in the respective appendix for each jurisdiction.

- Information Sources, Assumptions, and Limitations includes limitations of the data and assumptions related to the analytical methods that were presented in earlier sections of the report or addressed in the appendices tables.

2 GRANT COUNTY OVERVIEW

Grant County is located in the geographic center of Washington State and encompasses a total area of 2,791 square miles (7,228.7 km^2), of which 2,681 square miles (6,943.8 km^2) is land and 110 square miles (284.9 km^2) (3.95%) is water. The County is bordered by Douglas and Okanogan counties to the north, Adams and Lincoln counties to the east, Franklin and Benton counties to the south, and Yakima and Kittitas counties to the west. The Columbia River flows in a deep valley along the southwestern boundary of the County. The northern part of the County is characterized by loess-mantled volcanic bedrock hills that have been eroded by floodwaters to form canyons and coulees. Babcock Ridge and Beezley Hills border the southern portion of the County, which in general is a smooth, southward-sloping plain that is interrupted by the Saddle Mountains and Frenchman Hills. This plain includes the Quincy Basin and Wahluke Slope. Elevations in the County range from 380 feet along the Columbia River in the southern part of the County to 2,882 feet at the top of Monument Hill.

Fourteen incorporated cities and numerous unincorporated small towns and rural communities are located throughout the County, the largest of which are Moses Lake, Ephrata, and Quincy. Six of the seven cities with shoreline jurisdictional lands are participating in the Coalition effort; the City of Moses Lake SMP update is occurring through a separate grant and planning effort.

Coulee City is located at the south end of Banks Lake and Electric City is located at the north end of Banks Lake. Grand Coulee is located between Banks Lake and Lake Roosevelt on the Columbia River. Krupp is located along Crab Creek (river mile [RM] 44) and Wilson Creek is located at the confluence of Wilson and Crab Creeks (RM 37.5). The City of Soap Lake is located on the southern end of Soap Lake, the southern-most of the Sun Lakes in the north-central portion of the County.

2.1 Land Use/Land Cover and Ownership

A majority of the County is primarily used for agriculture where topographic and soil conditions allow; however, the naturally arid conditions require extensive irrigation practices that play a prominent role in the hydrology of waterbodies and function of

shorelines. Irrigated cropland covers approximately 40% of the County (Table 2-1). Several irrigation wasteways are located throughout the County that capture and convey irrigation runoff, the largest being the Winchester and Frenchman Hills Wasteways, respectively, which flow through the Quincy Basin and terminate at the Potholes Reservoir. These Columbia Basin Project-developed waterways have become a part of the landscape over time and provide habitat and recreational value. Non-irrigated lands are primarily used for rangeland, wildlife areas, and non-irrigated cropland, which is primarily winter wheat. Recreation and developed urban areas make up a small percentage of County land use/land cover.

Table 2-1
Land Use Statistics of Grant County
(County Comprehensive Land Use Plan Designations)

Land Use Type	Percent of County
Agriculture Service Center	0.01%
Commercial (Urban)	0.01%
Dryland	19.40%
Irrigated Agriculture	40.78%
Master Planned Industrial	0.12%
Master Planned Resort	0.34%
Open Space (Rural)	7.23%
Open Space (Urban)	0.09%
Port of Moses Lake	0.27%
Public Facility (Urban)	0.03%
Rangeland	12.50%
Recreational Development	0.06%
Residential, Medium Density	0.01%
Residential, High Density	0.04%
Residential, Low Density	0.42%
Residential, Medium Density	0.22%
Residential, Suburban	0.01%
Rural Commercial	0.04%
Rural Community	0.06%
Rural Industrial	0.05%
Rural Remote	9.35%
Rural Residential 1	3.23%

Land Use Type	Percent of County
Rural Residential 2	0.78%
Rural Village	0.06%
Shoreline Development	0.07%
Urban Commercial	0.17%
Urban Industrial	0.39%
Urban Reserve	0.08%
Urban Reserve (Rural)	0.16%
Wahluke SubArea Plan	4.02%

Table 2-2
Land Cover Statistics of Grant County

Land Cover Type	Percent of County
Agriculture	45.17%
Forested	0.04%
Wetlands	1.56%
Shrub steppe or herbaceous	44.97%
Developed	3.95%
Open Water	4.26%
Barren	0.06%

Table 2-3 shows land ownership coverage for Grant County. Private land makes up approximately 78%, a majority of which is farmed. A majority of public lands are owned by the federal government and designated as federal and state wildlife and recreation areas.

Table 2-3
Land Ownership of Grant County

Owner	Percent of County
Federal	19.08%
State	2.53%
Public Utility District	0.71%
Municipal	0.01%
Private	77.67%

2.2 Geology

The geology, soils, and topography of Grant County are primarily dictated by glacial outburst flooding that occurred near the end of the last major glacial period, approximately 18,000 to 20,000 years before present. This event is referred to as the Missoula Floods. The geologic makeup of the County is the result of erosion of pre-Floods geologic units, deposition of sediments carried by the floodwaters, and the formation of the unique topographic features that influence present-day hydrology. Prior to the Floods, the geology of the County consisted primarily of Miocene-aged Columbia River Basalt (CRB) flows that were in some places (e.g., plateaus) capped with varying thicknesses of wind-blown fine sands and silt known as loess. The CRB bedrock units were formed by numerous separate flows of molten volcanic rock, resulting in stratified layers of rock with distinct contacts that are visible between each volcanic event. The cooling process of each these types of lava flows results in a relatively dense but highly jointed rock that is subject to fracturing and erosion. Metamorphism of the CRB also contributed to its weakness and to the development of fold axes that later became preferential pathways for floodwaters. Miocene/Pliocene-aged lacustrine sedimentary rock known as the Ringold Formation also formed pre-Floods, and earlier Eocene-aged intrusive crystalline rocks were present locally in the northern portion of the County (Grolier and Bingham 1978).

During the Missoula Floods, the rapid drainage of glacial Lake Missoula sent floodwaters through northern Idaho and eastern Washington, where the extremely high-erosive energy flows were primarily focused on folds and joints in the bedrock. Today these areas are characterized by steep-walled canyons and coulees. The Grand Coulee and the Crab Creek Valley were two of the major flow paths for the floodwaters and remain as major hydrologic features. The wide, flat, Quincy Basin, which is currently heavily developed for agriculture, is located at the outlet of these two constricted flowpaths, where the floodwaters spread out significantly and temporarily ponded, depositing large quantities of flood-carried sands and gravels; the surficial geology of the Wahluke Slope is similarly dominated by these outburst deposits(Easterbrook and Rahm 1970). Wind-driven fine material from these outburst flood deposits have more recently formed active sand dunes that are in some locations used for off-road vehicle recreation but are not well suited to agriculture or other uses. Several smaller-scale erosional features are present throughout the County, such as complexes of lakes that were once scour pools of flooding channels; many of these have eroded to bedrock at the

surface. This unique topography lends itself well to the development of modern drainage channels and reservoirs.

Additional prominent geologic features present in the County include loess (wind-blown silt) deposits atop high-relief areas that were not eroded in the Floods and talus and landslide deposits-associated uplift features such as the Beezley Hills and Saddle Mountains. Loess-dominated areas are typically the source of excellent soils and are dominated by agriculture, particularly wheat farming. Recent fluvial deposits (alluvium) deposited by post-glacial and modern-day streams are present in most of the major stream valleys; these deposits are typically comprised of sands and gravels.

2.3 Climate

Grant County falls within the Central Basin region of Washington, which has the lowest precipitation rates within Washington State. Annual precipitation in the areas of Saddle Mountain, Frenchman Hills, and Rattlesnake Mountain average around 7 inches and precipitation is commonly associated with summer thunderstorms and winter rains and snowfall. Snowfall depths rarely exceed 8 to 15 inches and occur from December through February. High temperatures in January can range from 30 to 40 degrees with low temperatures between 15 to 25 degrees. Summer high temperatures are usually in the lower 90s with low temperatures in the upper 50s (WRCC 2012a).

2.4 Water Resources

Approximately 4% (110 square miles) of Grant County surface area is water, which is somewhat striking when considering that the County receives less than 10 inches of precipitation annually.

Water resources in the County are significantly affected by the Columbia Basin Project (CBP). The CBP is a large multi-purpose development that utilizes Columbia River water for irrigation, power, recreation, and flood control. Grand Coulee Dam is the key structure that provides water and energy for the CBP. Water is pumped from Grand Coulee Dam to Banks Lake, an equalizing reservoir that allows irrigation requirements to be met without extensive scheduling of pumping from Lake Roosevelt. Water can be pumped into Banks Lake when

both power and water are available at Grand Coulee Dam and stored until needed for irrigation (Anchor Environmental 2007).

Water from Banks Lake travels to Billy Clapp Lake through the Main Canal before being distributed to the irrigation districts. Much of the irrigation water delivered is recycled and reused before returning to the Columbia River. It is initially used for irrigation and then recaptured in drains, wasteways, and natural channels before being used again to irrigate additional farmland. Potholes Reservoir and O'Sullivan Dam are the key structures that facilitate water conservation for the CBP (Anchor Environmental 2007).

Development of the CBP has caused an increase of water available for recreation. Before the CBP was developed, there were 35 lakes in the project area, including portions of Grant, Lincoln, Adams, and Franklin counties. There are now more than 140 lakes, ponds, and reservoirs (USBR 2011).

The Columbia River within Grant County is regulated through the operation of multiple hydroelectric dams within the County, but also upstream. Columbia River flows are dependent on the coordination of dam operations of all seven dams in the mid-Columbia River, which ranges from Grand Coulee Dam to Priest Rapids Dam. Flows and water levels for the Columbia River within Grant County are regulated by operations of Wanapum and Priest Rapids dams in accordance with Federal Energy Regulatory Commission (FERC) licensing for the Priest Rapids Hydroelectric Project.

2.4.1 Groundwater

Groundwater in Grant County is part of the Columbia Plateau regional aquifer system. This system occupies about 50,600 square miles and extends across northern Idaho, northeastern Oregon, and a large part of southeastern Washington. Miocene basaltic rocks are the major aquifers in the Columbia Plateau regional aquifer system. Unconsolidated deposits are also a major source of groundwater, and some unconsolidated-deposit aquifers in Grant County are up to 1,000 feet thick and can yield as much as 3,200 gallons per minute. Miocene basaltic rocks that underlie the unconsolidated deposits yield as much as 4,800 gallons per minute (Whitehead 1994).

The Columbia Plateau aquifer system is subdivided into four aquifers: the suprabasalt sediment (overburden) aquifer, Saddle Mountains aquifer, Wanapum aquifer, and Grande Ronde aquifer. The overburden aquifers are found within the main structural basins (such as Quincy Basin) and are the main recipients of surface recharge water, primarily from the Columbia Basin Project (GWMA 2001).

The Columbia Basin Project has impacted Grant County groundwater levels within the project area. The extensive canal system of the Columbia Basin Project combined with non-uniformity in sediment characteristics largely influences groundwater movement (GWMA 2001). For example, before the Columbia Basin Project, Upper Crab Creek only connected to Moses Lake during high water conditions. Today, several springs join the Crab Creek channel because of elevated groundwater from the Columbia Basin Project development (USBR 2007).

Groundwater typically originates as precipitation that infiltrates through soil and underlying unsaturated geologic materials until reaching the water table. In the case of the Columbia Basin Project, groundwater mainly originates as irrigation supply (USBR 2007).

A portion of eastern Grant County is within the Odessa Groundwater Management Subarea (Odessa Subarea), an area designated by Washington State Legislature in 1967 due to groundwater declines. Since the 1980s, groundwater levels in the Odessa Subarea have declined as much as 200 feet (USBR and Ecology 2012).

A major portion of central Grant County is within the Quincy Groundwater Management Subarea (Quincy Subarea), an area designated by that Washington State Legislature in 1969 to establish boundaries and depth zones to develop a groundwater management program for the area (173-124 WAC).

Grant County is one of four counties that make up the Columbia Basin Ground Water Management Area (GWMA). The GWMA was designated by Ecology in 1998 due to concerns over high nitrate concentrations in groundwater. In 1998, median nitrate-N values were 3.7 milligrams per liter (mg/L) in Grant County. In general, shallow wells had higher

nitrate levels than deep wells, which suggests that surface application is the primary source of nitrate loading (GWMA 2001).

Several federal, state, and local regulations are in place to help minimize negative impacts to groundwater quality. These include regulations on drinking water wells, septic tanks, and runoff from landscaping practices.

In general, groundwater is the major source of drinking water in Washington State, including Grant County. To protect groundwater used for drinking water supplies as required by the federal Safe Drinking Water Act, the Washington State Department of Health requires all Group A public water systems (those that serve 25 or more people or 15 or more connections) that use groundwater as their supply source to implement a wellhead protection program. The wellhead protection program has several requirements that are designed to prevent contamination of groundwater used for drinking water (DOH 2010).

Septic (on-site sewage) systems that are improperly sited, operated, or maintained can affect groundwater quality by discharging contaminants to groundwater. WAC Chapter 246-272A regulates on-site sewage system location, design, installation, operation, maintenance, and monitoring to limit the discharge of contaminants and to minimize public health impacts from septic systems. The Grant County Health Department is the authority in Grant County regarding on-site sewage systems.

Runoff from landscaping practices can contain herbicides and pesticides, which could impact groundwater quality. Title 16 of the WAC contains regulations on pesticide and herbicide use. Additional details on pesticide and herbicide impacts are included in Section 4.2.5 of this document.

2.5 Floodplains and Floodways

Detailed studies that delineate the floodway have been conducted near the town of Wilson Creek and for Crab Creek between Moses Lake and RM 3.5 (FEMA 2009). In addition to these floodways, 100-year floodplain (Zone A) mapping is available in digital format for the entire County.

2.6 Channel Migration Zones

The Channel Migration Zone (CMZ) is the area along a river within which the channels can be reasonably predicted to migrate over time as a result of natural and normally occurring hydrological and related processes when considered with the characteristics of the river and its surroundings (WAC 173-26-020). These areas adjacent to a stream or river are susceptible to future erosion (Rapp and Abbe 2003). CMZs were delineated for the shoreline extents in Grant County for Upper Crab, Lower Crab, and Rocky Ford Creeks. As part of SMP development process, the location of the general CMZ was identified for these shoreline areas. CMZs may require implementation of regulations that are unique to these areas due to the migration potential of a given stream throughout its extents.

The CMZs were delineated in a geographic information (GIS) database and are presented graphically in the Appendix B figures for Rocky Ford Creek, Lower Crab Creek, and Upper Crab Creek, including F (Town of Krupp) and H1 (Town of Wilson Creek) figures. Associated text is also provided in Appendices B, F, and H1 characterization tables. The channel migration zones represent the existing and potential locations the stream channels may occupy within their valleys.

The CMZ delineations are based on various physical characteristics including existing geology, geomorphology, infrastructure, topography, vegetation, soils, and floodplain and wetland extents. At the time of this analysis, Light Image Detection and Ranging (LiDAR) coverage was not available for the stream extents included in the Shorelines jurisdiction. Aerial photography was limited to recent aerial photos years with one set of older historical air photos dating to the 1950s. Each stream was evaluated along its entire shoreline jurisdiction length and a CMZ line was delineated along each bank depending on the conditions present.

2.7 Geologic Hazards

Geologic hazards as defined in the Grant County Comprehensive Plan include “areas that, because of their susceptibility to erosion, sliding, earthquake, or other geologic events, are not suited to the siting of commercial, residential, or industrial development consistent with

public health or safety concerns." Primary geologic hazards are soils susceptible to erosion and landslides or rock fall areas. Seismic hazards and mine sites are secondary geologic hazards that generally present less of a concern in most areas. Table 2-4 summarizes each of the hazards that may be associated with County shorelines, as well as the sources of information that were evaluated.

Table 2-4
Geologic Hazards of Grant County

Hazard	Description	Summary	Source
Soils	Soil units susceptible to erosion by wind, water, and unstable slopes.	Approximately 75% of the County area contains soils classified as having moderate to severe susceptibility to erosion. Many of these soil units are associated with loess deposits, outburst floods, and thin soils overlying bedrock.	Natural Resources Conservation Service (NRCS) Soil Survey (Gentry 1984)
Landslides	Active landslides	No active landslides are mapped in Grant County.	1:24,000-scale landslide mapping (Washington State Department of Natural Resources [DNR] 2012
	Steep slopes	The Comprehensive Plan defines landslide-hazard areas as slopes of 15% or greater, which corresponds to approximately 4% of the area of the County.	10-meter digital elevation model (DEM)
Seismic Hazards	Active faults	The largest mapped active faults in the area are located along the Frenchman Hills, Saddle Mountains, and just south of the County along Umtanum Ridge.	Active fold and fault GIS data layers (DNR)
	Liquefaction susceptibility and National Earthquake Hazards Reduction Program (NEHRP) Site Classes	Outburst flood sediments and loess soils are mapped in the low and low to moderate categories for liquefaction susceptibility (classes C to D); alluvium is mapped as moderate susceptibility (classes D to E).	DNR
	Earthquake locations	138 earthquakes of at least 3.0 in magnitude have been identified within 50 miles of the County boundaries since the late 1800s. Of these events, 16 were 4.0 magnitude or greater, and 5 were 5.0 or greater.	DNR
Mine Sites	Active (permitted) mine sites	48 mine sites were identified; 14 were for rock or stone. Underground mining practices	GIS data layer (DNR)

Hazard	Description	Summary	Source
		are not known to take place in the County due to the geologic composition; however, these areas may present slope hazards.	

3 SHORELINE JURISDICTION ANALYSIS

The Washington State Shoreline Management Act defines the Shoreline of the State as "all 'shorelines' and 'shorelines of statewide significance' within the state" (RCW 90.58.030).

Shorelines are defined as:

> *"[A]ll of the water areas of the state, including reservoirs, and their associated shorelands, together with the lands underlying them; except*
>
> *(i) shorelines of statewide significance;*
>
> *(ii) shorelines on segments of streams upstream of a point where the mean annual flow is twenty cubic feet per second or less and the wetlands associated with such upstream segments; and*
>
> *(iii) shorelines on lakes less than twenty acres in size and wetlands associated with such small lakes."* (RCW 90.58.030)

Shorelines of statewide significance for east of the crest of the Cascades (RCW 90.58.030) are defined in the statute as:

> *(i) "Those lakes, whether natural, artificial, or a combination thereof, with a surface acreage of one thousand acres or more measured at the ordinary high water mark; and*
>
> *(ii) Streams or rivers (or segments of natural streams) "that have either: a mean annual flow of 200 cubic feet per second or more, or;*
>
> *(iii) The portion downstream from the first 300 square miles of drainage area."*

Shorelands (also known as shoreland areas) are defined by the statute as:

> *"[T]hose lands extending landward for two hundred feet in all directions as measured on a horizontal plane from the ordinary high water mark; floodways and contiguous flood plain areas landward two hundred feet from such floodways; and all wetlands and river deltas associated with the streams, lakes, and tidal waters which are subject to the provisions of this chapter; the same to be designated as to location by the department of ecology. Any county or city may determine that portion of a one hundred-year flood plain to be included in its master program as long as such portion*

includes, as a minimum, the floodway and the adjacent land extending landward two hundred feet therefrom."

