RECLAMATION
Managing Water in the West

–FINAL–

UPPER GRANDE RONDE RIVER TRIBUTARY ASSESSMENT GRANDE RONDE RIVER BASIN

Tributary Habitat Program, Oregon

U.S. Department of the Interior
Bureau of Reclamation
Pacific Northwest Region
Boise, Idaho

January 2014

U.S. DEPARTMENT OF THE INTERIOR

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The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

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Acronyms and Abbreviations

BiOp	Biological Opinion
BPA	Bonneville Power Administration
cfs	cubic feet per second
ELJ	engineered log jams
ESA	Endangered Species Act
FCRPS	Federal Columbia River Power System
FEMA	Federal Emergency Management Agency
GIS	geographic information system
HCMZ	historic channel migration zone
LiDAR	light distance and ranging
LWM	large woody material
NLCD	National Land Cover Data
NOAA Fisheries	National Oceanic and Atmospheric Administration National Marine Fisheries Service
NPCC	Northwest Power and Conservation Council
Reclamation	U.S. Bureau of Reclamation
RM	river mile
RPA	Reasonable and prudent alternative
TA	Tributary Assessment

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Introduction

The Bureau of Reclamation (Reclamation) and Bonneville Power Administration (BPA) contribute to the implementation of salmonid habitat improvement projects in the Grande Ronde River subbasin to help meet commitments contained in the 2010 Supplemental Federal Columbia River Power System (FCRPS) Biological Opinion (BiOp) (NOAA Fisheries 2012). This BiOp includes a Reasonable and Prudent Alternative (RPA), or a suite of actions, to protect salmon and steelhead listed under the Endangered Species Act (ESA) across their life cycles. Habitat improvement projects in various Columbia River tributaries are one aspect of this RPA. Reclamation provides technical assistance to states, tribes, federal agencies, and other local partners for identification, design, and construction of stream habitat improvement projects that primarily address streamflow, access, entrainment, and channel complexity limiting factors. Reclamation's contributions to habitat improvement are all meant to be within the framework of the FCRPS RPA or related commitments. The assessments described in this document provide scientific information on geomorphology and physical processes that can be used to help identify, prioritize, and implement sustainable fish habitat improvement projects and to help focus those projects on addressing key limiting factors to protect and improve survival of salmon and steelhead listed under the ESA.

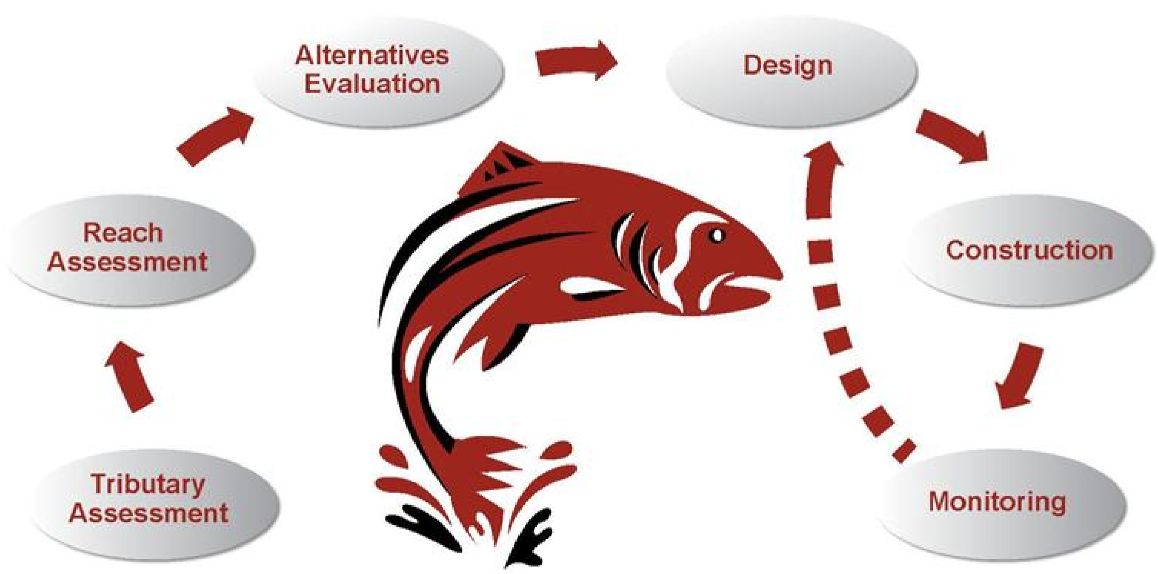

Figure 1. Flow chart illustrating generalized steps in the approach to habitat improvement.

Purpose of this Reach Assessment

This Tributary/Reach Assessment is a compilation report providing a range of scientific information relevant to habitat improvements for salmon and steelhead over a spatial scale fine enough to identify specific habitat improvement actions and coarse enough to support continuity between those actions. The purpose of this Tributary/Reach Assessment is to assess and document reach-scale physical characteristics and how they have changed over time for the purpose of identifying suitable habitat improvement actions that address limiting factors within the reach. The completed Tributary/Reach Assessment may be used to guide future habitat rehabilitation, ensuring that specific projects are developed and advanced in a manner suitable to the geomorphic character and trends prevalent throughout the reach. In this way, a watershed and reach-scale approach to habitat improvement can be facilitated.

Tributary/Reach Assessment Philosophy

This Tributary/Reach Assessment summarizes general watershed and refined reach-scale data and analyses presented in existing reports such as the *Grande Ronde Subbasin Plan* (NPCC 2004) and *Development and Evaluation of a Data Dictionary to Standardize Salmonid Habitat Assessments in the Pacific Northwest, Fisheries* (NOAA Fisheries 2012). Information in the Tributary/Reach Assessment is not intended to duplicate previous efforts, rather it is intended to provide a summary of pertinent larger-scale background information and expand upon that information at the reach scale.

Tributary/Reach Assessment Goals

There are four primary goals for this Tributary/Reach Assessment:

1. Identify watershed scale characteristics and summarize a timeline of historic events that have altered the physical processes.
2. Delineate individual reaches based on physical characteristics and identify the responses reaches within the watershed. Respones reaches are typically the most dynamic sections of a river and represent the greatest potential for improvement.
3. Estimate past, document existing (baseline), and identify potential target physical conditions within the response reaches.
4. Identify geomorphically appropriate potential actions to improve processes and thereby habitat, and classify each action's ability to address limiting factors within the response reaches.

Using This Document

This report is intended for the use of interdisciplinary scientists, engineers, and planners focusing on fish habitat improvement and rehabilitation. Conclusions from this Tributary/Reach Assessment are intended to guide future project development as one tool among many others in a collaborative effort to improve habitat. The Tributary/Reach Assessment provides pertinent background information regarding reach-scale geomorphic conditions and physically appropriate habitat improvement actions. As a follow-up to this report, appropriate habitat improvement actions should also be assessed and prioritized based on perceived biological benefit and landowner cooperation. This reach-scale assessment should not be used exclusively as the basis for site-specific habitat designs. Detailed, site-specific analyses should be conducted to identify the most appropriate suite of actions, refine conceptual plans, and develop detailed designs for implementation.

This Tributary/Reach Assessment was prepared by physical scientists at Reclamation with assistance and feedback from an interdisciplinary team of local and regional scientists familiar with the Upper Grande Ronde River. This document was prepared following a review of available background information, limited site visits and significant remote analysis using a Geographic Information System (GIS). Information documented in this report is focused around physical processes and physical changes occurring within four response reaches on the Upper Grande Ronde River. Species such as steelhead and spring Chinook salmon evolved with the physical environment of the Upper Grande Ronde River over thousands of years, and it is assumed that efforts to re-establish natural and appropriate physical conditions provide the best approach for habitat improvements intended to benefit these species.