WAC Title 173, Chapter 18, Section 170 contains a listing of Streams of Statewide Significance in Grant County.

These were used as a starting point for determining shoreline jurisdiction, as summarized in Table 3-1. Though it is identified in WAC 173-18-170 and in Table 3-1, Wilson Creek has been recommended for exclusion as a shoreline jurisdiction waterbody, as described in more detail in Section 3.4.

Table 3-1
Streams of Statewide Significance per WAC 173-18-170

Stream Name	Legal Description
Columbia River	From the Douglas County line on the Columbia River (Sec. 18, T20N, R23E) downstream left bank only to Hanford Works boundary (Sec. 10, T13N, R24E). The flow exceeds 200 cubic feet per second (cfs) million acre feet (MAF) at Douglas County line.
Crab Creek	From the Lincoln County line (Sec. 13, T22N, R30E) downstream through Brook Lake to mouth at Parker Horn of Moses Lake (Sec. 14, T19N, R28E). This stream has more than 300 square miles drainage area.
Lind Coulee	From south section line (Sec. 18, T18N, R30E) downstream to mouth of Potholes Reservoir (Sec. 1 and 12, T17N, R28E). This stream has more than 300 square miles of drainage area ending at Lind Coulee (Sec. 18, T18N, R30E).
Wilson Creek	From Lincoln County line (Sec. 1, T24N, R30E) downstream to mouth at Crab Creek (Sec. 12, T22N, R29E). This stream has more than 300 square miles of drainage area, but less than 20 cfs annual average flow.

Table 3-2 contains lakes specifically listed in WAC 173-20-290 as meeting the criteria for Lakes of Statewide Significance. Though Billy Clapp Lake is identified in WAC 173-18-170 and in Table 3-2, the area of Billy Clapp Lake is now estimated to be less than 1,000 acres, as provided in the analysis results in Section 3.4.2 and would no longer be appropriately characterized as a Lake of Statewide Significance.

Table 3-2
Lakes of Statewide Significance per WAC 173-20-290

Stream Name	Acreage in Grant County (Total Acreage)
Priest Rapids Dam Reservoir	4540.0 (7700.0)
Wanapum Dam Reservoir	6748.0 (14680.0)
Potholes Reservoir	28200
Moses Lake	6815.2
Lenore Lake	1670.0
Billy Clapp Lake	1010.0
Banks Lake	24600.0 (24900.0)

3.1 SMP Jurisdiction Determination Methodology

Anchor QEA collaborated with Grant County Planning Department staff to review and improve existing GIS-based mapping of all streams, lakes, and wetlands in Grant County. This review was done by making comparison of available vector datasets to two separate, recent high resolution satellite image mosaics (USDA 2011 and ESRI 2010). The review indicated that the best available data source varied somewhat by location, but in general was found to be a dataset of waterbodies maintained by the Grant County Planning Department (specifically [waterbodies]). This dataset includes a waterbody type attribute indicating if a polygon represents a stream, lake, or wetland.

This [waterbodies] dataset was used as the basis for developing an improved dataset ([SMA_Lakes_and_Streams_Final_Polygons]) that accurately maps the extents of all lakes and streams under SMA jurisdiction in Grant County at the ordinary high water mark (OHWM). The process steps involved in the creation of this dataset from the Grant County dataset are as follows:

1. Review and revise waterbody boundaries using multiple sources of recent aerial imagery.
2. Review stream data and stream statistics to determine if streams meet the criteria for inclusion under SMA jurisdiction, and the points where SMA jurisdiction begins. Ecology's recommendations [SMA_points] were found to underestimate the length of stream under SMA jurisdiction.
3. Remove lakes less than 15 acres.

4. Review lakes between 15 and 25 acres on a case-by-case basis to determine if the GIS data used appeared to accurately represent the current lake area. Lakes less than 20 acres were removed based on this review.
5. Review mapped wetlands to determine if lakes had been misclassified or were contiguous with other mapped lakes, and where the resulting total area was greater than 20 acres. Edits to the lake dataset were made.
6. The draft dataset was again reviewed and several refinements made based on comparison to additional, available imagery. Areas of mosaic wetlands and lakes around Potholes Reservoir were included.

The resulting dataset [SMA_Lakes_and_Streams_Final_Polygons] was used to create a second dataset representing the mapped extent of the shoreline jurisdiction. The process steps involved in the creation of that dataset are as follows:

1. [SMA_Lakes_and_Streams_Final_Polygons] was buffered by 200 feet (horizontally) on all sides utilizing the estimated OHWM.
2. The National Wetlands Inventory (NWI) layer (which was generally found to represent wetland areas more accurately than the Grant County [waterbodies] layer) was dissolved to create a new layer that included all wetland areas without boundaries between wetlands of differing in classifications.
3. All wetlands that intersected the [SMA_Lakes_and_Streams_Final_Polygons] were selected and exported into a temporary dataset of potential associated wetlands.
4. The potential associated wetlands were reviewed and areas determined to be separated by a clearly distinct upland area from shoreline waters were removed from dataset of potential associated wetlands.
5. The NWI dataset was then reviewed and wetlands that did not intersect the [SMA_Lakes_and_Streams_Final_Polygons] layer in the GIS but clearly appeared to be associated wetlands in the imagery were included in the dataset of potential associated wetlands.
6. In rare cases where uplands clearly existed within NWI wetlands, polygons were split and extraneous areas were removed from the dataset of potentially associated wetlands.
7. The floodway of Crab Creek between Center Lake and Moses Lake was included in the dataset of potential associated wetlands based on modeling data from the U.S.

Bureau of Reclamation (USBR), using a flow of 650 cubic feet per second (cfs) to create the final associated wetland dataset.

8. The original [SMA_Lakes_and_Streams_Final_Polygons] buffered by 200 feet was merged with the final associated wetlands dataset to create the mapped extent of the shoreline jurisdiction [SMA_Lakes_and_Streams_Final_Polygons_Buffer_200_ft_DRAFT].

3.2 Shoreline Jurisdiction Analysis

Anchor QEA received GIS-formatted datasets from Grant County Planning, Grant County Public Utility District (PUD), USBR, the U.S. Geological Survey (USGS), U.S. Department of Agriculture (USDA), U.S. Fish and Wildlife Service (USFWS), Ecology, and several of the incorporated cities and towns. These data sets contained information from a variety of sources on the waterbodies and potential shorelands within Grant County. Anchor QEA has reviewed and appended a waterbodies dataset developed by Grant County to identify those waterbodies that meet the definition of Shorelines of the State or Shorelines of Statewide Significance in RCW 90.58.030. Anchor QEA used several data sources in determining whether a waterbody met this definition, including:

- Designated streams named in WAC 173-18-170
- Designated lakes named in WAC 173-20-280
- Ecology-suggested shoreline arcs (stream) and points (at which streams reach the threshold of significance)
- Ecology-suggested shoreline polygons (for lakes)
- USGS National Hydrography Dataset
- USDA National Agriculture Imagery Program 2011 Imagery
- USFWS National Wetland Inventory
- Federal Emergency Management Agency (FEMA) Flood Study for Upper Crab Creek and Wilson Creek (2009)
- A variety of other derivative GIS and map products
- Hydraulic model-derived data showing the predicted area of inundation after planned increases in flows in Crab Creek are added between Billy Clapp Lake and Moses Lake (USBR 2007)

3.3 GIS Data Limitations

Anchor QEA reviewed the existing datasets and classified the accuracy of the Grant County waterbodies data to represent the estimated OHWM of the shoreline. There were significant variations in the accuracy related to differences in the sources of data and changes to the hydrologic regime in the County brought about by large-scale irrigation projects. In many cases, recent aerial imagery was used to determine which of the available datasets provided the most accurate representation of the estimated shoreline locations. The updated estimated shoreline locations are only an approximation for purposes of updating the SMP for the Coalition members. Precise OWHM delineation and associated shoreline jurisdiction boundaries will be determined on a project-by-project basis, based on site-specific analysis during the proposal development application and review process.

3.4 Determining Stream Shoreline Master Program Jurisdiction

Anchor QEA used the information sources identified above along with hydrology information provided by USBR and applied state criteria to identify the upstream extent of shoreline jurisdiction for applicable streams, identify the boundary of shoreline jurisdiction lands, and determine whether waterbodies should be excluded from shoreline jurisdiction.

This resulted in extending the upstream extent of Lower Crab Creek to the Grant/Adams County line, and Lind Coulee up to the intersection with the East Columbia Basin Irrigation District East Low Canal. These modifications were based on hydrology information provided by USBR (Smith, personal communication on February 22, 2012).

Lower Crab Creek was extended because the annual average flow is greater than 20 cfs when it re-enters Grant County. The mean annual flow of Lower Crab Creek at McManamon Road (in Adams County) is 44.8 cfs (Smith, pers. comm. 2012).

Lind Coulee was extended because the annual average flow is greater than 20 cfs after receiving flow from the East Low Canal. The mean annual flow from the East Low Canal into Lind Coulee from 2007 to 2011 was 31.4 cfs (Smith, pers. comm. 2012).

Wilson Creek was excluded from SMP jurisdiction because it has a mean annual flow of less than 20 cfs (RCW 90.58.030). It does have an upstream area of more than 300 square miles, but flow is typically non-existent in the period of record except for a few winter months, resulting in a mean annual flow of 14.1 cfs for the 20-year period of record, as measured upstream of the Grant County line and at the Town of Wilson Creek (Anchor QEA 2012a – see also Appendix H).

Within the vicinity of the Town of Wilson Creek, the floodway of Crab Creek was mapped using the definition from WAC 173-26-030(18)(b) based on the extent of "changes in surface soil conditions or changes in types or quality of vegetative ground cover condition, topography, or other indicators of flooding that occurs with reasonable regularity, although not necessarily annually." This was done using: information collected in the field and described above; gage data described above; and aerial imagery from 1990 to present. Backwater effects in Wilson Creek resulting from synchronous or asynchronous flows were also considered. This estimated floodway for Upper Crab Creek within the Town of Wilson Creek, plus 200 feet, was used to determine the area of shoreline jurisdiction within the town relative to Upper Crab Creek (Anchor QEA 2012b – see also Appendix H).

Sand Hollow was initially excluded from shoreline jurisdiction, but was included after comments from Washington Department of Fish and Wildlife (WDFW) (WDFW 2012a), and evaluation of limited USGS gage data (USGS 2012e). Sand Hollow has a mean annual flow of 57 cfs for the gage period of record (water years 1994-1995).

Frenchman Hills Wasteway, Winchester Wasteway, and Rocky Coulee were excluded from SMP jurisdiction even though all have mean annual average flows greater than 20 cfs after receiving flow from the West Canal (Smith, pers. comm. 2012). These are functionally man-made irrigation conveyance channels, often with maintenance roads and associated right-of-way on either side. Frenchman Hills and portions of Winchester Wasteway have irrigation water conveyed through open channels that are more natural in appearance but in reality do not follow natural water courses that existed prior to the CBP. These waterbodies were excluded, along with all other Columbia Basin Project irrigation canals in Grant County per WAC 173-22-030 provisions, which states:

"(15) A "stream" is a naturally occurring body of periodic or continuously flowing water where:
(a) The mean annual flow is greater than twenty cubic feet per second; and
(b)The water is contained within a channel.
A channel is an open conduit either naturally or artificially created. This definition does not include artificially created irrigation, return flow, or stockwatering channels."

It is recognized that these wasteways and canals provide, directly and also indirectly, significant fish and wildlife habitat benefits. These habitat functions and values for this area are protected through public land ownership/management, through the Grant County Unified Development Code, Chapter 24.08, Critical Areas and Cultural Resource Lands, and through the inclusions of lakes and associated wetlands greater than 20 acres in size in the Grant County SMP update.

3.4.1 Rivers and Streams

Based on the shoreline jurisdiction analyses, one river and three streams are identified for inclusion in SMP jurisdiction as shorelines of statewide significance. A summary of these are provided in Table 3-3.

Table 3-3
Recommended Revised Stream Shorelines of Statewide Significance

Stream Name	Included in 1975 SMP	Total Length Proposed Shoreline (feet)
Columbia River	Yes	609,440
Lower Crab Creek	Yes	402,203
Upper Crab Creek	Yes	511,965
Lind Coulee	Yes	233,071

3.4.2 Lakes

Based on the shoreline jurisdiction analyses, four lakes are identified for inclusion in SMP jurisdiction as shorelines of statewide significance, with Priest Rapids and Wanapum Dam reservoirs included as part of the Columbia River Stream Shorelines of Statewide

Significance. Billy Clapp Lake was removed from the list but remains a jurisdictional shoreline as it exceeds the 20-acre threshold. A summary of these are provided in Table 3-4.

Table 3-4
Recommended Revised List of Grant County Lakes of Statewide Significance

Stream Name	Acreage in Grant County (Total Acreage)
Potholes Reservoir	14773
Moses Lake	6680
Lenore Lake	1412
Banks Lake	26291

Each of the lakes identified for inclusion in Grant County SMP jurisdiction are listed in Table 3-5.

Table 3-5
Shoreline Jurisdiction Lakes

Lake Name	Total Area Proposed Shoreline (acres)	Included in 1975 SMP		Lake Name	Total Area Proposed Shoreline (acres)	Included in 1975 SMP
Alkali Lake	286	Yes		Park Lake	340	Yes
Ancient Lakes	33	Yes		Pit Lakes	39	No
Babcock Ridge Lake[1]	22	Yes		Potholes Reservoir	14,773	Yes
Banks Lake	26,291	Yes		Quincy Lake	54	Yes
Billy Clapp Lake	974	Yes		Red Rock Lake	154	No
Blue Lake	544	Yes		Rocky Ford Creek (Lake -North)[4]	153	Yes
Blythe Lake	37	Yes		Rocky Ford Creek (Lake -South)[5]	23	Yes
Bobby Lake	20	No		Roosevelt Lake	220	Yes
Brook Lake	404	Yes		Round Lake	66	Yes
Burke Lake	69	Yes		Royal Lake	20	No
Burkett Lake	41	No		Saddle Mountain Lake	639	No
Canal Lake	79	Yes		Saddle Mountain Wasteway[6]	77	No
Chukar Lake	22	Yes		Sand Coulee Siphon	56	No
Coffee Lake[1]	22	No		Sand Hollow Lake	66	No

Lake Name	Total Area Proposed Shoreline (acres)	Included in 1975 SMP		Lake Name	Total Area Proposed Shoreline (acres)	Included in 1975 SMP
Corral Lake	71	Yes		Sand Lake[7]	39	Yes
Crater Lake[1]	20	Yes		Soap Lake	830	Yes
Crescent Bay	94	Yes		Soda Lake	180	Yes
Crescent Lake	22	Yes		South Teal Lake[8]	21	Yes
Deep Lake	105	Yes		South Warden Lake	24	Yes
Dry Falls Lake	95	Yes		Stan Coffin Lake	53	Yes
Dusty Lake	75	Yes		Susan Lake	25	Yes
Evergreen Reservoir	255	Yes		Thompson Lake	32	Yes
Flat Lake	85	Yes		Un-named Lake in T15-0N R23-0E S28[9]	91	Yes
Hampton Lake (North)	71	Yes		Un-named Lake in T15-0N R23-0E S28[9]	71	Yes
Hampton Lake (South)[1]	22	Yes		Un-named Lake in T17-0N R25-0E S04[7]	13	Yes
Heart Lake[1]	23	Yes		Un-named Lake in T17-0N R26-0E S07[7,10]	105	Yes
Hilltop Lake[2]	68	Yes		Un-named Lake in T17-0N R27-0E S05[7]	27	Yes
Lenice Lake	88	Yes		Un-named Lake in T17-0N R29-0E S34[10]	25	No
Lenore Lake	1,412	Yes		Un-named Lake in T18-0N R25-0E S31[7]	61	Yes
Little Soap Lake	123	Yes		Un-named Lake in T18-0N R26-0E S11[7,10]	25	Yes
Long Lake (North)[3]	18	Yes		Un-named Lake in T18-0N R26-0E S14[7]	148	Yes
Long Lake (South)	95	Yes		Un-named Lake in T18-0N R26-0E S15[7]	33	Yes
Lower Goose Lake	65	Yes		Un-named Lake in T18-0N R26-0E S36[7]	40	Yes
Marsh Unit One	25	No		Un-named Lake in T18-0N R27-0E S31[7]	43	Yes
Martha Lake[1]	27	Yes		Hiawatha Lake (formerly "Un-named Lake in T19-0N R27-0E S29")	72	No
Moran Slough	36	Yes		Un-named Lake in T22-0N R29-0E S23	29	Yes
Moses Lake	6680	Yes		Un-named Reservoir in T24-0N R28-0E S27	129	No

Lake Name	Total Area Proposed Shoreline (acres)	Included in 1975 SMP		Lake Name	Total Area Proposed Shoreline (acres)	Included in 1975 SMP
North Teal Lake	22	Yes		Upper Goose Lake	130	Yes
Nunnally Lake	163	Yes		Warden Lake	200	Yes
Osborn Bay Lake	312	Yes		WinchesterLakes[11]	424	Yes
				Windmill Lake	36	Yes

1. These lakes were originally shown as less than 20 acres in the data provided, but were re-digitized by Anchor QEA to confirm their area based on observation of the 2011 aerial photo.
2. Referred to as Hillton Lake in USGS topography mapping and the digital dataset provided; however, the 1975 SMP refers to this lake as Hilltop Lake.
3. A 3-acre portion of this lake is located outside of Grant County, for a total of 21 acres.
4. This lake is referred to as Ephrata Lake in some maps; it was attributed as Rocky Ford Creek in the data provided.
5. This pond is located on the upstream side of the hatchery; it was attributed as Rocky Ford Creek in the data provided.
6. This is an un-named lake located in an area referred to as Saddle Mountain Wasteway in USGS topography mapping.
7. Part of the greater Winchester or Frenchman Hills Wasteway complexes of lakes, ponds, and wetlands. The definition of these waterways in the 1975 SMP is unclear. Here it is assumed that these waterbodies are included in the 1975 jurisdiction.
8. South Teal Lake meets the 20 acre threshold when the portion of the lake outside the County boundary is included.
9. These two rows are part of the same waterbody, and have been re-digitized in the digital data set. Its total area exceeds 20 acres.
10. The polygons provided encompass both wetland and open-water areas. Anchor QEA measured the open water areas and established these lakes were greater than 20 acres in area.
11. These two lakes are just north of I-90 and referred as Winchester Wasteway Lakes 1 and 2. It is assumed that these waterbodies are included in the 1975 jurisdiction.