Background Information

The Upper Grande Ronde River flows out of the Blue Mountains of eastern Oregon that rise to an elevation of greater than 7710 feet (Rheinheimer 2007). The Grande Ronde River flows north and then northeast through Oregon, eventually flowing through the southeast corner of Washington State before joining the Snake River at river mile (RM) 169 (Figures 2 and 3) (NPCC 2004). This Tributary/Reach Assessment focuses on the Upper Grande Ronde River from RM 164.2 on the Grande Ronde River just downstream of its confluence with Sheep Creek, downstream for a distance of approximately 30 RMs to Perry, Oregon at RM 133.65 (Figure 3).

Figure 2. Location of the Upper Grande Ronde River.

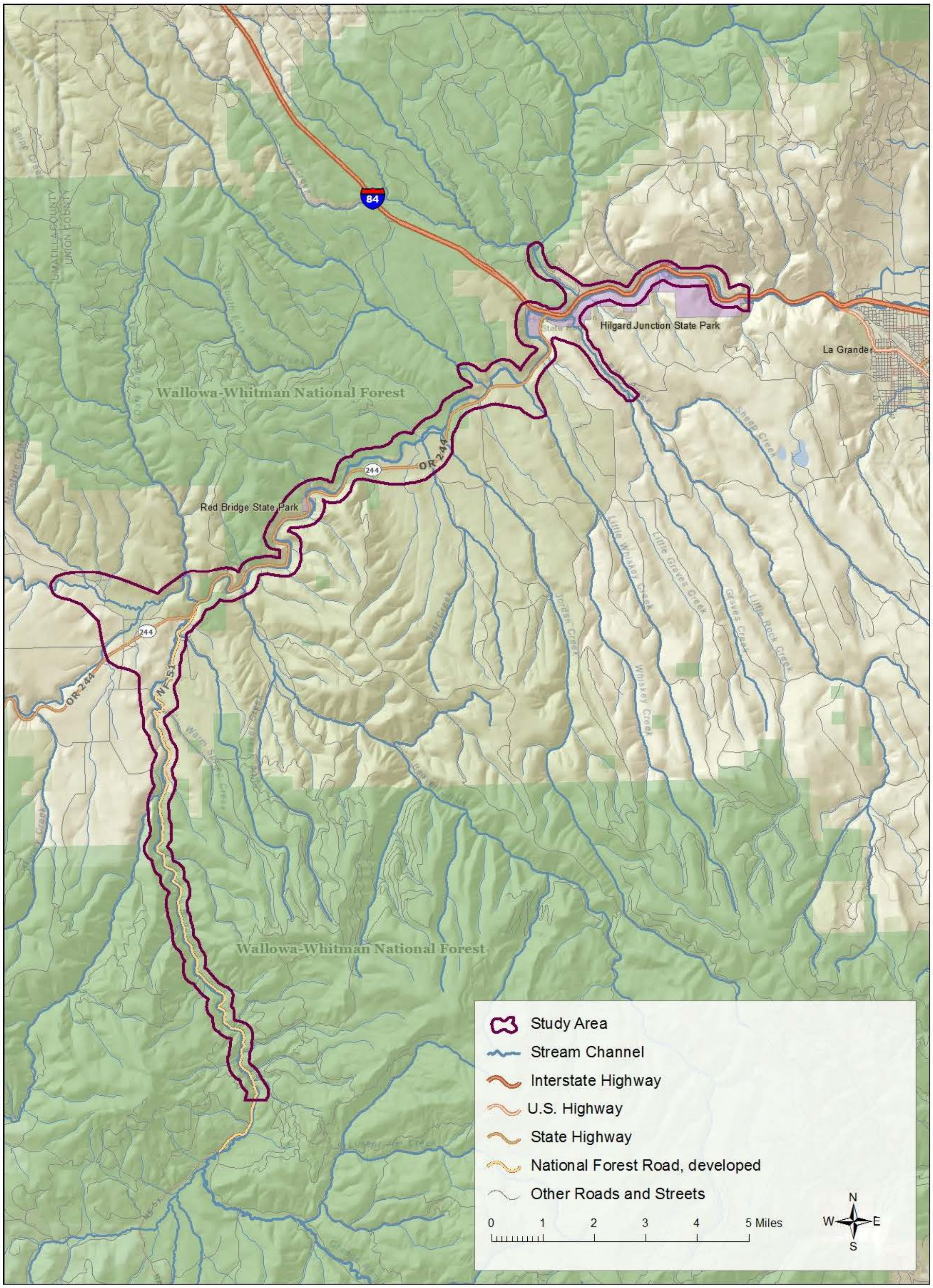

Figure 3. The area of focus on the Upper Grande Ronde River.

Summary of Existing Reports

The Upper Grande Ronde River has been the subject of many reports and analyses that suggested the river has been severely impacted by anthropogenic alterations resulting in the degradation of fish habitat (NPCC 2004; McIntosh et al. 1994; McIntosh et al. 1990). This assessment will identify the anthropogenic impacts at the watershed scale and within the identified response reaches. Impacts will be assessed based on their affect to instream habitat cover and complexity, channel pattern, migration rates, and floodplain interaction.

Specific broad-scale background information from existing reports and analyses has been summarized to help develop a better perspective regarding the reach-scale information to follow.

Regional Scale

The Grande Ronde River watershed is located in the Blue Mountains physiographic province which is an uplifted, mountainous region with several large, roughly north-trending, fault-bounded valleys and depressions (Figure 4) (Ferns et al. 2010).

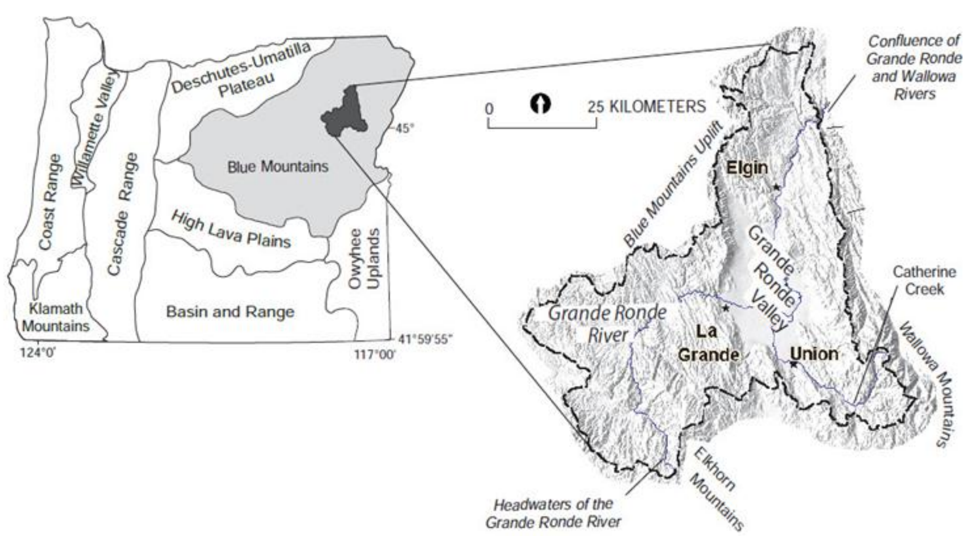

Figure 4. A map showing location of the Grande Ronde River basin in relation to the Blue Mountains physiographic province or Oregon from Ferns et al. (2010).

Structural Geology

The Grande Ronde River subbasin has been divided into five sections or sub regions based on structural variation (Ferns et al. 2010). The Upper Grande Ronde River is located in the western uplands region, and is part of the Blue Mountains uplift and includes all of the area drained by the Grande Ronde River upstream from Grande Ronde Valley (Figure 5). Major structural features in the western uplands include 1) northeast-trending folds and faults of the Blue Mountains uplift, and 2) cross-cutting northwest-trending fault zones that break the core of the uplift into a series of shallow basins separated by faulted ridges (Ferns et al. 2010).