4 SHORELINE INVENTORY, ANALYSIS, AND CHARACTERIZATION

4.1 Ecosystem-wide Processes and Structure

An ecosystem is a natural system consisting of biological (plants, animals, and microorganisms), physical, and chemical factors that together make up the environment. Ecosystem-wide processes are the naturally occurring physical and chemical cycles that shape the landscape and determine habitat types and associated ecological functions (WAC 173-26-020 (14)). Processes occur at multiple scales and are influenced by hydrology, geology, topography, soils, land cover, and land use characteristics. These processes determine the types and quality of shoreline functions or services that contribute to the maintenance of aquatic and terrestrial environments that make up an ecosystem (WAC 173-26-020 (13)). The following sections discuss ecosystem processes and habitat structures that these processes form and maintain. Ecosystem processes are discussed below in hydrology, sediment, and water quality, followed by a discussion of habitat structure.

4.1.1 Hydrology

The process of water delivery, movement, and storage within an ecosystem is largely affected by landform, geology, soil characteristics, and climate including precipitation. Rain and snowmelt provide the hydrologic inputs into a watershed. This cycle affects other physical, chemical, and biological functions of a waterbody or water course. The speed with which water flows through the watershed also affects whether nutrients, sediments, or other materials are deposited or retained in the water and transported through the watershed. Within Grant County, the CBP operations artificially input, store, convey, and divert water and have a greater effect than rain and snow on this process. Grant County PUD operations of Priest Rapids and Wanapum dams also have some effects on the Columbia River hydrology within Grant County.

4.1.1.1 Lake and Reservoir Hydrology

The horizontal structure of lakes includes two zones: the littoral zone, which occurs between the areas where rooted aquatic plants can grow due to light penetration to the highest seasonal water level, and the pelagic zone or open water area further offshore. The pelagic zone has within it photic (light penetrating) and aphotic zones, which influence temperatures and in turn nutrient processes and species composition. The bottom surface

and sediment of a lake is termed the benthic zone, which supports a majority of the organisms that are the foundation of the aquatic food chain. The size and depth of the lake, as well as the amount of flow in and out of the lake, affect the hydraulic residence time of water in the lake. Hydraulic retention time controls several aspects of water quality and the rate of sediment deposition.

4.1.1.2 Stream Hydrology

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

4.1.2 Sediment

Sediment delivery through a watershed is based on interactions between, gravity, wind, and water across the various geologic features, soils, and land covers. Soil erosion, landslides, and mass wasting provide the majority of sediment inputs within Grant County. Landslides and mass wasting are a function of slope, soil, and water interacting to create instability. Soil erosion is a function of slope, soil cohesiveness, and cover interacting with water or wind forces. Sediments transported by water or wind are deposited wherever and whenever the water or wind transporting them slow. This is often within topographic depressions where sediment is deposited into lakes and stream pools, wetlands, and floodplains. The sediment erosion, transport, and deposition cycle is a major aspect of river and stream channel formation and channel migration. It is also responsible for the evolution of lakes to wetlands and ultimately meadows or plains.

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

4.1.3 Water Quality

The combined processes that deliver, transport, and store water and sediment in the ecosystem have a substantial impact on water quality. Solar input of energy is another important factor that impacts water quality, especially in the summer time when high temperatures coincide with high nutrient loads from agricultural runoff. This can result in high water temperatures and very low levels of dissolved oxygen, both of which can alter the ecology of streams and lakes. Water temperature, a physical characteristic, affects the chemical process of breaking down organic material into nutrients, as well as the biological processes of phytoplankton and zooplankton reproduction and the metabolism of fish species. Water quality in lakes is particularly affected by physical, chemical, and biological processes. These processes involve the interactions between water temperatures; dissolved oxygen levels; alkalinity/pH; nutrients such as phosphorus and nitrogen; and, if present, toxins such as metals and organic compounds like polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), and pesticides.

4.1.4 Habitat

Habitats are the natural environment in which a particular species or population lives. Habitats typically provide the physical conditions and biological functions needed to support the species as part of a larger ecosystem and food web. The lifecycle of invertebrates, aquatic, avian, and terrestrial species are often interdependent meaning that the habitat requirements of a single species include all other species on which they depend. The habitat requirements are unique for different species and can be unique for different life stages of a species. Habitat elements that are applicable to Grant County include riparian, shrub-steppe,

and grassland vegetation recruitment; foraging, breeding/nesting and migration elements for terrestrial species; and spawning, rearing, and migration requirements for aquatic species.

4.1.4.1 Fish Habitat

Some of the ecosystem features that are generally applicable to Grant County freshwater fish habitat include water temperature; water depth; instream cover, including larger rocks and wood; substrate size; instream and riparian vegetation; floodplain health; water quality; and migration access.

Freshwater fish in Grant County include cold water fish (including trout and salmon) that have an upper lethal limit of approximately 25 degrees Celsius (°C), warm water fish (largemouth bass) that can tolerate temperatures as high as 36°C, and cool water fish (non-native smallmouth bass) that have similar tolerances to warm water fish but require cooler average temperatures during the growing season.

Water depth requirements vary by species and life stage; in general, shallow water depths are needed for migration and spawning for salmonid species. Substrate requirements can vary by species, but many fish cannot reproduce in substrate smaller than gravel.

Instream cover increases the structural complexity of a system through wood and larger rocks that improve the habitat quality for most fish. Instream vegetation, similar to instream cover, can improve habitat as long as the amount of aquatic vegetation does not create a low dissolved oxygen issue; in general, native aquatic vegetation provides quality vegetated aquatic habitat while introduced species such as Eurasian watermilfoil (*Myriophyllum spicatum*) does not.

Riparian vegetation stabilizes banks, reduces summer temperatures, and provides nutrients through leaf debris and insect fall, and provides in-stream cover through tree-fall where trees exist along Grant County shorelines. Floodplain habitat is required for many fish species during multiple life stages. Extensive and unaltered floodplains that are accessible to fish species are ideal.

Water quality constraints to fish survival include low dissolved oxygen conditions (less than 3 parts per million [ppm] in warm water streams, or less than 5 ppm in cold water streams), very low alkalinity, or high turbidity conditions.

4.1.4.2 Shoreline (Riparian Habitat)

Riparian areas are a small part of the Grant County landscape (less than 1% of the total area), but this habitat has greater structural diversity and productivity in terms of organic material than adjacent upland areas. Habitat characteristics of healthy riparian areas include a connected corridor for fish and wildlife travel; vegetation types adapted to wetter soils occasional flooding, and natural disturbance regimes.

Shrub steppe upland habitat is the largest native land cover type in Grant County. In some areas of the County, shrub steppe communities abut or nearly abut the shoreline. The largest shrub steppe plant association type in the Columbia Basin is the big sagebrush-bunch wheatgrass association. The habitat structure of this association includes an overstory of 2-meter tall big sagebrush, an understory of bluebunch wheatgrass and Sandberg's blue grass, and groundcover dominated by algae, lichens, and moss providing a microbiotic crust (Link et al. 2006). Recommendations for preserving shrub steppe habitat includes limiting development footprints including agricultural land cover changes, limiting road and utility corridors to avoid fragmenting habitat, restricting vegetation clearing, keeping domestic pets and livestock out of sensitive species habitat, limiting fencing to avoid barriers to native wildlife, and limiting irrigation canals through shrub steppe habitat (Azerrad et al. 2011).

4.2 Process Alterations

4.2.1 Columbia Basin Project Storage

The CBP is the largest water reclamation initiative in the United States, currently providing irrigation to approximately 671,000 acres of land (USBR 2011). Development of the CBP changed the amount of lakes within its jurisdiction from 35 natural lakes to a total of 140 lakes (USBR 2011). The conversion of steppe shrub habitat to irrigated fields and the transport of water through the project have resulted in major changes to the surface and groundwater hydrology of Grant County. The development of new waterbodies and wetlands related to canals, irrigated areas, and wasteways is one such change. The CBP has

also affected management of certain lake outlets, including Banks, Billy Clapp/Brook Lakes, Moses Lake, Potholes Reservoir, and some other smaller lakes. This can affect the hydraulic retention time of the waterbody by either increasing or decreasing the amount and rate at which water leaves the system. This change in the hydraulic regime affects the cycling of sediment, nutrients, and organic materials in these lakes in the County. Riparian vegetation and aquatic species adapt to seasonal inundation fluxes; more rapid pool elevation changes due to an outlet control may adversely affect these systems and species.

4.2.2 Columbia Basin Project Diversion/Conveyance

The main purpose of the CBP is to divert and convey surface water to support irrigation of agricultural lands. Power generation facilities have also been located within the CBP. The irrigation network begins with water pumped from Roosevelt Lake to a 16-mile feeder canal that carries the water to Banks Lake, which serves as an equalizing reservoir. The Main Canal flows from the outlet of Dry Falls Dam on Banks Lake into the northern extent of agricultural lands. The West, East High, and East Low canals are fed by this Main Canal. Potholes Reservoir, in the southeast portion of the County is impounded through the O'Sullivan Dam. Return flows from the northern portion of the CBP are captured within this reservoir and the Potholes Canal extends irrigation water into the lower, southern portion of the CBP area (USBR 2011). The alterations to the landscape through water diversion and conveyance include the creation of new watercourses and wetlands and groundwater recharge areas. Where streams have been channelized, water velocities increase; this in turn affects local sediment and nutrient deposition rates.

4.2.3 Impervious Surface

Water delivery and water quality can be affected by soil compaction, and road and building construction typically associated with development and urbanization in the County and within the Coalition cities and towns. These activities increase the amount of impervious surface (e.g., parking lots and roads), reduce the percolation of precipitation into the ground, and concentrate pollutants into stormwater discharge areas as discussed in more detail in Section 4.2.5. Reduced water infiltration increases the amount and rate of surface water runoff causing high stream discharge or high direct delivery of water to the stream and lake shorelines (Dunne and Leopold 1978; Arnold and Gibbons 1996; Poff et al. 1997). Shoreline

and bank erosion can result from stormwater discharges in areas such as Banks Lake and other applicable Grant County waterbodies where higher flow velocities may periodically collect from impervious surfaces. Soap Lake, Blue Lake, Banks Lake, Moses Lake, and other waterbodies have roads directly adjacent to the shoreline area. Residential, commercial, and recreation development with associated impervious surfaces, such as structures, parking areas, and roads in the County and within some of the towns and cities are also directly adjacent to the shoreline in many cases.

4.2.4 Vegetation Alterations

Grant County is dominated by agricultural land cover (45% of total area) and shrub steppe vegetation (45% of total area). Croplands are largely located in former shrub steppe habitat. The shrub steppe habitat provides many ecosystem services including soil stabilization, wildfire moderation, and overall biodiversity. The displacement of shrub steppe plant species by the invasive cheat-grass (*Bromus tectorum*), Russian thistle (*Salsola Tragus*), and other invasive species, in particular, increase fire intensity and frequency, which in addition to the hazards this creates for humans and wildlife also impacts the dominant shrub steppe plant species big sagebrush (*Artemisia tridentata*), an important species for rare birds such as the sage grouse (Link et al. 2006).

Grazing, off-road vehicles (ORVs), and other recreational activities can lead to greater soil erosion and establishment of invasive upland species, as well as affect sediment inputs to water systems affecting aquatic habitat. Invasive plant species tend to be prolific, germinating and growing under a wide variety of conditions. When soil disturbance occurs, invasive plants are often the first species to colonize.

Washington DNR is currently leading development of a Coordinated Weed Management Plan for invasive aquatic species in the mid-Columbia region, including Grant County, which will include all the lakes, streams, and USBR facilities in the CBP. Participating agencies include WDFW, DNR, State Parks, USBR, USFWS, CBP irrigation districts, City of Moses Lake, the Grant County Weed Control District, several County noxious weed boards, and other entities (WDFW 2012b).

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

4.2.5 Water Quality Impacts

Human-induced changes to water quality (e.g., industrial effluents, sewer overflows, and runoff from upland areas) can alter river and lake water temperatures, turbidity, and oxygen content, as well as nutrient, toxin, and pathogen concentrations (Karr 1995; Welch and Lindell 2000). In general, these changes can affect the presence, abundance, and vitality of all aquatic organisms.

Water temperatures, plant respiration, and biological decomposition are also inversely related to dissolved oxygen levels, which play a critical role in supporting aquatic organisms such as salmonids. Similarly, alkalinity/pH and nutrient concentrations influence biological processes, particularly phytoplankton production. Historically, the natural background levels of nutrients likely limited growth of algae in the few naturally occurring lakes in Grant County through much of the year. With the CBP development, and associated irrigated agriculture development, inputs of excess nutrients from agricultural runoff often lead to an abundance of algal blooms in lakes. All components of water quality can be affected by contaminants in runoff (e.g., fertilizers, pesticides, and vehicular pollutants), by discharges from recreational, industrial, and commercial activities (e.g., heavy metals, dioxins, and organic compounds), and by wind-blown soils, likely affecting most, if not all, the lakes and streams in Grant County to varying degrees.

Fertilizers, pesticides, and automobile- and boat-generated pollutants are linked to runoff borne pollution that enters streams and lakes. These toxins can settle in pools and the bottom of lakes, thereby contaminating the sediments of the benthic zone. This leads to

toxins either directly affecting benthic species through illness and mortality, or indirectly affecting aquatic and terrestrial species through bioaccumulation from animals lower on the food chain.

Many pathogenic protozoa, bacteria, and viruses can be found in the environment. These come from fecal material of wildlife and domesticated animals deposited within upland areas that drain into aquatic ecosystems or deposited directly into them (Sherer et al. 1992; Stanley et al. 2005). Development near lakes in Grant County increases the potential for pathogens to be added to the system because of increased impervious surface runoff, as described above.

4.2.6 Structural Effects on Habitat

Habitat fragmentation, through the building of dams, roads, utility corridors, agricultural and urban development, and irrigation channels throughout the County can affect, in varying degrees, aquatic ecosystems and habitat types. The CBP has helped to increase aquatic habitat within the County, while urban and agricultural development has resulted in loss of shrub-steppe habitat, habitat degradation, and fragmentation.

4.2.7 Shoreline Hardening/Stabilization

Humans can affect sediment transport through wave energy recreational boat wakes, shoreline armoring (e.g., bulkheads and rock revetments on the shore), and building overwater structures including docks, and bridges. Boat traffic can increase the amount of wave energy or frequency of waves reaching the shoreline and can increase erosion. CBP facilities, including reservoir fluctuations and releases, also affect shoreline erosion. The CBP increases recreation opportunities within Grant County, particularly through the associated development of boating amenities including marinas, overwater structures, and boat ramps. Increased wave energy through boat wakes and associated wave reflectance on hardened shorelines affects soil erosion rates and the preservation of shallow water habitat substrate. Banks Lake is a good example of where significant erosion can occur from CBP project operations (reservoir fluctuations and currents), affecting both habitat conditions and recreational facilities such as beaches and boat launches.

The natural dissipation of wave energy on the shoreline is altered by shoreline armoring that reflects wave energy and exacerbates erosion of nearby substrate. For Grant County, shoreline armoring typically exists in developed areas or areas where significant infrastructure exists, such as along the Columbia River, Banks Lake, Moses Lake, Soap Lake and other waterbodies. These armoring structures tend to disconnect natural sediment sources from erosion by forming a physical barrier between the shore and the water itself. The wave energy reflected off of these types of armoring leads to the washing away of smaller substrate sizes that support small benthic animals, and also prevents riparian vegetation establishment with associated habitat functions.

4.2.8 Channelization

Channelization of streams can include hardening of banks with levees or revetments, straightening of channels, removal of roughness that impedes flow, and other efforts to minimize the migration of the channel while maximizing flow capacity. In Grant County, confinement, channelization, and channel incision has occurred primarily along both Upper and Lower Crab Creek for certain agricultural lands, but extensive riparian wetlands and floodplains exist in other, more dynamic sections of the streams. Local effects include steeper slopes due to stream length reductions, higher water velocities, increased sediment transport, potential headcutting, and bank instability. Downstream effects include greater deposition of transported sediments, increased flood stage, and loss of channel capacity (Brookes 1988). Channelization, especially associated with further human development can increase water temperatures and decrease vegetation and instream cover through the loss of riparian and floodplain connectivity. The lakes, wetlands, and floodplain areas accessible below channelized areas on Grant County streams can help to mitigate these effects. Sedimentation in Moses Lake remains a significant issue. Rain-on-snow episodic events could contribute up to an estimated 4,500 tons of sediment to Moses Lake from Rocky Coulee and Crab Creek (Grette Associates 2009). The Crab Creek supplemental feed route expansion (see Section 4.5.1 for details) will increase the overall flow into Moses Lake and could affect sediment transport and deposition in the lake.

4.2.9 Other Alterations

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

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

An additional urban impact is the invasion of non-native plant and animal species, which change the community structure and availability of prey items for other species. Domestic pets can have direct impacts on wildlife through disturbance and predation.

4.2.10 General Ecological Processes and Major Alterations Summary

Table 4-1 summarizes the applicable Grant County ecological processes and structures and associated physical and biological functions that are affected by major alterations.

Table 4-1
Ecological Processes and Structures Affected by Major Alterations

		Ecological Processes & Structure																		
			Hydrology					Sediment		Water Quality			Habitat							
		Physical & Biological Functions	Storage	Subsurface Infiltration and flow	Surface flows	Hyporheic Exchange	Groundwater Recharge	Soil Erosion	Deposition/Storage	Nutrient Sources	Temperature/Dissolved Oxygen	Toxins/Pathogen sources	Riparian Vegetation Recruitment	Native grasslands and shrub steppe	Terrestrial Species - Foraging	Terrestrial Species - Breeding/Nesting	Terrestrial Species - Migration	Aquatic Species - Spawning	Aquatic Species - Rearing	Aquatic Species - Migration
Major Alterations	**Stressor Mechanism**																			
Columbia Basin Project Storage	Restricts water movement		x		x						x	x						x	x	x
	Restricts sediment movement							x	x	x										
	New lakes and wetlands						x							x	x	x	x	x	x	x
	More rapid pool elevation fluctuations					x		x					x					x	x	x
Columbia Basin Project Diversion/Conveyance	New or relocated channels and wetlands						x							x	x	x	x	x	x	x
	New recharge areas						x													
	Water velocity increases							x	x			x								
Impervious Surfaces	Run-off rather than infiltration		x	x	x			x			x	x						x	x	
	Stormwater management/infrastructure		x	x			x			x		x								
	Habitat loss												x	x	x	x	x			
Vegetation Alterations	Loss of nutrient and organic inputs, reduced evapotranspiration and bioinfiltration, increased toxin and nutrient loading									x	x	x	x	x						
	Invasive species (terrestrial and aquatic)												x	x				x	x	
	Aquatic species															x	x		x	x
	Increased soil erosion							x					x		x					
Water Quality Impacts	Fertilizer/Pesticide/Herbicide Inputs											x								
	Effluent Inputs											x								
	Temperature increases										x									
	Bioaccumulation of toxins														x	x				
Structural Effects on Habitat	Habitat fragmentation by roads												x	x	x	x	x			
	Over-water structures alter sediment, organic material pathways and the photic zone				x													x	x	x
	Aquatic fill, reduced water storage																	x		
Shoreline Hardening/Stabilization	Habitat loss, replacement of variable sized material with large homogenous substrate												x		x	x	x	x	x	x
	Increased wave energy at toe of slope and energy transfer downstream/down current of hardening							x	x											
	Sediment and subsurface water cycle disruption					x			x											
	Organic material cycle disruption									x										
Channel Realignment	Water velocity increases				x				x									x	x	x
	Reduced floodplain connection and functions					x														
	Decreased temporary storage of sediment, nutrient-, toxin-, or pathogen-laden water in streams								x	x		x								
Other Alterations	Artificial lighting increases light delivery at unnatural times														x	x	x	x	x	x
	Increased noise														x	x	x			
	Recreation infrastructure increases wave energy at shoreline (boat ramps, wakes)							x	x									x	x	x
	Non-native species predation														x	x	x	x	x	x
	Competition for resources from non-native species												x	x	x	x	x	x	x	x

4.3 Grant County Shoreline Ecosystem Characterizations

Building from the ecological process and structure descriptions, and major alterations discussion for the County, the next step in assessing and characterizing the SMA shoreline conditions was to organize the waterbodies into ecosystem groups. Within Grant County, three shoreline ecosystems were identified:

- **Columbia River**: The Columbia River is primarily dominated by dam operations in Grant County and greatly exceeds other County watercourses in size.
- **Other Streams**: This ecosystem includes all other flowing watercourses except the Columbia River.
- **Lakes and Reservoirs**: Because a majority of the natural lakes and depressions in the County are included within the CBP, the distinction between natural lakes and reservoirs is often unclear, and these waterbodies are associated with similar ecosystem processes.

4.4 Columbia River

A majority of the western and southern boundary of Grant County is delineated by 72 river miles of the Columbia River. The Columbia River has the largest flow of any North American river that drains to the Pacific Ocean. It has a watershed area of approximately 258,000 square miles that includes nearly all of Idaho; large portions of Colorado, Montana, Oregon, and British Columbia; and smaller portions of Wyoming, Utah, and Nevada. All of the area of Washington State east of the Cascade Crest, including Grant County, is located within the greater Columbia River watershed.

4.4.1 Existing Conditions

The Columbia River from Crescent Bar on the Wanapum Reservoir, downstream past the Priest Rapids Hydroelectric Project to White Bluffs along the Hanford Reach National Monument, forms the western and southern boundaries of Grant County. The entirety of the Columbia River within this segment is impounded (Priest Rapids Dam at RM 397.5 and the Wanapum Dam at RM 415.5) with the exception of that portion downstream of Priest Rapids Dam, called the Hanford Reach. The Hanford Reach is the last unimpounded reach of the mainstem Columbia River (Williams et al. 2006).

A majority of the water in the system falls as snow and accumulates in the upper watershed from November to March, then melts and produces peak runoff during April, May, and June, although the Columbia River peaks in May/June. During late summer and fall, stream flows in tributary streams often decline substantially and remain relatively low through February. Although uncommon, heavy rainfall in late fall or early winter can also lead to increased runoff, and in the past these rain-on-snow events in the eastern Cascades have caused some of the most significant flooding events in the region (Grant PUD 2010).

One active real-time USGS gage location currently exists on the Columbia River within Grant County SMP jurisdiction (below Priest Rapids Dam, #12472800). The Columbia River at the USGS gage referenced has a drainage area of 96,000 square miles and an annual average flow of 118,500 cfs for the period of record (water years 1918 to 2011) (USGS 2012a).

The Columbia River is highly regulated due to operations of multiple hydroelectric dams. Flows and water levels for the Columbia River within Grant County are regulated by operations of Wanapum and Priest Rapids dams in accordance with FERC licensing for the Priest Rapids Hydroelectric Project. Columbia River flows are dependent on the coordination of dam operations of all seven dams in the mid-Columbia River, which ranges from Grand Coulee Dam to Priest Rapids Dam.

Pool levels at Wanapum and Priest Rapids dams are typically drafted during the day and refilled overnight to meet daily electrical generation requirements. Drafting typically draws down the pool elevation from 1 to 3 feet below normal maximum pool elevation (FERC 2008). At their normal operations, the maximum elevation fluctuation is 11.5 feet for Wanapum Dam and 6.5 feet for Priest Rapids Dam (FERC 2006). These pool changes are relatively small compared to the pool level changes at Grand Coulee Dam, which has a maximum operating elevation fluctuation of 80 feet (FCRPS 2001).

License requirements include maintaining a minimum flow of 36,000 cfs at all times to provide cooling water for a downstream generating plant. Additionally, the Priest Rapids Hydroelectric Project must provide adequate flow for salmon eggs and fry in the Vernita Bar in accordance with the Vernita Bar Settlement Agreement. These flows limit daytime flow from 50,000 to 70,000 cfs during the spawning period (mid-October to late November) and

require minimum flows of 50,000 to 70,000 cfs during the emergence period (late November to May). Other non-power operation requirements include spill to increase downstream passage of spring and summer migrants and shaping flow rates to limit flow fluctuations during juvenile Fall Chinook emergence (late March to early June) (FERC 2006).

Only two streams, Trinidad Creek and Sand Hollow, drain from Grant County into the Columbia River upriver of Wanapum Dam (Grant PUD 2010). Trinidad Creek is a small creek with moderate but consistent flows that appear to be strongly influenced by groundwater recharge (Baldwin 2007). Sand Hollow carries waste water for the Columbia Basin Project (Grant PUD 2010). Downriver from Wanapum Dam, Crab Creek enters the Columbia River at the town of Schawana. Crab Creek is a major tributary that drains much of Grant County, as well as Lincoln County.

Water quality in the Columbia River has been classified by Ecology as "Class A" water. On a scale ranging from Class AA (extraordinary) to Class C (fair), Class A waters are rated as excellent. State and federal regulations require that Class A waters meet or exceed certain requirements for all uses. Primary concerns include levels of dissolved gases above biological thresholds for fish species utilizing the river. The hydroelectric projects in Project Boundary on the Columbia River are "run-of-river" with reservoirs that have little storage capacity. Water velocities are fast enough to prevent the formation of a thermocline (Grant PUD 2010).

The fish community in this segment of the Columbia River supports more than 40 species, including individuals from 14 families of freshwater fishes. Among these species are both anadromous and resident fishes, including non-native species (Grant PUD 2010). Six anadromous fish species are known to occur in this reach: spring, summer, and fall Chinook (*Oncorhynchus tshawytscha*), steelhead (*O. mykiss*), sockeye salmon (O*. nerka*), Coho salmon (*O. kisutch*), and pacific lamprey (*Lampetra tridentata*). The Columbia River serves as a migration corridor to and from the Pacific Ocean for adult and juvenile salmon, steelhead, and pacific lamprey. Fall Chinook are the only anadromous fish species that spawn in the Grant County section of the Columbia River; Pacific lamprey, steelhead, and spring Chinook spawn and rear in tributaries to the Columbia River (Grant PUD 2010). The Hanford Reach, the area of the Columbia River located immediately downstream of Priest

Rapids Dam and extending downstream to approximately the town of Richland, supports the largest, most productive wild Chinook salmon population remaining in the Columbia River Basin (Anglin et al. 2006). Studies of sub-yearling (summer) Chinook juveniles indicate some rearing likely does occur in the reservoir environments of the Wanapum and Priest Rapids reservoirs (Chapman 2007).

The entirety of Grant County falls within the Columbia Basin Province, the largest single province of 15 physiographic provinces identified in Oregon and Washington states (Franklin and Dyrness 1973). Vegetation adjacent to the Columbia River is characterized by shrub steppe habitat with upland vegetation, where undisturbed, dominated by Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*) and associated shrubs, perennial bunchgrasses, and forbs. Plant communities associated with less developed soils may be characterized by bitterbrush (*Purshia tridentata*) and desert buckwheat (*Eriogonum*) species, respectively, along with associated grasses and forbs. Where disturbed, plant communities may be converted to annual grasslands dominated by cheatgrass (*Bromus tectorum*), a non-native grass species. Riparian areas are naturally limited to those rare shoreline locations in this segment of the Columbia River not characterized by steep basalt cliffs with associated steep drop-offs waterward of the high water line. Where low gradient shorelines and elevated water tables occur adjacent to the Columbia River or where drainages lead down to the shoreline, diverse riparian and wetland vegetative communities may develop providing special fish and wildlife values. Riparian habitat is characterized by shrubs such as woods rose (*Rosa woodsii*), mock orange (*Philadelphus lewisii*), and travelers joy (*Clematis ligusticifolia*); by occasional trees such as black cottonwood (*Populus trichocarpa*), quaking aspen (*P. tremuloides*), and willows (*Salix* spp.); and by moisture-loving graminids and forbs (TNC 2003).

There are an estimated 304 wildlife species (not including fish) that likely occur in the lands adjacent to the Columbia River in this reach of the Columbia River that forms part of the boundaries of Grant County. Of these species, 111 (36%) are closely associated with riparian and wetland habitat and 74 (24%) consume salmonids during some portion of their lifecycle. Thirty-three species of wildlife are listed as federal or as state candidate, threatened, or endangered wildlife species. A total of 43 wildlife species are managed as game species in Washington State (Grant PUD 2010).

4.5 Other Streams

4.5.1 Crab Creek

The Crab Creek basin includes portions of Grant County, as well as portions of Douglas, Lincoln, Adams, and Spokane counties. The basin drains nearly 3,300,000 acres. The upland areas include loess-covered hillsides and steep basalt terraces. The streambeds within the basin were likely sculpted by the Missoula Floods (KWA Ecological Sciences 2004).

The average temperatures measured in Ephrata range from 21 degrees Fahrenheit (°F) in January to 89°F in July (WRCC 2012b). The annual precipitation in the basin ranges from 8 to 15 inches per year in the Upper Crab watershed to 7 to 10 inches per year in the Lower Crab watershed (WRIA 2011a and 2011b).

Upper Crab Creek is located in the eastern portion of Grant County. It enters Grant County near the town of Krupp and flows west for approximately 20 miles before flowing south until its mouth at Parker Horn of Moses Lake. One active real-time USGS gage location currently exists on Crab Creek within Grant County SMP jurisdiction (near Moses Lake, #12467000). Crab Creek at the USGS gage has a drainage area of 2,228 square miles and an annual average flow of 64.3 cfs (water years 1952 to 2011) (USGS 2012b).

Most flow from the upper basin passes the USGS gage station underground, and return flow from the Columbia Basin Project has increased flow in Crab Creek during the summer. Additionally, many small water diversions occur upstream of this location for irrigation and domestic use (USGS 2012b).

Crab Creek from Brook Lake to the mouth will be utilized as a supplemental feed route to convey water from Banks Lake to Potholes Reservoir for Columbia Basin Project irrigation use. The supplemental feed route is necessary to ensure a reliable supply for water for the South Columbia Basin Irrigation District. The supplemental feed will increase the overall flow in Crab Creek, which will increase the inundation area (and, therefore, shoreline area) of the stream (USBR 2007). This increased inundation area has been accounted for in determining Crab Creek shorelands area addressed in this SMP update.

Lower Crab Creek is located in the southern portion of Grant County. Grant County SMP jurisdiction begins at the Grant County/Adams County line and travels west approximately 30 miles to its confluence with the Columbia River.

One recent USGS gage location exists on Lower Crab Creek within Grant County SMP jurisdiction (near Beverly, #12472600). Lower Crab Creek at the USGS gage has a drainage area of 4,840 square miles and an annual average flow of 201 cfs (water years 1960 to 1999, 2001 to 2004, 2007, and 2010). A major portion of flows in Lower Crab Creek consists of return flows from the Columbia Basin Project (USGS 2012c).

4.5.2 Rocky Ford Creek

Rocky Ford Creek is located in central Grant County. It begins below Ephrata Lake and the small unnamed lake just south of Ephrata Lake and discharges to Moses Lake after traveling approximately 8 miles south.

One historical USGS gage is located on Rocky Ford Creek (near Ephrata, #12470500). Rocky Ford Creek at the USGS gage has a drainage area of 458 square miles; however, only 12 square miles contribute to streamflow. The remaining drainage area runoff is captured by Banks Lake and Soap Lake. Rocky Ford Creek has an annual average flow of 73.7 cfs (water years 1943 to 1991) (USGS 2012d).

4.5.3 Lind Coulee

Lind Coulee is located in southeastern Grant County. It enters Grant County approximately 2 miles east of Warden and travels 12 miles northwest to its confluence with Weber Coulee. Lind Coulee then travels another 6 miles southwest to Potholes Reservoir.

Lind Coulee is used as a minor feed route from the East Low Canal to Potholes Reservoir to provide water to the South District. It also drains a portion of East Columbia Basin Irrigation District land.

Although no active USGS stream flow gages are located on Lind Coulee, USBR collects Lind Coulee flow data. From 2007 to 2011, the amount of feed from the East Low Canal to Lind

Coulee averaged 31.4 cfs annually, while the total flow in Lind Coulee averaged 206 cfs annually (Smith, pers. comm. 2012).

4.5.4 Ecosystem Processes and Alterations for Streams

Crab Creek is the main stem water course within the overall basin; Upper Crab Creek flows through several lakes including Brook, Round, Willow, and Moses lakes and the Potholes Reservoir. Lower Crab Creek empties into the Columbia River. Rocky Ford Creek flows into Moses Lake and Lind Coulee was an intermittent stream within this basin prior to the CBP. The CBP greatly influences the hydrology of the Crab Creek basin, with more water imported from the Columbia River than is provided through natural precipitation sources. The CBP has affected groundwater table elevations in different ways within the basin. The Lower Crab Creek table has risen as a result of the project and the Upper Crab Creek groundwater table has fallen due to irrigation exports (KWA Ecological Sciences 2004). This will likely be changing for Upper Crab Creek between Brook Lake and Moses Lake once USBR modifies project operations within this area by increasing operational flows and associated surface water elevations.

Fine sediment inputs to these streams are accelerated through agricultural tillage and livestock impacts to soil structure. Sediment transport is affected by channelization and diking of stream segments within the basin. Dikes reduce spring flooding and associated sediment deposition within the surrounding floodplain, channeled reaches increase flow velocities and transport more sediment downstream, depositing sediment most prominently in Brook and Moses lakes. Water quality listings for these streams include those for dissolved oxygen, temperature, pH, dichloro-diphenyl-dichloroethene (DDE), PCB, dieldrin, and fecal coliform. DDE and PCB listings within lower Crab Creek may be influenced by Columbia River backwater. Listings in other portions of Crab Creek and in other streams are influenced by surrounding agricultural uses and potentially fish hatchery operations at Rocky Ford Creek. However, high water temperatures are very much a function of natural desert conditions though warmed lake and irrigation discharges may further exacerbate this issue.

Uplands that are not converted to agricultural or impervious land covers are typically shrub steppe though “meadowsteppe” and “steppe” habitat with lower amounts of shrub are

common. Plant species are similar to those described for the Columbia River (Section 4.4.1) though non-native downy brome (*Bromus tectorum*) is also present. Riparian vegetation is limited but can include willows, rose, water birch, black cottonwood, aspen, hawthorn, and service berry (KWA Ecological Sciences 2004).

Lower Crab, Sand Hollow, and Trinidad Creeks support anadromous fish, including fall Chinook (Lower Crab) and summer steelhead (all three streams) (WDFW 2012c). The draft Crab Creek Subbasin plan hypothesizes that juvenile steelhead, requiring longer freshwater residence, would not survive summer temperatures, suggesting steelhead are pioneers from another run. Fall juvenile Chinook are better adapted to this area as they migrate in the first year prior to high summer water temperatures (KWA Ecological Sciences 2004). Other fish supported within the basin include brown and rainbow trout, bass, walleye, and mountain whitefish. Impacts to aquatic habitat include water quality issues and road and railroad crossings.

Wetlands and shrub steppe habitat support a number of priority species such as sagebrush lizard, sharptail snake, striped whipsnake, pygmy rabbit, Lewis' woodpecker, Columbia spotted frog, Northern leopard frog, mule deer, Washington ground squirrel, and mink. Bird species include but are not limited to peregrine falcon, burrowing owl, ferruginous hawk, ring-necked pheasants, white pelican, bald eagle, and a number of other resident and migratory species. Terrestrial species may be impacted by habitat fragmentation from roads and railroads, and direct disturbance from human development.

4.6 Lakes and Reservoirs

Lakes and reservoirs are divided into several groups. Groups were chosen based on location and general lake characteristics (such as geology or hydrology).

4.6.1 Crescent Bay and Lake Roosevelt

Lake Roosevelt is an approximately 80,000 acre reservoir located in the northeastern corner of Grant County. Lake Roosevelt is created from the impoundment of the Columbia River by Grand Coulee Dam. Only a small portion of Roosevelt Lake is located within Grant County. Crescent Bay is located between Lake Roosevelt and the City of Grand Coulee.

Although it does not have a surface water connection to the reservoir, a subsurface connection between Crescent Bay and Lake Roosevelt provides hydraulic continuity.

4.6.2 Banks Lake

Banks Lake is a 26,291-acre reservoir located in northern Grant County. Banks Lake is a 27-mile-long equalizing reservoir that was created by enclosing an outburst flood channel in the Upper Grand Coulee with North Dam at the northern end and Dry Falls Dam at the southern end. North Dam is 14,500 feet long and 145 feet high, and Dry Falls Dam is 9,800 feet long and 123 feet high (Anchor Environmental 2007).