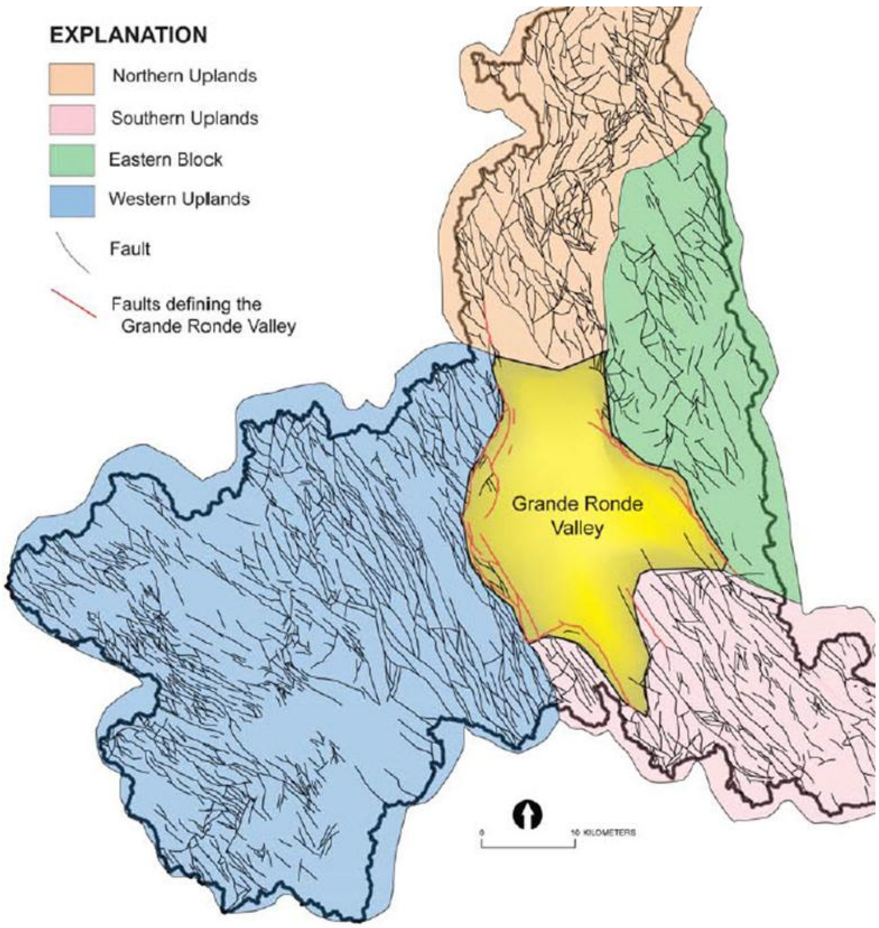

Figure 5. Map showing the five areas of the Grande Ronde Subbasin delineated by structural geologic differences (Ferns et al. 2010).

Climate

Climate in the Grande Ronde subbasin (and eastern Oregon and Washington) is affected to a large degree by the Cascade Mountains to the west, where much of the moisture of the Pacific Ocean air is lost to orographic precipitation (i.e., precipitation that occurs when moving air is forced upward—and consequently cooled—by mountains), resulting in relatively dry air east of the Cascades (Rheinheimer 2007). The area experiences a relatively cool climate with a short growing season and little or no summer precipitation. Annual precipitation averages 20 inches per year and ranges from 15 to 30 inches, primarily as snow. Temperatures range from an average summer high of 80 degrees F to an average winter low of 17 degrees F. Summer temperatures fluctuate widely with hot days and cold nights. Portions of the drainage are located within summer thunderstorm corridors and may experience localized brief, torrential rain events. At higher elevations, frost can occur almost any night of the year. Winter temperatures remain low for long periods with considerable snow accumulation.

Watershed Scale

Limiting Factors

Limiting factors are defined as those conditions or circumstances which limit the successful growth, reproduction, and/or survival of select species of concern. This report focuses exclusively on physical conditions for Grande Ronde River Upper Mainstem population of the Snake River steelhead (*Oncorhynchus mykiss*) and Grande Ronde River Upper Mainstem population of the Snake River spring/summer Chinook salmon (*O. tshawytscha*), both of which are listed under the ESA. The National Oceanic and Atmospheric Administration National Marine Fisheries Service (NOAA Fisheries) (2012) refined the limiting factors for the two species within assessment units that correspond to focus area covered in this Tributary/Reach Assessment. Tables 1 and 2 show the limiting factors for the Upper Grande Ronde River population of the Snake River steelhead and Upper Grande Ronde River spring Chinook salmon respectively, within this Tributary/Reach Assessment area.