Banks Lake has a total storage capacity of 1,275,000 acre-feet of water. Approximately 715,000 acre-feet is active storage. Water is pumped into Banks Lake when power and water are available at Grand Coulee Dam and is stored until needed for release for CBP irrigation districts. Pumping into Banks Lake normally precedes or coincides with start-up of irrigation operations and continues intermittently through October. During the final weeks of the irrigation season, a water reserve is built up that can be used during the early fall and following spring before pumping is resumed and when Grand Coulee Dam power demands have lessened (Anchor Environmental 2007).

4.6.3 Coffee and Long Lakes

Coffee and Long lakes are located in northern Grant County, southeast of Banks Lake. These are naturally low-lying lakes with water surface elevations that fluctuate seasonally. Coffee Lake is approximately 22 acres and Long Lake, which extends into Lincoln County, is approximately 21 acres, 18 acres of which are in Grant County.

4.6.4 Sun Lakes

The Sun Lakes are a group of lakes located along the northwestern boundary of Grant County. The lakes include Lake Lenore, Blue Lake, Park Lake, Alkali Lake, Deep Lake, Dry Falls Lake, and Little Soap Lake. All of these lakes are natural low-lying features and all but Little Soap Lake are affected by CBP operations.

4.6.5 Soap Lake

Soap Lake is located in central Grant County to the south of the Sun Lakes chain. This lake is naturally low-lying and without any outlet or inlet, inflow is from groundwater, precipitation, and surface runoff. The east and west banks have steep bedrock outcroppings. The lake water contains a naturally high concentration of minerals.

4.6.6 Reservoirs along Main Canal

Billy Clapp Lake (formerly Long Lake Reservoir), Trail Lake, and Brook Lake are surface water features located along the Main Canal of the CBP in north-central Grant County. These lakes are located within natural depressions of the existing coulees. The water surface elevation in the lakes is controlled by an outlet structure. The lake levels fluctuate seasonally according to water storage operations. Billy Clapp Lake is the largest lake; it receives water from Summer Falls Power Plant and is connected to the Main Canal and Brook Lake. Billy Clapp Lake is normally used in CBP irrigation operation as a waterway but can store water flowing from the Main Canal in emergency situations (Anchor Environmental 2007). Billy Clapp Lake is impounded by Pinto Dam to the south, a 130-foot-high and 1,900-foot-long earthfill dam. Billy Clapp Lake has an active storage capacity of 21,200 acre-feet (USBR 2009).

4.6.7 Small Lakes South of Wilson Creek

Three lakes south of Wilson Creek are included in SMP jurisdiction. These lakes are located in eastern Grant County and include Sand Coulee Syphon, Round Lake, and an un-named lake. These lakes are naturally low-lying lakes that capture surrounding surface water. Sand Coulee Siphon and Round Lake are used as reservoirs with a controlled water surface elevation. The water surface elevation of the lakes fluctuates seasonally.

4.6.8 Ephrata Lake and Rocky Ford Lake

Two lakes on Rocky Ford Creek are included in SMP jurisdiction. These lakes are located in central Grant County and include Ephrata Lake and Rocky Ford Lake. These are natural lakes sourced by spring water and connected by a dry channel that appears to become inundated during floods. Rocky Ford Lake is perched in a bedrock depression.

4.6.9 Moses Lake

Moses Lake is located in central Grant County within the Quincy Basin. Moses Lake receives water from Rocky Ford Creek and Crab Creek from the north and is controlled by an outlet at Potholes Reservoir to the south. This report addresses the unincorporated areas around Moses Lake; the City of Moses Lake is developing a separate SMP.

4.6.10 Quincy Basin Lakes

The Quincy Basin lakes are located in western Grant County northwest of Potholes Reservoir and northeast of Potholes Coulee and Frenchman Coulee lakes. The lakes include nine un-named lakes ranging in size from 27 to 355 acres, Winchester Lakes, Babcock Ridge Lake, Crater Lake, Frenchman Hills Lake, Hiawatha Lake, Martha Lake, and San Lake. The Quincy Basin lakes are located in local depressions, many of which are underlain by bedrock. The Frenchman Hills and Winchester wasteway lakes are located through active dune areas and hummocky terrain that create dynamic chains of small lakes and wetlands. These lakes are generally affected by irrigation runoff and return flows and are specifically along the Winchester and Frenchman Hills wasteways.

4.6.11 Potholes Coulee and Frenchman Coulee Lakes

The Potholes Coulee and Frenchman Coulee lakes are in western Grant County and include Ancient Lake, Burke Lake, Dusty Lake, Evergreen Reservoir, Flat Lake, Hilltop Lake, Quincy Lake, and Stan Coffin Lake. These lakes are all naturally low-lying features within the surrounding bedrock.

4.6.12 Potholes Reservoir

Potholes Reservoir is located in southeastern Grant County and receives water from Moses Lake to the north, Lind Coulee to the east, and Winchester and Frenchman Hills wasteways to the west. Several smaller irrigation drains and wasteways from Quincy and East Districts also drain to Potholes Reservoir.

Potholes Reservoir is formed by O'Sullivan Dam, a 200-foot-high and 19,000-foot-long earthfill dam. Potholes Reservoir has an active storage capacity of 332,200 acre-feet and is the main feed to the South District (USBR 2009).

4.6.13 Drumheller Channel Lakes

The Drumheller Channel lakes are located south of Potholes Reservoir, west of Lind Coulee, and north of the Grant County/Adams County boundary. Twenty-two lakes are included within this category, the largest of which are Warden Lake (200 acres), Soda Lake (154 acres), and Upper Goose Lake (130 acres). They are all channel scablands within bedrock that are formed through the collection of seepage and runoff. These lakes are managed by the USFWS as part of the Columbia National Wildlife Refuge.

4.6.14 Lakes North of Lower Crab Creek

Several lakes were grouped north of Lower Crab Creek in southwestern Grant County. Stretching from the Columbia River toward Othello, this complex includes Bobby Lake, Burkett Lake, Lenice Lake, Nunnally Lake, Red Rock Lake, and Sand Hollow Lake.

4.6.15 Lower Grant County Lakes

The Saddle Mountain Lake, Saddle Mountain Wasteway, and an un-named lake are grouped in lower Grant County. The Saddle Mountain Lake and Wasteway are located on the Hanford Site, within the Hanford Reach National Monument/Saddle Mountain Wildlife Refuge. These lakes were established in existing depressions by routing irrigation water returns from the CBP. The un-named lake is located between the Columbia River and the Town of Mattawa; water levels likely fluctuate based on inputs from an irrigation wasteway to the east and the Priest Rapids and Wanapum dams operations.

4.6.16 Lake Ecosystem Processes and Alterations

Many of these water features are a product of the CBP and the description of ecosystem processes and alterations below distinguishes artificial and natural lakes, identifying natural lakes as those that are understood to have existed prior to construction of the CBP and other significant alterations of the regional hydrology.

Natural lakes within SMP jurisdiction include: Coffee, Long, Ephrata, Moses, and Soap, as well as the Drumheller Channels lakes (20 total), the lakes north of Lower Crab Creek (6 total), the small lakes south of Wilson Creek (3 total), and the three lower Grant County lakes.

The natural lakes are located in low topographic areas that collect surface runoff during rain and snowmelt events, and may also receive groundwater inputs. To a lesser extent than the artificial lakes, CBP seepage and runoff may also contribute to water quantity in these lakes. Water surface elevations of these lakes fluctuate throughout the year, with higher elevations occurring in winter and spring and lower elevations occurring in summer and fall.

Fine sediment inputs to these lakes are accelerated through agricultural tillage and livestock impacts to the soil structure of nearby uplands. Only a few of the natural lakes have water quality listings, though impacts from agricultural/irrigation practices could decrease water quality over time. The few water quality listings include 4,4'-DDE and dieldrin, which are likely due to runoff from irrigated farmlands and chloride in Soap Lake may be due to runoff from transportation or livestock operations; bioaccumulation of pesticides in fish has also been documented in the Saddle Mountain lakes (USFWS 2008).

Wetland habitat adjacent to the natural lakes provides forage and breeding opportunities particularly for waterfowl, as well as other avian and terrestrial species including mink. Rainbow trout are found in a few of the Drumheller Channels Lakes, and warm water fish species such as largemouth bass and kokanee are supported in the Drumheller Channels and Saddle Mountain lakes. As these natural lakes are farther removed from development, many support rare plant species including constricted Douglas' onion, arrow thelypody, and Piper's daisy. Within the upland shrub steppe habitat, mule deer, ring-necked pheasant, and chukar are present.

4.6.17 Artificial Waterbodies

Artificial waterbodies in the Grant County reservoirs formed through the construction of dams and other outlet structures, and lakes fed by irrigation wasteways. The lowest portion of the Quincy Basin was formed and once filled by ancient glacial floodwater. Prior to the CBP, this area was composed of desert habitat. The natural basin now collects irrigation wastewater creating the Winchester and Frenchman Hills wasteways. The water is transported southeasterly through the basin and eventually stored within Potholes Reservoir, which is impounded by the O'Sullivan Dam. Dam operations are responsible for the largest lakes within Grant County. The dams include Grand Coulee, which impounds Lake

Roosevelt; Dry Falls Dam, which holds Banks Lake; Pinto Dam associated with Billy Clapp Lake; and O'Sullivan Dam, which affects Potholes Reservoir upstream through Moses Lake.

Small sediment input reductions may occur due to hardened banks often associated with dams, outlets, or transportation infrastructure. However, the rapid fluctuation of water surface elevations may increase soil erosion where artificial or natural hardened banks are not present. Sediment is impounded behind dams and smaller control structures rather than transported further downstream within the larger basins.

Water quality listings are much more prevalent within the artificial waterbodies compared to the natural lakes. These impacts are likely due to heavy recreation use, contaminated irrigation waste flows, stormwater runoff from developed areas, and electrical transformer processes. As with the Columbia River and other stream ecosystems, irrigation runoff and impacts from grazing, and livestock operations also contribute to water quality listings. The impounded nature of these waterbodies exacerbates this issue as toxins are not flushed out through natural outlets. In particular, methyl mercury, which naturally occurs in new reservoirs through the decomposition of organic material, can bioaccumulate through the aquatic food chain.

Artificial lakes have created novel habitat types that support a number of aquatic, avian, and terrestrial species. Warm water-tolerant lake species dominate the aquatic composition and include trout, mountain whitefish, bass, kokanee, burbot, and walleye. Management strategies can favor recreation aquatic resources, which may conflict with goals and objectives for other wildlife. Terrestrial species include mule deer, jack rabbits, and, in select areas, Rocky mountain elk. Bald eagles, peregrine falcons, golden eagles, and prairie falcons are present along some shorelines and cliffs. Waterfowl and shorebird use of the area makes it an important resource for bird watchers; species include dabbling ducks, diving ducks, Canadian geese, as well as rare birds including white pelican, sandhill crane, ring-necked pheasant, great blue heron, tundra swans, grebes, and long-billed curlew. Rare plants are less common near artificial lakes than natural lakes, but species identified include valley sedge, Idaho fescue, constricted Douglas' onion, Artemisia species, dwarf evening primrose, narrow-stem crypantha, Suksdorf's money-flower, saltgrass, greasewood, and bluebunch wheatgrass.

4.7 Reach Breaks and Grouping of Waterbodies

The analysis and characterization information in this report is organized using a system of analysis reaches and subreaches to represent variations in land use and geomorphic characteristics along the shoreline. Physical changes often translate into differences in the function of the shoreline with regards to ecological and physical processes, which in turn may influence the shoreline designation. Some lakes with similar characteristics are discussed together as a group to reduce redundancy in the description and analysis. Moses Lake and Potholes Reservoir have both been broken into multiple reaches and subreaches to provide an appropriate level of detail in the analysis and characterization.

Stream reaches were delineated initially based on coarse-scale geomorphic breaks. Examples include the end of a natural confinement (e.g., bedrock) or a lake between two stream reaches (e.g., Brook Lake on Upper Crab Creek). Secondary consideration was given to reach size in an effort to keep reaches within a range of sizes suitable for analysis and characterization; this resulted in some of the initial reaches being combined with adjacent reaches. The initial reach delineation was performed by evaluating aerial photography, topographic data, geologic maps, and land cover data, which were compiled in a GIS database. Specific factors that influenced the delineation of stream reaches include channel and floodplain geomorphology, geologic controls, channel confinement and modification, hydrology and irrigation practices. In the case of the Columbia River reservoirs, the reservoir operations vary and greatly affect shoreline conditions, so dams were typically used as reach breaks. Stream subreaches were delineated primarily on changes in land-use and parcel density and zoning, but in some cases also reflect significant geomorphic changes. Reach breaks were also modified further on input from the Coalition representatives, Ecology, and other stakeholders throughout the inventory and characterization process to be consistent with shoreline regulation and planning.

Because Grant County contains 80 lakes that qualify for SMA jurisdiction, describing each lake individually at the reach scale would be a lengthy and impractical process, particularly in light of the relatively limited development pressures expected on most of these waterbodies, which are often located on public lands set aside for fish, wildlife, and recreation. Instead, as described above, the lakes were lumped into 16 different groups with similar land cover, ownership, hydrologic, and geographic associations. Three of these

groups (Soap Lake, Moses Lake, and Potholes Reservoir) are actually individual waterbodies. The largest lakes – Potholes Reservoir, Moses Lake, and Banks Lake – were subdivided into reaches and subreaches following a process similar to the delineation of stream reaches. Lake reaches were primarily dictated by land cover and ownership, but were also influenced somewhat by physical characteristics such as steep bedrock shorelines versus low-lying banks.

Subreaches were used in the analysis and characterization primarily to distinguish different patterns in land use, ownership, zoning, and level of development. Subreaches were delineated primarily where changes in land use, parcel density, or zoning affected the current or potential future ecosystem function. In the case of lake groups, this level of analysis was often conducted at the level of individual lakes within a larger group or to differentiate different patterns of development stress within a single lake.

Figures depicting these reaches, and subreaches where applicable, are provided in Appendices B through H along with characterization tables as described in more detail in Section 4.8.

Table 4-2a

Reach Breaks and Waterbody Groupings: Grant County

Rivers and Streams	Reach Breaks (# of Subreaches)
Columbia River	Reach 1 (N/A), Reach 2 (4), Reach 3 (3), Reach 4 (N/A), Reach 5 (N/A)
Upper Crab Creek	Reach 1 (3), Reach 2 (5)
Lower Crab Creek	Reach 1 (6)
Rocky Ford Creek	Reach 1 (2)
Lind Coulee	Reach 1 (2)
Waterbody Groups	**Lakes Groups and/or Reach Breaks**
Crescent Bay and Lake Roosevelt	Crescent Bay (N/A), Lake Roosevelt (3)
Banks Lake	Banks, Osborn Bay, and Thompson Lake (N/A)
Coffee and Long Lakes	Coffee and Long lakes
Sun Lakes	Blue (6), Park (2), Other: Alkali, Deep, Dry Falls, Lenore, and Little Soap lakes (N/A)
Soap Lake	Soap Lake (N/A)
Reservoirs along Main Canal	Trail, Billy Clapp, and Brook lakes (N/A)
Small Lakes South of Wilson Creek	Sand Coulee Syphon, Round Lake, Un-named Lake (N/A)
Ephrata Lake and Rocky Ford Lake	Ephrata and Rocky Ford lakes (N/A)
Moses Lake	Reach 1 (3), Reach 2 (8), Reach 3 (4)
Quincy Basin Lakes	Babcock Ridge, Crater, Frenchman Hills, Hiawatha, Martha, Sand, Winchester, and 9 Un-named lakes (N/A)
Potholes Coulee and Frenchman Coulee Lakes	Ancient, Burke, Dusty, Evergreen Reservoir, Flat, Hilltop, Quincy and Stan Coffin lakes (N/A)
Potholes Reservoir	Reach 1(N/A), Reach 2 (2)
Drumheller Channel Lakes	Blythe, Canal, Chukar, Corral, Crescent, Hampton, Heart, Long, Lower Goose, Marsh Unit One, North Teal, Pit, Royal, Soda, South Teal, South Warden, Susan, Upper Goose, Warden, Windmill and Un-named lakes (N/A)
Lakes North of Lower Crab Creek	Bobby, Burkett, Lenice, Nunnally, Red Rock, Sand Hollow lakes (N/A)
Lower Grant County Lakes	Saddle Mountain Lake, Saddle Mountain Wasteway, and one Un-named Lake (N/A)

Table 4-2b

Reach Breaks and Waterbody Groupings: Town of Coulee City

Waterbody Groups	Reach Breaks (# of Subreaches)
Banks Lake	Banks Lake (2)

Table 4-2c

Reach Breaks and Waterbody Groupings: City of Electric City

Water body Groups	Reach Breaks (# of Subreaches)
Banks and Osborn Bay Lakes	Banks and Osborn Bay Lakes (4)

Table 4-2d

Reach Breaks and Waterbody Groupings: City of Grand Coulee

Water body Groups	Reach Breaks (# of Subreaches)
Banks Lake	Banks Lake (N/A)
Crescent Bay	Crescent Bay (N/A)
Lake Roosevelt	Lake Roosevelt (N/A)

Table 4-2e

Reach Breaks and Waterbody Groupings: Town of Krupp

Rivers and Streams	Reach Breaks (# of Subreaches)
Upper Crab Creek	Upper Crab Creek (2)

Table 4-2f

Reach Breaks and Waterbody Groupings: City of Soap Lake

Waterbody Groups	Reach Breaks (# of Subreaches)
Soap Lake	Soap Lake (4)

Table 4-2g

Reach Breaks and Waterbody Groupings: Town of Wilson Creek

Rivers and Streams	Reach Breaks (# of Subreaches)
Upper Crab Creek	Upper Crab Creek (2)

4.8 Reach Characterizations

Characterization of shoreline reaches and subreaches are provided in Appendices B through H. The Grant County characterization is provided in Appendix B; the Town of Coulee City, City of Electric City, City of Grand Coulee, Town of Krupp, City of Soap Lake, and Town of Wilson Creek characterizations are provided in Appendices C through H respectively. Each appendix describes existing and proposed land use patterns, and land capacity analysis results for each local government unit. The appendices also include reach and subreach characterization tables summarizing existing physical conditions; characterizations and analyses for water quantity and sediment, water quality, and habitat and species; ecological functions analysis, including identifying functional conditions, stressors, and restoration and protection opportunities; preliminary shoreline environment designation considerations; existing public access and potential additional public access opportunities; and cumulative impact considerations.