Table 1. Limiting factors for Grande Ronde upper mainstem population of the Snake River steelhead (NOAA Fisheries 2012).

Assessment		
UGS4	Upper Grande Ronde River Mainstem - Upstream End of Grande Ronde Valley to Meadow Creek	4.1: Riparian Condition: Riparian Vegetation
		4.2: Riparian Condition: LWM Recruitment
		6.1: Channel Structure and Form: Bed and Channel Form
		6.2: Channel Structure and Form: Instream Structural Complexity
		7.2: Sediment Conditions: Increased Sediment Quantity
		8.1: Water Quality: Temperature
		9.2: Water Quantity: Decreased Water Quantity
UGS17	Upper Grande Ronde River Mainstem, Meadow Creek to Limber Jim Creek	1.1: Habitat Quantity: Anthropogenic Barriers
		4.1: Riparian Condition: Riparian Vegetation
		4.2: Riparian Condition: LWM Recruitment
		6.2: Channel Structure and Form: Instream Structural Complexity
		7.2: Sediment Conditions: Increased Sediment Quantity
		8.1: Water Quality: Temperature
		9.2: Water Quantity: Decreased Water Quantity

Table 2. Limiting factors for Grande Ronde River upper mainstem population of the Snake River spring/summer Chinook (NOAA Fisheries 2012).

Assessment Unit	Geographic Area	Limiting Factor
UGC1B	Middle GR Mainstem (Mouth of State Ditch to Five Points Creek)-excludes Five Points Creek	1.1: Habitat Quantity: Anthropogenic Barriers
		4.1: Riparian Condition: Riparian Vegetation
		4.2: Riparian Condition: LWM Recruitment
		6.1: Channel Structure and Form: Bed and Channel Form
		6.2: Channel Structure and Form: Instream Structural Complexity
		7.2: Sediment Conditions: Increased Sediment Quantity
		8.1: Water Quality: Temperature
		9.2: Water Quantity: Decreased Water Quantity
UGC2	Middle GR Mainstem (Five Points Creek To Meadow Creek)	1.1: Habitat Quantity: Anthropogenic Barriers
		4.1: Riparian Condition: Riparian Vegetation
		4.2: Riparian Condition: LWM Recruitment
		6.1: Channel Structure and Form: Bed and Channel Form
		6.2: Channel Structure and Form: Instream Structural Complexity
		7.2: Sediment Conditions: Increased Sediment Quantity
		8.1: Water Quality: Temperature
		9.2: Water Quantity: Decreased Water Quantity
UGC5	UGR Mainstream (Meadow Creek To Sheep Creek)	1.1: Habitat Quantity: Anthropogenic Barriers
		4.1: Riparian Condition: Riparian Vegetation
		4.2: Riparian Condition: LWM Recruitment
		6.2: Channel Structure and Form: Instream Structural Complexity
		7.2: Sediment Conditions: Increased Sediment Quantity
		8.1: Water Quality: Temperature
		9.2: Water Quantity: Decreased Water Quantity

Geology

The valley walls adjacent the Upper Grande Ronde River consist of various types of volcanic bedrock. The following description and ages are based on work by Ferns et al (2010). In the upper and mid-section of the watershed, the predominant volcanic rocks of the valley walls include the Jurassic/Cretaceous aged (206 -65 million years [my]) Nevadan Intrusives, and the Eocene/Oligocene aged (5.48 – 2.38 my) John Day/Clarno Group. There are also small sections of metamorphic rocks of the Carboniferous /Jurassic aged (354 – 144 my) Baker Terrane and Quaternary aged (1.8 my to present) landsides. Within the mid- and lower- sections of the watershed, Grande Ronde basalt of the Miocene aged (23.8 – 5.3 my) Columbia River Basalt group predominates. Other types of rock include sections of Miocene/Pliocene (2.38 – 1.8 my) sedimentary rocks and small sections of Miocene aged (2.38 – 5.3 my) Powder River Volcanics. Quaternary aged (1.8 my –

present) landslides and some terraces of semi- to unconsolidated deposits are found in the mid and lower sections of the watershed.