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

The potential ecological function is defined as the highest ecological status a shoreline reach can attain given no development or management constraints, but does take into account the extent to which management (particularly water management) supports ecological function. This is a distinction that is fairly important in Grant County, where the management, storage, diversion, use, and reclamation of water for agriculture, hydropower, and other uses has a substantial effect on the amount of shoreline as well as the overall function of those shorelines.

Ecological function is defined here as the degree of similarity between existing physical and biological conditions, and the potential ecological function of a site; the higher the ecological function, the closer the site is to potential. Potential, for this assessment, encompasses all the resources defined by the interaction of hydrology, vegetation, water quality, and

erosion/deposition (soils), and aquatic and riparian habitat. For example, the potential of the hydrologic component includes the concept of a stream channel's physical characteristics (dimension, pattern, and profile) being within a "normal or usual" range (e.g., entrenchment, sinuosity, width, depth, and slope of the bankfull channel) as defined by landform and geomorphic stream type given current flows.

- **Functioning** is a state of resiliency that will allow a shoreline to hold together during high-flow events with a high degree of reliability. This resiliency allows an area to then produce desired values, such as fish habitat, bird habitat, or forage, over time. Riparian-wetland areas that are not functioning properly cannot sustain these values over time and are susceptible to stochastic disturbances such as fire.
- **Partially functioning** is a state in which the ecological function of the shoreline is somewhat compromised by development or management trends, or is particularly susceptible to future degradation due to development, management or ecological conditions. A partially functioning shoreline has some ability to recover through changes in management or the removal of identified stressors on ecological function.
- **Impaired** is a state in which the ecological functions of the shoreline are heavily compromised by development or management of the reach. An impaired reach has a low probability of recovery without major restoration, due to the degree of structural change to the shoreline, waterbody, and surrounding shorelands. Impaired shorelines can be functionally improved, but are unlikely to be self-sustainable, without major restoration.

It is important to note that this assessment does not include any analysis of potential change to infrastructure operations or management of the CBP or Columbia River dams. The types of changes that are not considered in future actions include major alterations to the management and distribution of water, significant changes to dam structures (e.g., new fish passage facilities) and dam modifications.

5 CRITICAL AREAS AND OTHER APPLICABLE REGULATIONS

SMPs provide provisions for the protection of archaeological and historic resources, environmentally critical areas within the shoreline and maintain flood hazard protection (WAC 173-26-221). Environmentally sensitive areas (critical areas) within Grant County include wetlands, frequently flooded areas, critical aquifer recharge areas, geologically hazardous areas, and fish and wildlife habitat conservation areas. In addition to Grant County requirements, federal and state regulations also apply to these features. Federal regulations include the Clean Water Act, Section 404, 401, Endangered Species Act, Federal Water Pollution Control Act, the National Environmental Policy Act (NEPA), and the National Floodplain Insurance Program. State regulations are administered through the RCW and include the State Environmental Policy Act (SEPA), the Hydraulic Project Approval (HPA), the Bald Eagle Protection Rules, the Surface Mining Act, the State Water Code and Water Pollution Control Act, and the SMA (Grant County Unified Development Code, Chapter 24.08). Critical areas for each shoreline jurisdiction are described in Appendices B through H within the flooding and geological hazards and habitat characteristics sections. Each critical area feature is described generally below.

Grant County and the Coalition cities and towns each have critical areas regulations for wetlands, frequently flooded areas, geologically hazardous areas, aquifer recharge areas, and fish and wildlife habitat conservation areas. These areas are identified, as applicable to each jurisdiction, in the map folio. Table 5-1 includes a summary of these regulations by jurisdiction:

Table 5-1
Critical Areas Regulation Summary (as of 2012)

Jurisdiction	Date of Last Update	Wetland Rating System	Stream Classification System	Protection Standards				
Grant County	2011	Ecology E.WA (1991 version)	None	**Wetlands**				
Title No.				**Buffer (feet)**	Cat 1	Cat 2	Cat 3	Cat 4
UDC 24.09.010 - 24.08.630 General; Wetlands; Fish & Wildlife Cons. Areas; Critical Aquifer Recharge Areas; Geologically Haz. Areas; Freq. Flooded Areas.					100	75	50	25
				Mitigation Ratio	Cat 1	Cat 2	Cat 3	Cat 4
					4:1	2:1	1.5:1	1.25:1
				HCA (Habitat Conservation Area)				
				Buffer (feet)	No permit unless development activities are mitigated within 300 feet of HCA, possible conditions including buffer zones (24.08.340).			
				Mitigation	Mitigation shall be required for loss of area or function and value of fish and wildlife habitat regulated under this subsection.			
				Habitat Management Plan	If it is determined by the Administrative Official that a proposed development will likely have a significant adverse impact on a HCA, the applicant shall prepare and implement a Habitat Management Plan in accordance with GCC § 24.08.360			

Jurisdiction	Date of Last Update	Wetland Rating System	Stream Classification System	Protection Standards				
Coulee City	2006	Ecology E.WA (not specified)	None	**Wetlands**				
Title No.				**Buffer (feet)**	Cat 1	Cat 2	Cat 3	Cat 4
16.08.160 - 16.08.230 Wetlands; Critical Aquifer Recharge Areas; Geologically Haz. Areas; Freq. Flooded Areas; Fish & Wildlife Habitat Cons. Areas.					50	25	20	10
				Aquatic Habitat				
				References compliance with general species population standards but these are not specified				

Jurisdiction	Date of Last Update	Wetland Rating System	Stream Classification System	Protection Standards				
Soap Lake	2009	Ecology E.WA (not specified)	Priority/Important Two-tiered system based on sensitivity of habitat to development related disruption	**Wetlands**				
Title No.				**Buffer (feet)**	Cat 1	Cat 2	Cat 3	Cat 4
14.12.100 - 14.12.140 Critical Aquifer Recharge Areas; Fish & Wildlife Habitat Cons. Areas; Freq. Flooded Areas; Geologically Haz. Areas; Wetlands.				Major Development	250	200	150	50
				Minor Development	125	100	75	25
				Mitigation	Mitigation efforts, when allowed, shall ensure that development activity does not yield a net loss of the area or function.			
				Aquatic Habitat				
				Buffer (feet)	Establishment of appropriate and adequate buffer zones within mitigation plans			
				Habitat Management Plan	A fish/wildlife habitat management and mitigation plan is required for all proposed developments determined to be within a "Priority Habitat Area". For those proposed developments determined to be within "Important Habitat Area", a fish/wildlife habitat management and mitigation plan may be required			

Jurisdiction	Date of Last Update	Wetland Rating System	Stream Classification System	Protection Standards				
Grand Coulee	2011	Ecology E.WA (2004/2007)	Federal, State, Priority, Local. Four-tiered system based on sensitivity of habitat to development related disruption	**Wetlands**				
Title No.				**Buffer (feet)**	Cat 1	Cat 2	Cat 3	Cat 4
17.18.070 - 17.18-090 Critical Aquifer Recharge Areas; Fish & Wildlife Habitat Cons. Areas; Freq. Flooded Areas; Geologically Haz. Areas; Wetlands.				Standard	250	200	150	50
				Additional (20-28 habitat points)	Add 50 feet	Add 50 feet	Add 70 feet	N/A
				Additional (29-36 habitat points)	Add 100 feet	Add 100 feet	N/A	N/A
				Mitigation Ratio	Cat 1	Cat 2	Cat 3	Cat 4
					6:1	3:1	2:1	1.5:1
				Riparian				
				Buffer (feet)	Residential	Commercial and Industrial	Open Space	
					50	100	150	

Jurisdiction	Date of Last Update	Wetland Rating System	Stream Classification System	Protection Standards				
Wilson Creek	2009	Ecology E.WA (2004/2007)	Priority, Feedling, Habitat. Three-tiered system based on sensitivity of habitat to development related disruption	**Wetlands**				
Title No.				**Buffer (feet)**	Cat 1	Cat 2	Cat 3	Cat 4
Critical Areas Regulations (Draft) Aquifer Recharge Areas; Fish & Wildlife Habitat Cons. Areas; Freq. Flooded Areas; Wetlands; Geologically Haz. Areas.					250	200	150	50
				Mitigation Ratio	Mitigation ratios shall be established using Best Available Science. Table 8D-11 in Wetlands in Washington State, Volume 2: Guidance for Protecting and Managing Wetlands shall be the preferred source of BAS for wetland mitigation projects.			
				Aquatic Habitat				
				Buffer (feet)	Buffer widths shall reflect the classification and sensitivity of the habitat and the intensity of activity proposed, and shall be consistent with any management recommendations issued by the WDFW or other Best Available Science			

Table 5-1
Critical Areas Regulation Summary (as of 2012)

Jurisdiction	Date of Last Update	Wetland Rating System	Stream Classification System	Protection Standards

Jurisdiction	Date of Last Update	Wetland Rating System	Stream Classification System	Protection Standards				
Krupp	2006	Ecology E.WA (2004/2007)	none	**Wetlands**				
Title No.				**Buffer (feet)**	Cat 1	Cat 2	Cat 3	Cat 4
Critical Areas Ordinance 7.2 Wetlands; Aquifer Recharge Areas; Fish & Wildlife Habitat Cons. Areas; Freq. Flooded Areas; Geologically Haz. Areas.					250	150	75	50
				Aquatic Habitat				
				General species population standards				

Jurisdiction	Date of Last Update	Wetland Rating System	Stream Classification System	Protection Standards				
Electric City	2005	Ecology E.WA (2004/2007)	Critical, Awareness. Two-tiered system based on sensitivity of habitat to development related disruption	**Wetlands**				
Title No.				**Buffer (feet)**	Cat 1	Cat 2	Cat 3	Cat 4
16.10.130-16.10.270 Wetlands; Aquifer Recharge Areas; Fish & Wildlife Habitat Cons. Areas; Freq. Flooded Areas; Geologically Haz. Areas.					250	200	150	50
				Mitigation Ratio	Cat 1	Cat 2	Cat 3	Cat 4
					6:1	3:1	2:1	1.5:1
				Aquatic Habitat				
				Buffer (feet)	When needed to protect the functions and values of habitat conservation areas, the administrator shall require the establishment of buffer areas for activities in or adjacent to such areas.			
				Habitat Management Plan	Appropriate habitat conservation, management and monitoring plan(s) shall be developed and implemented, with any necessary surety to ensure compliance with such plan(s) being provided as described in this chapter. (Ord. 367 § 2, 2005)			

6 PUBLIC ACCESS

A characterization of each shoreline's public access characteristics are provided in Appendices B through H. The Public Access section of each table discusses existing public access features, identified public access improvements, and potential public access opportunities.

Grant County and most of the cities' Comprehensive Plans and Park Plans include multiple goals, strategies, and policies relating to shoreline public access. In addition, a significant portion of Grant County shoreline is owned and operated by federal and state agencies or municipal or local utility districts. These shoreline areas provide public access and recreation opportunities and, in most cases, agencies have their own management and conservation plans that affect public access. Through a review of these documents, the overall intent of public access for Grant County shorelines was identified and the priorities, characteristics, and implementation of current proposals were assessed.

6.1 Grant County

Grant County's Comprehensive Plan includes Shoreline Management Goals and policies relating to public access and recreation:

Goal NS-9: The County should recognize and protect the functions and values of the shoreline environments of statewide and local significance. For shorelines of statewide significance, protection and management priorities are to:

- Increase public access to publicly owned areas of shorelines
- Increase recreational opportunities for the public in shoreline areas

Policy NS-9.1: General Shoreline Use:

- Develop, as an economic asset, the recreation industry along shorelines in a manner that will enhance public enjoyment

Policy NS-9.5: Public Access:

- Ensure that developments, uses, and activities on or near the shoreline do not impair or detract from the public's access to the water. Where practicable, public access to the shoreline should be enhanced.
- Design public access projects such that they provide for public safety and minimize potential impacts to private property and individual privacy.

Policy NS-9.6: Recreation:

- Optimize recreational opportunities now and in the future in shoreline areas.
- Encourage federal, state, and local governments to acquire additional shoreline properties in Grant County for public recreational uses.

6.2 Other Grant County-related Public Access Information

6.2.1 Grant County PUD

Grant PUD prepared an SMP in 2010 as part of FERC license compliance for the Priest Rapids Project. This includes Grant County shoreline areas along the Columbia River, from the Crescent Bar Recreational Area to the north to the Priest Rapids Dam to the south. This plan includes general land and water use public access policies as follows:

Public Access Policy

- Public access to project lands and waters shall be non-exclusive, wherever possible, and shared by all members of the public
- Public access and recreational use of project lands and waters shall be without regard to race, color, sex, religious creed, or national origin and with consideration of the needs of disabled individuals
- Use of project lands and waters by the Wanapum Band and tribal members shall be accommodated

The plan's management goals and objectives also refer to public access and recreation.

- Goal 4: Provide Safe Access and Use of Project Lands
- Goal 5: Provide Opportunities for Public Recreation
    - Preserve and protect lands for future recreation opportunities

6.2.2 Moses Lake Irrigation District

Moses Lake Irrigation District is legally required to provide a delicate balance of social, economic, and environmental services for the community. This includes providing recreation services at Connelly Park.

6.2.3 National Parks Services

Several management policies are identified by the National Parks Services (NPS) in the *Lake Roosevelt National Recreation Area Shoreline Management Plan Environmental Assessment* (NPS 2009). These policies aim to provide for enjoyment of the parks. The National Park Service will encourage visitor activities that:

- *"are appropriate to the purpose for which the park was established; and*
- *"are inspirational, educational, or healthful, and otherwise appropriate to the park environment; and will foster an understanding of and appreciation for park resources and values, or will promote enjoyment through a direct association with, interaction with, or relation to park resources; and*
- *"can be sustained without causing unacceptable impacts to park resources or values."*

The NPS SMP identifies alternatives for the Crescent Bay Development Concept Plan. All alternatives would include strategies to improve public access to shoreline, improve visitor use of the shoreline, and increase recreational capacity of the lake. Alternatives also identify ways to enhance public use and provide more educational information to visitors. The Preferred Alternative (Alternative B) places more emphasis on visitor use management and education.

6.2.4 U.S. Bureau of Land Management

The BLM recognizes that public access to public lands is not exclusive to the BLM. It intends to work to secure partnerships with its sister federal agencies, state, and local entities, as well as private organizations interested in improving access (BLM 2009).

6.2.5 U.S. Bureau of Reclamation

The USBR's Banks Lake Resource Management Plan (USBR 2001) indicates multiple recreational resource management goals as follows:

- Provide a diverse range of recreation opportunities and services consistent with public use trends
- Protect and enhance recreational importance and visitor experience
- Ensure compatibility between motor vehicle traffic and natural and cultural resource protection, land use compatibility and suitability conflicts, and public safety concerns
- Limit or eliminate motorized travel or recreation activity on soils sensitive to compaction, have a high soil erosion potential rating, or exhibit existing accelerated erosion problems (USBR 2001)

The USBR's resource management goals relating to public access for the Potholes Wildlife Area include the following:

- Provide a balance between recreation and resource protection
- Expand facilities and provide access to relieve crowding and congestion
- Maintain current diversity of recreation opportunities (USBR 2002)

The USBR's Recreation Sites and Improvements management strategies for the Potholes Reservoir area are as follows:

- Provide permanent or portable toilets in high use, dispersed camping areas where human wastes pose a public health or environmental hazard
- Construct trails and boardwalks to control public access and foot traffic through wetland and riparian habitats in high-use recreation areas (i.e., within the Developed Corridor)
- Perform minor road improvements (e.g., grading or the placement of gravel) as needed to improve vehicular access or reduce soil erosion and public safety concerns where continued primitive road access is desirable (USBR 2002)

6.2.6 U.S. Fish and Wildlife Service

6.2.6.1 Columbia National Wildlife Refuge Comprehensive Conservation Plan

USFWS prioritizes protection of biological and cultural resources. Goal 5 of the Columbia National Wildlife Refuge Comprehensive Conservation Plan (CNWR 2011) is to "provide access and opportunities for high-quality recreation compatible with resource protection."

Objective of providing general public access would be implemented through multiple strategies, including:

- Monitor visitor use patterns and identify unused parking lots for closure
- Maintain horseback riding on the refuge on roads open to vehicular traffic
- Maintain bicycle riding on the refuge on roads open to vehicular traffic
- Implement and evaluate seasonal openings of Marsh Units I and IV for public access to protect migrating sandhill cranes and waterfowl
- Provide general public access for activities like hiking, wildlife observation, and fishing, exclusive of hunting
- Provide access for hunting in some form (different areas will have different seasons and species hunted)

According to the plan, wildlife refuges would be open and available to the public for its use and enjoyment whenever possible and when compatible with resource protection. The USFWS "makes a special effort to provide wildlife-dependent public use opportunities across the NWRS." The selected alternative of the Columbia National Wildlife Refuge intends to keep some of the USFWS land in this management area open to public year-round. The Columbia National Wildlife Refuge area is intended to stay open to public from March 1 to September 30 each year (CNWR 2011).

6.2.6.2 Hanford Reach National Monument

The Hanford Reach National Monument is protected by Presidential proclamation in 2000. The key purpose of the monument is to protect the areas special landscape and resources. The monument's goals relating to public access include:

- Compatible with resource protection, provide a rich variety of educational and interpretive opportunities for visitors to gain an appreciation, knowledge, and understanding of the monument
- Compatible with resource protection, provide access and opportunities for high-quality recreation
- Protect the natural visual character and promote the opportunity to experience solitude in the monument

The proclamation also identified multiple resource protection mechanisms that prohibit ORV use and grazing (USFWS 2008).

6.2.6.3 National Wildlife Refuge System Improvement Act

The National Wildlife Refuge System Improvement Act of 1997 establishes wildlife dependent recreation policies such as allowing compatible wildlife-dependent recreational uses on a refuge. Compatible wildlife-dependent recreational uses such as hunting, fishing, wildlife observation and photography, and environmental education and interpretation are identified as priority public uses of the Refuge System under this Act and will receive enhanced and priority consideration in refuge planning and management over all other general public uses (National Wildlife Refuge System Improvement Act of 1997).