Sediment Supply

Sediment supply sources along the watercourse of the Upper Grande Ronde River include localized bank erosion, and input from infrequent mass wasting events associated with landslides deposits. Surface runoff also contributes fine sediment at the watershed scale.

Land Cover

The vegetation within the Upper Grande Ronde Watershed includes grassland along the valley floor with shrub and herbaceous plants that grade into coniferous forests in the upper elevation (NPCC 2004). Table 3 is a summary of the vegetation in the Upper Grande Ronde River subbasin derived from the National Land Cover Data (NLCD).

Table 3. Vegetation and land cover in the Upper Grande Ronde River subbasin (NLCD 2006).

Land Cover Classification	Area (acres)
Open Water	121
Developed, Open Space	1,800
Developed, Low Intensity	333
Developed, Medium Intensity	2
Barren Land (Rock/Sand/Clay)	16
Evergreen Forest	307,494
Mixed Forest	28
Shrub/Scrub	116,549
Grassland/Herbaceous	6,226
Pasture/Hay	21
Cultivated Crops	706
Woody Wetlands	53
Emergent Herbaceous Wetlands	964

Hydrology

The Upper Grande Ronde River is a snow-melt runoff dominated river. Due to the high variation in elevation among tributaries and the Grande Ronde River, runoff timing and magnitudes can vary substantially but typically river flows in the Lower Grande Ronde peak around April and May and are at their lowest from August through October (Figure 6) (Reclamation 2011; NPCC 2004).

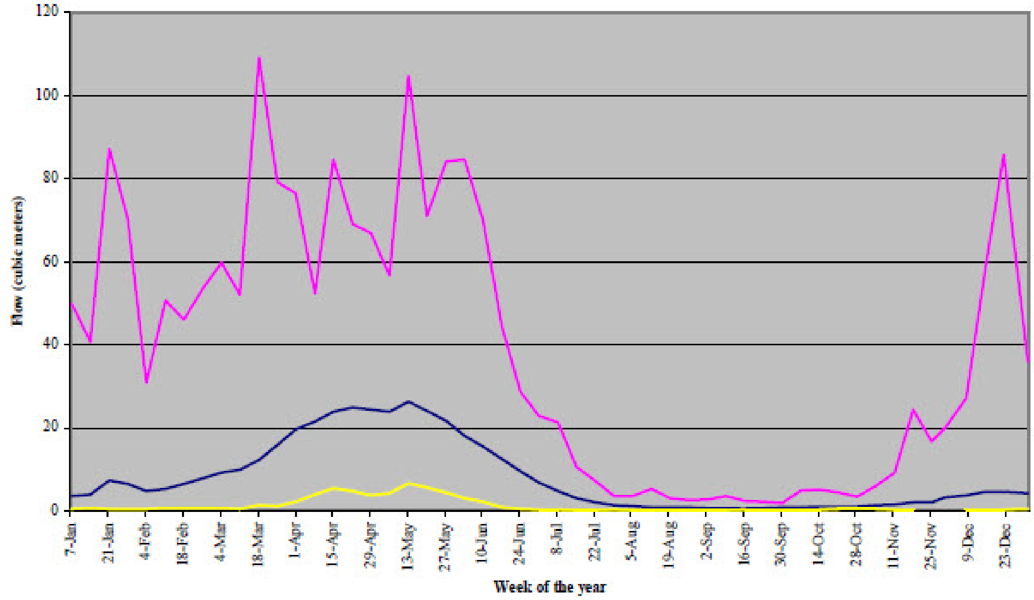

Figure 6. Hydrograph of mean daily flows in the Upper Grande Ronde River near Hilgard 1937-1955 and 1966-1981. The bottom line (yellow) represents minimum; the middle line (blue) mean; and the upper line (purple), maximum flows (NPCC 2004).