6.2.7 Washington State Department of Fish and Wildlife

6.2.7.1 Columbia Basin Wildlife Area Management Plan

WDFW's Columbia Basin Wildlife Area (CBWA) Management Plan indicates that the agency's management objective to provide recreation compatible with fish, wildlife, and habitat protection. The Columbia Basin Wildlife Area Goals mention to provide "diverse opportunities for the public to encounter, utilize, and appreciate wildlife and wild areas" Fitzgerald 2006. The management strategy of the plan for recreational opportunities includes the following:

- Manage public use impacts on the CBWA by careful planning of access developments and improvements, controlling vehicles, implementing seasonal and use restrictions, and using other land and resource management techniques
- Manage the CBWA primarily for walk-in access only; maintain many permanent and four seasonal vehicle access closures

6.2.7.2 Lands 20/20, A Clear Vision for the Future

WDFW's vision for Lands 20/20 (WDFW 2005) intends to offer all Washington citizens "an opportunity to access and appreciate this state's fish and wildlife." Recreational uses of land are consistent with WDFW's land policy for providing outdoor recreation opportunities

when they "don't threaten fish and wildlife or degrade the habitats that support them." WDFW intends to continue providing wildlife viewing opportunities.

6.2.7.3 Columbia National Wildlife Area Management Plan

Public access goals for the Potholes Wildlife area fall under CBWA goals identified by WDFW. The management goals for the CBWA include "providing diverse opportunities for the public to encounter, utilize and appreciate wildlife and wild areas" (Fitzgerald 2006).

6.2.8 Washington State Parks and Recreation Commission

6.2.8.1 Steamboat Rock State Park Management Plan

The Steamboat Rock State Park Management Plan establishes park management objectives for the Steamboat Rock State Park. Its objectives relating to public access are as follows:

Recreational Resources

- Provide an array of high quality day use and overnight facilities and services that are compatible with natural and cultural resource management objectives
- Provide a full range of accessible park experiences and opportunities

Trail Management

- Routinely coordinate with user groups and agency staff to address ongoing trail network maintenance and safety needs and concerns
- Identify and reduce natural and cultural resource impacts resulting from trail use
- Develop and maintain effective orientation to trail network routes, rules, and conditions
- Identify and maintain safe trail standards and conditions for all users

Interpretation and Outdoor Education

- Utilize interpretation as a tool to enhance visitor experience, understanding and stewardship of natural, historical, and cultural resources
- Provide year-round interpretive and outdoor learning programming and opportunities

Park Enterprise

- Explore alternatives to increase overnight occupancy during non-peak use periods; increase appropriate revenue opportunities

6.2.8.2 Sun Lakes Dry Falls Management Plan

Washington State Park's Sun Lakes Dry Falls Management Plan establishes park management objectives for the park. Its objectives relating to public access are as follows:

Recreation

- Provide for a wide range of outdoor recreation opportunities including utility, standard, primitive, and group camping sites; trails for equestrians, bicyclists and pedestrians; boating; fishing; wildlife viewing; picnicking; interpretive activities; and a variety of group activities

Interpretation and Environmental Education

- Combine the resources and skills of State Parks with local and statewide organizations and individuals specializing in resource education, interpretation, and curatorial services, to expand programs and facilities that promote Sun Lakes-Dry Falls State Park as a major destination for environmental education and interpretation.

6.3 Town of Coulee City

The Town of Coulee City's Park Plan (2006) establishes goals for the Coulee City Community Park. All of the goals focused on public access opportunities are as follows:

- Improve operations and functionality of the park
- Increase park attendance
- Meet current needs

6.4 City of Electric City

The City of Electric City's Comprehensive Plan land use goal states that "the town should identify and protect open space corridors within and between urban growth areas. These

corridors should include trails and other lands useful for recreation, while emphasizing wildlife habitat, and connection of critical areas, where feasible." The land use goal also aims to "promote coordination among the County, State Parks and other agencies, cities, grant County PUD, USBR, and other appropriate jurisdictions in order to protect linked greenbelts, parks, and open spaces" (City of Electric City 2006).

6.5 City of Grand Coulee

The City of Grand Coulee's parks and recreation goal reads, "The many and varied existing resources available for recreational activities in and around the city of Grand Coulee can be developed and enhanced to attract and expand tourism. This should happen only within their capacities so as to prevent degradation of the resources and the quality of life already in place."

6.6 Town of Krupp

No specific public access goals have been identified by the Town of Krupp. The Comprehensive Plan's Environment and Critical Area policy states to "allow for open space and recreational use of critical areas where such use does not negatively impact the critical areas."

6.7 City of Soap Lake

The City of Soap Lake's Comprehensive Plan shoreline goal is to "ensure that public access to the lake is maintained an encouraged." Its public access policies are as follows:

- The City of Soap Lake should maintain existing ownership and seek opportunities to place additional shoreline areas into public ownership.
- The City of Soap Lake should adopt into the City Code adequate regulations to insure that all citizens have equal opportunity to enjoy the benefits of Soap Lake.
- The City of Soap Lake should encourage joint use docks and common access points when the shoreline of Soap Lake is privately owned and developed.
- The City of Soap Lake should encourage community events and public gatherings to utilize the facilities within City parks adjacent to Soap Lake.

6.8 Town of Wilson Creek

The Town of Wilson Creek's Parks and Recreation goals aim to "provide park facilities and recreational opportunities. It also aims to enhance and preserve open space areas as the Town seeks to preserve, acquire and enhance open space areas" (Wilson Creek Planning Commission 2002). The Town's Comprehensive Plan open space policy goal is to "preserve Wilson Creek and Crab Creek for open space and flood control to enhance the community."

7 CULTURAL RESOURCES

Grant County is the Southern Plateau culture area, which is bounded by the Okanogan Highlands to the north, the Bitterroot Mountains to the east, the Cascade Mountains to the west, and the Deschutes and John Day River drainages to the south (Ames et al. 1998). It forms part of the larger Columbia Plateau culture area.

The oldest archaeological sites in the Southern Plateau date to the end of the Pleistocene, when hunters of large mammals fanned out across North America. The earliest Paleoindian sites in the area are attributed to the Clovis culture, including the Ritchey-Roberts Clovis cache in East Wenatchee, which dates to 12,250 before present (Mehringer and Foit 1990). Clovis sites are rare across the region.

After the brief but widespread Clovis occupation, a "broad-spectrum" hunter-gatherer culture developed in the region and persisted until the middle Holocene, around 5,300 years ago. Sites dating to this time period are generally limited to lithic assemblages (basalt projectile points and flake tools) and lack evidence of long-term habitation (Ames et al. 1998).

A shift towards more permanent settlement began around 6,000 years ago and initiated a period that lasted until the beginning of the early Holocene around 3,000 years ago (Chatters and Pokotylo 1998; Ames et al. 1998). In general, tool assemblages are characterized by the addition of ground stone and bone/antler tools to the existing flaked stone technology. The appearance of woodworking tools correlates with the first semi-subterranean structures.

Late Holocene cultures in the Plateau region exhibit "a "shift in adaptations…to storage-dependent collector strategies" (Chatters and Pokotylo 1998), which are characterized by intensive salmon fishing and associated storage features, social inequality, large permanent winter villages, and diverse tool assemblages. This shift began around 4,000 years ago and persisted until historic contact (Chatters and Pokotylo 1998). In the southern Plateau, this period also included evidence of intensive camas processing and fiber and wood artifacts preserved in the relatively dry climate (Ames et al. 1998). The late Holocene archaeological cultures correlate with historic ethnographic descriptions.

Most of Grant County is in the traditional territory of the Sinkayuse peoples, a Middle Columbia River Salishan group who speak the Columbian language (Miller 1998). A small portion of the southeastern extent of the County, from the Wanapum Dam south, is in the traditional territory of the Sahaptin-speaking Wanapum peoples (Schuster 1998). Many Sinkayuse people are now members of the Confederated Tribes of the Colville Reservation, while Wanapum people belong to the Wanapum Tribe (Ruby and Brown 1986).

The communities of the southern Columbia Plateau began to see the effects of Euroamerican contact decades before the first explorers and traders arrived in the area. These effects, beginning around A.D. 1600, included introduced diseases, trade goods, and the introduction of the horse (Walker and Sprague 1998). The earliest Euroamerican settlers in the County, primarily ranchers, arrived in the mid-19th century (Flom 2006). As railroad and irrigation infrastructure improved from the 1890s onward, crop agriculture replaced ranching as the most important aspect of the economy. In the early 20th century, plans began to take shape for major reclamation projects along the Columbia River. The construction of Grand Coulee Dam, championed by Grant County leaders, was authorized in 1933 (Flom 2006). The dam was completed in 1941 and ushered in an era of cheap power and relatively plentiful water (Kirk and Alexander 1990).

Given the history of Grant County from the late Pleistocene to the present, a number of archaeological and historical site types could be expected, including:

- Lithic scatters, quarries, and caches
- Precontact habitation sites (camps, villages, and cave sites)
- Resource procurement sites (fish traps and camas ovens)
- Pictographs and petroglyphs
- Historic habitation sites (homesteads, farms, and cabins)
- Historic agricultural infrastructure
- Historic and precontact transportation corridors (trails , routes, railroad grades, and road grades)
- Historic public works infrastructure (dams and transmission corridors)

Some sites may be on or near the surface, and others may be deeply buried, depending on the localized geomorphology.

The Department of Archaeology and Historic Preservation (DAHP) maintains an electronic database of archaeological sites, historic structures, and cemeteries. The database lists nearly 2,000 recorded archaeological sites, 179 recorded structures older than 50 years, 21 structures that are listed on the National Register of Historic Places, and 60 recorded cemeteries in Grant County. There are undoubtedly hundreds or thousands more cultural resources that have not been recorded. Traditional cultural properties, places that are historically significant because of their association with historical and ongoing cultural practices or beliefs of a living community, are also likely present in Grant County.

State and local cultural resources laws apply to shoreline development. State laws include RCW 27.53 (Archaeological Sites and Records), which prohibits the unpermitted removal of archaeological materials and establishes a permitting process, and RCW 27.44 (Indian Graves and Records), which describes how human remains must be treated. The Grant County Unified Development Code (Chapter 24.08) requires applicants to:

- Conduct background research at DAHP
- Conduct a site assessment if cultural resources are recorded in the proposed project area
- Recover archaeological materials in compliance with RCW 27.53 prior to construction
- Consult with the County, DAHP, and Native American tribes if resources are discovered during construction
- Design development to complement properties on-site that are eligible for listing on the Washington Heritage Register or National Register of Historic Places
- Consider cultural resources in planning for public spaces and access

Given the importance of shoreline locations throughout the human history of Grant County, the potential for cultural resources should be considered high for any shoreline development permit unless demonstrated otherwise. To comply with state and local law, applicants should perform records searches at DAHP and require cultural resources site assessments where resources are recorded. Because the probability of unrecorded resources is high, applicants should be prepared to follow the provisions of RCW 27.53 and 27.44 if cultural resources are identified or encountered during the planning or construction process.

8 LAND CAPACITY ANALYSIS

The purpose of the shoreline land capacity analysis is to estimate potential development that may take place in the planning timeframe along shorelines, according to the planned land use indicated in the Comprehensive Plan land use designations and/or adopted zoning code.

The information is intended to provide an understanding of the future level of intensity that may occur given current plans and regulations. Future developments in UGAs can take place in two ways, the area develops within the county regulations, or the area is annexed and develops per the city or town standards. Based on the development densities identified in the county and the cities' Comprehensive Plans, development under the county regulations could be, in some cases, less intense than development within the city or town's urban density. This analysis assumes the most intense scenario, using the city and town densities per comprehensive plans and zoning.

Although the Comprehensive Plan's future land use designations provide a starting point for future development potential, development in many reaches is further restricted by public land ownership and purposes, and other geographic factors such as topography, wetlands, and other natural features. Several reaches on Banks Lake, Columbia River, Lake Roosevelt, and Potholes Reservoir would see minimal potential development (low intensity recreation) due to public ownership and the nature of the shoreline (e.g., wildlife or recreation area; Table 8-1). Land uses in these reaches are consistent with publically owned land purposes and restrict development, avoiding potential use conflicts. Except for DNR-owned land, most of the public lands have natural resource protection and recreation as the primary purposes. Shoreline uses in these areas currently include SMA preferred water-oriented and recreational uses. Shorelines within the Town of Coulee City and the cities of Electric City, Grand Coulee, and Soap Lake also have significant areas publically owned, with these areas anticipated to have limited future development pressure.

Table 8-1
Reaches and Shoreline Acres Used for Public Recreation

Reach	Shoreline Acres	Public Recreation Acres	Public Recreation % of Total Shoreline
Banks Lake – Coulee City and UGA	47.13	46.81	99
Banks Lake – Electric City and UGA	163.15	154.98	95
Banks Lake – Grand Coulee and UGA	24.90	24.51	98
Banks Lake – Unincorporated	2,658.28	2,527.94	95
Columbia River – Vernita Bridge to County Line[1]	723.73	723.73	100
Crescent Bay – Unincorporated	23.03	23.03	100
Lake Group O	511.18	508.04	99
Lake Roosevelt – City of Grand Coulee and UGA	20.23	20.23	100
Lake Roosevelt – Unincorporated	62.65	62.65	100
Potholes Reservoir – Reach 1	6,961.06	6,855.64	98
Potholes Reservoir – Reach 2[2]	481.94	449.13	93

Note:
1. Access restricted to public
2. DNR-owned land added in the land capacity tables

Lands under private ownership are expected to develop under current land use and zoning regulations. Development capacity is most prominent within the Residential, Low Density, Rural Residential 1 and 2 and Master Plan Resort land use areas in the County. Reaches with predominant open space and agricultural uses (dryland, irrigated, and rangeland) are expected to see less changes in terms of development, with associated densities of one dwelling unit (du) per 40 acres. Moses Lake Reaches are anticipated to experience more development pressure compared to other reaches. Tables 8-2 and 8-3 summarize potential residential and commercial development capacity.

8.1 Methodology

The method to determine shoreline land capacity is summarized below.

1. **Determine shoreline boundaries and parcels.** Identify all parcels within or intersecting the 200 feet of shoreline, measured horizontally from the OHWM. This includes parcels that are entirely within the shoreline and parcels with a portion of area within the shoreline
2. **Prepare undeveloped land category.** From parcels identified in step #1, select all parcels with assessed improvement value of less than $5,000. Also include all land that indicates undeveloped under the Washington State Department of Revenue (DOR) land classification system.
3. **Exclude geologic hazards and wetlands.** Exclude land area with medium to steep slope and/or unstable soils, and also wetlands within the shoreline areas area. No additional area was excluded for jurisdictional or riparian buffers or other setbacks, as applicable, as these would be applied at the time of a development proposal.
4. **Identify public and private land ownership.** Reaches with more public ownership would have less development in general.
5. **Determine development potential.** Within each of the reaches, compare existing land use with planned land use designations.

Existing land use categories established from DOR land use classifications are agriculture, open space, recreational, industrial, utilities, resource, residential-single, residential-multifamily, commercial, institutional, and transportation. Using GIS tools, a data table for each reach was developed indicating existing land use, planned land use, and acreage under each category. This was the base data for analysis; it was then analyzed in terms of Comprehensive Plan land use density or zoning density, depending upon what was available. Some reaches were analyzed based upon current restrictions, such as the Hanford Federal Reserve in the County. Some land uses were considered to have very limited residential development capacity based on the land use and zoning regulations, such as agricultural service center, irrigated, rangeland, dryland and open space (county); and agricultural, R/W, and open space (cities).

Completing the steps outlined above resulted in the developable land area. For urban residential areas, an additional 20 percent in area was excluded from the developable land area for roads. The developable land was apportioned by the applicable land use or zoning

density to determine total potential residential units and commercial area, as applicable. Additionally, one unit was added for any category that indicates a total of 0.1 acre or less.

8.2 Data Gaps

This analysis excludes only wetlands and steep slopes from the developable land calculation, but doesn't exclude other critical areas. Setbacks and other buffers were not factored in the calculation, as these are applied at the time of development. Hence, the analysis is more conservative than may likely be realized over time. Also due to the very limited commercial land throughout the county's and cities' shorelines, mostly the residential land capacity has been analyzed. Commercial land capacity was analyzed for Electric City, Moses Lake Reach 3, and Sun Lakes – Park Lake. A 40 percent lot coverage was considered for commercial developments in Moses Lake Reach 3, and Sun Lakes – Park Lake, based on zoning and setback regulations and historic development pattern in this area and professional judgment. For Sun Lakes – Park Lake, commercial development capacity is estimated to support the state park uses. For Electric City, 50 percent lot coverage was used for DNR-owned property, and 80 percent lot coverage was used for Tourist Commercial zoning district based on the current zoning regulations, with values reported in acres due to the large area of the DNR property.

8.3 Land Capacity Analysis –Summary

The results of the shoreline jurisdiction land capacity analysis for each reach are summarized in Table 8-2. These results are intended to provide a general overview of the future development potential, but not to dictate how the development should occur. Future development potential may vary from this analysis based on the overall market condition, intent of the property owner or other local or regional factors. Discussion of the land capacity results by reach is included in the appendices.

Table 8-2
Estimated Shoreline Jurisdiction Residential Land Capacity Summary

Reach	Net Developable Acres	Total Capacity in Residential Units
County Reaches		

Reach	Net Developable Acres	Total Capacity in Residential Units
Banks Lake - Unincorporated	0	0
Columbia River - Crescent Bar	51	8
Columbia River - Downstream of Crescent Bar to Wanapum Dam, including Sunland Estates	656	34
Columbia River - Downstream of Wanapum Dam to Priest Rapids Dam	726	50
Columbia River - Priest Rapids Dam to Vernita Bridge	288	14
Crab Creek - Brook Lake to Moses Lake (waterbody)	2742	217
Crab Creek - County Line to Brook Lake	1141	29
Crescent Bat/ lake Roosevelt - Grant County	0	0
Lake Group C - Coffee and Long	62	2
Lake Group F - Billy Clapp/Trail/Brooks	180	7
Lake Group G - South of Wilson Creek	132	3
Lake Group H - Ephrata/North Rocky Ford	145	30
Lake Group J - Quincy Basin	1798	81
Lake Group K - Potholes/Frenchman Coulee	50	198[1]
Lake Group M - Drumheller Channels	57	7
Lake Group N - North of Lower Crab Creek	289	30
Lower Grant County Lakes	102	5
Lind Coulee	856	21
Lower Crab Creek	1405	39
Rocky Ford Creek	389	53
Moses Lake - Reach 1	322	90
Moses Lake - Reach 2	154	456
Moses Lake - Reach 3	177	587
Potholes - Reach 1	75	4
Potholes - Reach 2	9.41	9
Soap Lake – Unincorporated	58	20
Sun Lakes - All Others	248	12
Sun Lakes - Blue Lake	88	98
Sun Lakes - Park Lake	32	4
Cities and Towns		

Reach	Net Developable Acres	Total Capacity in Residential Units
Banks Lake - Coulee City	0	0
Banks Lake – Electric City	30	0
Banks Lake - Grand Coulee	3	0
Crab Creek and Wilson Creek - Town of Wilson Creek	0	0
Crescent Bay - Grand Coulee	23	2
Lake Roosevelt - City of Grand Coulee	0	0
Crab Creek - Town of Krupp and UGA	.84	4
Soap Lake - City of Soap Lake and UGA	14.8	57

Table 8-3

Estimated Shorelines Commercial Land Capacity Summary

Reach	Net Developable Acre	Total Building Area Capacity
Moses Lake - Reach 3	4	53,371 square feet[1]
Sun Lakes – Park Lake	1	17,000 square feet[1]
Banks Lake - Electric City and UGA	28	16.15 acres[2]

Note:

1. Based on 40 percent land coverage
   Based on 50 percent lot coverage for DNR land, and 80 percent lot coverage for other commercially zoned land in Electric City

Specific details for reaches within the County and for cities and towns are provided in the respective appendices.

9 INFORMATION SOURCES, ASSUMPTIONS, AND LIMITATIONS

This document is based on the best information available to the coalition at the time this document was produced. This information was obtained from a variety of sources and was collected and prepared for a variety of different purposes. The information was collected over a long time period; however, a substantial effort was made to use the most accurate and current information available.

Existing data, reports, and information used for the shoreline inventory are discussed in Appendix A. Generally, the documents used include Grant County and City Comprehensive plans, SMPs and critical area codes, Grant PUD shoreline management program reports, WDFW subbasin and habitat conversation plans, and USBR project studies. GIS data illustrated in the map folio includes information on hydrology, soils, topography, vegetation, land cover, priority habitat and species concentrations, and other features.

This report relied largely on GIS data and remotely sensed imagery. Integrating various GIS layers together into map folio projects often resulted in polygon boundary discrepancies. Rectification of these discrepancies was only conducted for layers and geographic locations most relevant to the SMP update. For example boundaries for zoning or land use designations do not always match identified OHWM. Additionally, there were significant variations in the accuracy related to differences in the sources of data and changes to the hydrologic regime in the County brought about by large-scale irrigation projects. The identified shoreline jurisdiction areas are only an approximation for purposes of updating the SMP for the Coalition members. Precise OWHM delineation and associated shoreline jurisdiction boundaries will be determined on a project-by-project basis, based on site-specific analysis during the proposal development application and review process.

Land use information for the Town of Wilson Creek was incomplete requiring interpretation of aerial imagery and reliance on site visit observations to characterize land uses.

Habitat restoration information is limited for Grant County, beyond what has been identified for the Columbia River by Grant PUD and a few other plans. This is in part due to the lack of anadromous salmonid habitat in the County, other than the Columbia River. It is also due to the regional focus on habitat conservation that includes numerous wildlife habitat

conservation areas managed by Federal, State and local entities. Hence, restoration actions are more limited than might be typically seen for other areas in the state and protection measures are more prominent.

10 REFERENCES

Anchor Environmental, 2007. *East Columbia Basin Irrigation District Comprehensive Water Conservation Plan*. May 2007.

Anchor QEA, 2012a. Memorandum on Wilson Creek Exclusion from Shoreline Jurisdiction, dated May 30, 2012.

Anchor QEA, 2012b. Memorandum on Town of Wilson Creek Floodway Definition for Shoreline Jurisdiction, October 1, 2012.

Ames, K., D.E. Dumond, J.R. Galm, and R. Minor, 1998. Prehistory of the Southern Plateau. In *Handbook of North American Indians, Volume 12, Plateau*, edited by D. E. Walker, pp. 103-119. Smithsonian Institution, Washington, D.C.

Anglin, D.R., S.L. Haeseker, J.J. Skalicky, H. Schaller, K.F. Tiffan, J.R. Hatten, P. Hoffarth, J. Nugent, D. Benner, and M. Yoshinaka, 2006. *Effects of hydropower operations on spawning habitat, rearing habitat, and stranding/entrapment mortality of fall Chinook salmon in the Hanford Reach of the Columbia River. Final Report*. Columbia River Fisheries Program Office, U.S. Fish and Wildlife Service. Vancouver, Washington.

Arnold, C.L. and C.J. Gibbons, 1996. Impervious Surface Coverage: The Emergence of a Key Environmental Indicator. *American Planners Association Journal* 62: 243–258.

Azerrad, J.M., K.A. Divens, M.F. Livingston, M.S. Teske, H.L. Ferguson, and J.L. Davis, 2011. *Management recommendations for Washington's priority habitats: managing shrub-steppe in developing landscapes*. Washington Department of Fish and Wildlife, Olympia, Washington.

Baldwin, C.M. 2007. *Steelhead Spawning Ground Surveys, Temperature, and Discharge Monitoring in Small Tributaries of the Columbia River Upper Middle Mainstem Subbasin, 2005-2007*. Washington Department of Fish and Wildlife, Wenatchee, Washington.

Brookes, A., 1988. *Channelized Rivers: Perspectives for Environmental Management*. John Wiley and Sons. Chichester, U.K.

Carrasquero, J., 2001. *Over-Water Structures: Freshwater Issues*. Prepared for Washington Department of Fish and Wildlife, Washington Department of Ecology and Washington Department of Transportation. Olympia, Washington.

Chapman, D.W., 2007. *Effects of Docks in Wells Dam Pool on Sub-yearling Summer/Fall Chinook Salmon*. Prepared for Douglas County Public Utilities Department. 18 pp.

Chatters, J. and D. Pokotylo, 1998. Prehistory: Introduction. *In Handbook of North American Indians, Volume 12, Plateau*, edited by D. E. Walker, pp. 73 - 80. Smithsonian Institution, Washington D.C.

CNWR and USFWS, 2011. *Columbia National Wildlife Refuge Comprehensive Conservation Plan*. Prepared by Columbia National Wildlife Refuge and U.S. Fish and Wildlife Services.

DOH (Washington State Department of Health), 2010. Washington State Wellhead Protection Program Guidance Document. DOH 331-018 (Revised). June 2010.

Dunne, T. and L.B. Leopold, 1978. *Water in Environmental Planning*. Freeman Press, New York. 818 pp.

Easterbrook, D.J. and Rahm, D.A., 1970. *Landforms of Washington*. Western Washington State College, Bellingham, Washington.

Ecology (Washington State Department of Ecology), 2012. Environmental Information Management Database. Accessed online at: http://www.ecy.wa.gov/eim/index.htm.

Environmental Systems Research Institute (ESRI), 2010. Bing Maps Group layer imagery from Microsoft Corporation and its data suppliers. Environmental Systems Research Institute. Redlands, California.

Federal Columbia River Power System (FCRPS), 2001. *The Columbia River System Inside Story*. Bonneville Power Administration, U.S. Army Corps of Engineers, and U.S. Bureau of Reclamation. April 2001.

Federal Emergency Management Agency (FEMA), 2009. Flood Insurance Study, Grant County, Washington, and Incorporated Areas. Flood Insurance Study Number 53025CV000A. Effective February 18, 2009.

Federal Energy Regulatory Commission (FERC), 2006. *Final Environmental Impact Statement Priest Rapids Hydroelectric Project Washington*. FERC Project No. 2114. November 2006.

FERC, 2008. Order Issuing New License, Project No. 2114-116. Public Utility District No. 2 of Grant County, Washington. Issued April 17, 2008.

Fitzgerald, G., 2006. *Columbia Basin Wildlife Area Management Plan*. Washington Department of Fish and Wildlife.

Flom, E.L., 2006. Grant County: A thumbnail history. HistoryLink.org Essay 8010. Electronic document accessed March 2012. http://www.historylink.org/index.cfm?DisplayPage=output.cfm&file_id=8010

Franklin, J.F. and C.T. Dyrness, 1973. *Natural vegetation of Oregon and Washington.* Reprinted by the Oregon State University Press in 1988. 452 pp.

Frodge, J.D., D.A. Marino, G.B. Pauley, and G.L. Thomas, 1995. Mortality of largemouth bass (*Micropterus salmoides*) and steelhead trout (*Oncorhynchus mykiss*) in densely vegetated littoral areas tested using in situ bioassay. *Lake and Reserv. Manage.* 11(2):343-358.

Gentry, H.R., 1984. Soil Survey Report of Grant County, Washington. United States Natural Resources Conservation Service (formerly United States Department of Agriculture, Soil Conservation Service) in cooperation with Washington State University, Agriculture Research Center.

Grant PUD (Grant County Public Utility District), 2010. *Priest Rapids Project Shoreline Management Plan*.

Grette Associates, 2009. *Moses Lake Sediment Management Plan*. Prepared for the Moses Lake Irrigation and Rehabilitation District. September 21, 2009.

Grolier, M.J. and Bingham, J.W., 1978. Bulletin No. 71: Geology of Parts of Grant, Adams, and Franklin Counties, East-Central Washington. Washington State Division of Geology and Earth Resources.

GWMA (Ground Water Management Area), 2001. *Columbia Basin Ground Water Management Area (GWMA) Plan*. Adopted by Boards of County Commissioners of Adams, Franklin, and Grant Counties in August, 2011 and by the Lincoln County Board of County Commissioners in August, 2005. Certified by Washington State Department of Ecology on December 6, 2001.

Karr, J.R., 1995. Clean water is not enough. *Illahee* 11: 51-59.

Kirk, R. and C. Alexander, 1990. *Exploring Washington's Past*. University of Washington Press, Seattle, Washington.

KWA Ecological Sciences, 2004. *Crab Creek Subbasin Plan*. Prepared for the Washington Department of Fish and Wildlife and Lincoln County Conservation District. May 2004.

Link, S.O., W.H. Mast, and R.W. Hill, 2006. Shrub Steppe. *Restoring the Pacific Northwest,* D. Apostol and M. Sinclair, editors, pp. 216-240. Island Press, Washington D.C.

Mehringer, P.J. and F.F. Foit, Jr., 1990. Volcanic Ash Dating of the Clovis Cache at East Wenatchee, Washington. *National Geographic Research* 6(4):495-503.

Miller, J., 1998. Middle Columbia River Salishans. In *Handbook of North American Indians, Volume 12, Plateau*, edited by D. E. Walker, pp. 253-270. Smithsonian Institution, Washington D.C.

NPS (National Parks Service), 2009. Available at: http://parkplanning.nps.gov/document.cfm?parkID=318&projectID=23046&documentID=29623. Accessed July 3, 2012.

Poff, N.L., J.D. Allan, M.B. Bain, J.R. Karr, K.L. Prestegaard, B.D. Richter, R.E. Sparks, and J.C. Stromberg, 1997. The Natural Flow Regime: A Paradigm for River Conservation and Restoration. *BioScience* 47: 769–784.

Prichard, D., J. Anderson, C. Correll, J. Fogg, K. Gebhardt, R. Krapf, S. Leonard, B. Mitchell, and J. Staats, 1998. Riparian Area Management—A user guide to assessing proper functioning condition and supporting science for lotic areas. *BLM Technical Reference* 1737-15. Denver, CO, 126 pp.

Rapp, C. and T. Abbe, 2003. A Framework for Delineating Channel Migration Zones. Washington State Department of Ecology Publication #03-06-027. November 2003.

Revised Code of Washington (RCW) 90.58, Shoreline Management Act of 1971.

Ruby, R.H. and J.A. Brown, 1986. *A Guide to the Indian Tribes of the Pacific Northwest: Revised Edition*. University of Oklahoma Press, Norman, Oklahoma.

Schuster, H.H., 1998. Yakima and Neighboring Groups. In *Handbook of North American Indians, Volume 12, Plateau*, edited by D. E. Walker, pp. 327-351. Smithsonian Institution, Washington D.C.

Sherer, B.M., J.R. Miner, J.A. Moore, and J.C. Buckhouse, 1992. Indicator bacterial survival in stream sediments. *J. Env. Quality* 21:591-595.

Smith, R.M., 2012. Email communication with Adam Hill, Anchor QEA. Subject: RE: Natural Coulee Flows – Columbia Basin Project. February 22, 2012.

Stanley, S., J. Brown, and S. Grigsby, 2005. Protecting aquatic ecosystems: A guide for Puget Sound Planners to understand watershed processes. Washington State Department of Ecology. Publication #05-06-027. Olympia, WA. Available at: http://www.ecy.wa.gov/b8iblio/0506027.html

Tilzer, M.M., Goldman, C.R., and E. Amezaga, 1975. The Efficiency of Photosynthetic Light Energy Utilization by Lake Phytoplankton. *Verhandlungen Internationale Vereinigung Limnologie* Vol. 19, p. 800-807.

The Nature Conservancy (TNC), 2003. *Biodiversity Studies of the Hanford Site. Final Report: 2002-2003*. Prepared for the U.S. Department of Energy and the U.S. Fish and Wildlife Service, Hanford Reach National Monument, in partial fulfillment of federal grant DE-FG-06-02RL14344. 149 pp + appendices.

USBR, 2007. *Potholes Reservoir Supplemental Feed Route Finding of No Significant Impact Draft Environmental Assessment Technical Memorandum Alternative A-Crab Creek*. Columbia Basin Project, Grant County, Washington. April 2007.

USBR, 2009. Lake Roosevelt Incremental Storage Releases Project Finding of No Significant Impact and Final Environmental Assessment. June 2009.

USBR, 2011. Columbia Basin Project. Available online at http://www.usbr.gov/projects/Project.jsp?proj_Name=Columbia Basin Project&pageType=ProjectPage. Updated February 15, 2011.

USBR and Ecology, 2012. *Odessa Subarea Special Study Final Environmental Impact Statement, Columbia Basin Project, Washington*. Ecology Publication No. 12-12-014. August 2012.

USDA (U.S. Department of Agriculture), 2011. National Agriculture Imagery Program. A-meter resolution, 4-band imagery. U.S. Department of Agriculture. Acquired Summer 2011.

USFWS (U.S. Fish and Wildlife Service), 1997. National Wildlife Refuge System Improvement Act of 1997. Public law 105-57-Oct.9, 1997. Available at: http://www.fws.gov/northeast/planning/downloads/NWRSimprovementact.pdf. Accessed: July 23, 2012.

USFWS, 2008. *Hanford Reach National Monument Comprehensive Conservation Plan and Final EIS*. August 2008.

USGS (U.S. Geological Survey), 2012a. Water-resources data for the United States, Water Year 2011: U.S. Geological Survey Water-Data Report WDR-US-2011, site 12472800, accessed at http://wdr.water.usgs.gov/wy2011/pdfs/12472800.2011.pdf.

USGS, 2012b. Water-resources data for the United States, Water Year 2011: U.S. Geological Survey Water-Data Report WDR-US-2011, site 12467000, accessed at http://wdr.water.usgs.gov/wy2011/pdfs/12467000.2011.pdf.

USGS, 2012c. Water-resources data for the United States, Water Year 2011: U.S. Geological Survey Water-Data Report WDR-US-2011, site 12472600, accessed at http://wdr.water.usgs.gov/wy2011/pdfs/12472600.2011.pdf.

USGS, 2012d. Water-resources data for the United States, Water Year 2011: U.S. Geological Survey Water-Data Report WDR-US-2011, site 12470500, accessed at http://wdr.water.usgs.gov/wy2011/pdfs/12470500.2011.pdf.

USGS, 2012e. NWIS Site Information for USA: Site Inventory. Available online at http://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=12464606. Accessed October 23, 2012.

WAC (Washington Administrative Code) Chapter 173-124. Quincy groundwater management subarea and zones. Last updated June 9, 1988.

WAC Chapter 246-272A. On-site sewage systems. Last updated August 2, 2010.

WAC Title 16. Agriculture, Department of. Last updated June 15, 2012.

WAC Chapter 173-26, 2012. Accessed online at http://apps.leg.wa.gov/wac/. August 1, 2012.

Walker, D.E. and R. Sprague, 1998. History until 1846. In *Handbook of North American Indians, Volume 12, Plateau*, edited by D. E. Walker, pp. 138-148. Smithsonian Institution, Washington, D.C.

Washington Department of Natural Resources Shallow Landslide Susceptibility Model, 2012. Available at: http://www.dnr.wa.gov/ResearchScience/Topics/GeologicHazardsMapping/Pages/Home.aspx. Accessed June 2012.

Washington State Parks and Recreation Commission and Washington State Parks Classification and Management Planning Project (CAMP), 2010. Available at: http://www.parks.wa.gov/plans/steamboatrock/Steamboat%20Management%20Plan%202010.pdf. Accessed July 12, 2012.

WDFW (Washington State Department of Fish and Wildlife), 2012a. Letter from Eric Pentico to Ben Floyd of Anchor QEA: Grant County Inventory, Analysis and Characterization Report Comments, dated November 28, 2012.

WDFW (Washington State Department of Fish and Wildlife), 2012b. Eric Pentico email communication with Ben Floyd on September 20, 2012 regarding noxious weeds management in the Columbia Basin.

WDFW, 2012c. WDFW Salmonscape. Available at: http://wdfw.wa.gov/mapping/salmonscape/index.html. Accessed on December 31, 2012.

Welch, E.B., and T. Lindell, 2000. *Ecological Effects of Wastewater: Applied Limnology and Pollutant Effects, Second Edition*. E& FN Spon, New Fetter Lane, London.

Whitehead, R.L., 1994. Ground Water Atlas of the United States. Idaho, Oregon, Washington. U.S. Geological Survey. HA 730-H.

Williams, R.N., J.A. Stanford, J.A. Lichatowich, W. J. Liss, C.C. Coutant, W.E. McConnaha, R.R. Whitney, P.R. Mundy, P.A Bission, and M.S. Powell, 2006. Return to the River; strategies for salmon restoration in the Columbia River Basin. In: *Return to the River*, pp. 629-666.

Wilson Creek Planning Commission, 2002. Town of Wilson Creek Comprehensive Plan. Highland Associates, Eads Consulting Services.

WRCC (Western Regional Climate Center), 2012a. Climate of Washington: Central Basin. Accessed online at: http://www.wrcc.dri.edu/narratives/washington/. August 1, 2012.

WRCC, 2012b. Monthly Climate Summary Tables. Accessed online at http://www.wrcc.dri.edu/coopmap/. August 1, 2012.

WRIA (Water Resource Inventory Area), 2011a. Upper Crab-Wilson Watershed, WRIA 43: Focus on Water Availability. Accessed online at: https://fortress.wa.gov/ecy/publications/publications/1111047.pdf. August 1, 2012.

WRIA, 2011b. Lower Crab Watershed, WRIA 41: Focus on Water Availability. Accessed online at https://fortress.wa.gov/ecy/publications/publications/1111045.pdf. August 1, 2012.