Historical Timeline

The first recorded historical events and activities in the Upper Grande Ronde River subbasin have impacted river form and process took place in the early 1800s with the extirpation of beaver. With the onset of Euro-American settlement, activities associated with economic development of the watershed continued to alter the river processes and conditions of the Upper Grande Ronde River. Some of the more significant historical events that were associated with the Upper Grande Ronde River are summarized in Table 4.

Table 4. Significant historical events or actions that impacted the Upper Grande Ronde River (Gildemiester 1998).

Year or Period	Event
1820-1830	Systematic decimation of beaver populations by the Hudson's Bay Company and American trappers.
1862	Charles Fox completes sawmill and dam on Grande Ronde River at Oro Dell near RM 131.3 ,W.J. Snodgrass establishes a water-powered grist mill at Oro Dell. This dam was the first that obstructed upstream passage of salmon to the Upper Grande Ronde.
1862	Gold discovered in Tanner Gulch
1872	Placer mining operations are active upstream of Camp Carson in the headwater area of the Upper Grande Ronde River
1880	Hilgard is a thriving community serving stockmen, loggers, and miners. By 1881, Daniel Chaplin has sawmills in operation at Hilgard and Meacham
1887	Mill at Stumptown (Perry) destroyed by fire; S.F. Richardson buys a new mill and

Year or Period	Event
	runs it there for a while before moving it to a new site about six miles above Hilgard on the Grande Ronde River. He continues operating the mill near the mouth of Spring Creek until selling it around 1881
1890	Grande Ronde Lumber Company acquires timberland up the Grande Ronde and begins constructing a series of splash dams (Beaver Creek, Meadow Creek, Dark Canyon, Fly Creek, and Vey Meadow) to add storage water for adding to spring snowmelt for annual log runs down the Grande Ronde River to the catch dam constructed at Perry. Each year 10-20 million board feet of mostly Ponderosa Pine logs are floated down the river
1890	Branch rail line of the O.R.&N. completed to Elgin on Oct 25th
1894	Dam about one mile upstream from La Grande blocks fish movement.
1896	French syndicate purchases old Camp Carson placer mines and renew operations with 200 men working the claims via hydraulic mining methods.
1900	An estimated 50 small sawmills are scattered around the valley and forest, producing railroad ties, fence rails, and lumber for homes, farms, businesses, and industry.
1900	Contracts are let for winter cutting and decking of 27 million board feet for the spring river run down the Grande Ronde to the mill at Perry and others in that vicinity
1900	Timber exports from the La Grande area are estimated at 32.5 million board feet.
1905	Placer mining still active on the Upper Grande Ronde River.
1925	The Grande Ronde River and its tributaries are adjudicated by the State Engineer: 1 cubic foot per second (cfs) was granted for 40 acres on a rotation basis equal to continuous flow of 1 cfs for 80 acres.
1926	Mt. Emily Lumber Co. purchases the timber holdings and mill site of the Grande Ronde Lumber Company. Extension of rail spurs continue in 1927 and 1928 into the upper Grande Ronde, with hauls up to 100 mbf per company train to Hilgard, then transferred via UPRR to mill in La Grande.
1930s	Reports and plans made for water storage, flood control, and stream channel improvements. Sites under consideration are: three Grande Ronde River sites near mouth of Meadow Creek, on Meadow Creek, Sheep Ranch, Fly Creek, and Spring Creek.
1934	Mt. Emily introduces log truck fleet to haul logs from landings to load out at the railhead at River Camp on the Grande Ronde.
1939	Ora Plata Mining Company begins dredging operations for gold on Tanner Gulch and down the Grande Ronde River, creating massive change to about two miles of creek and river channel and bottomland.
1955	Valsetz Lumber Co. purchase of Mt. Emily Lumber Co. brings the end to railroad logging in the Grande Ronde. Log transport converted entirely to trucks with construction of State Highway 244 up the Grande Ronde.
1960	Reconstruction of Old Oregon Trail Highway to interstate standards moves about 3.2 miles of the Grande Ronde River channel between Hilgard and the Oro Dell interchange west of La Grande.

Valley Formation

The Grande Ronde River Valley was influenced by a glacial climate that was cooler and wetter during the upper and middle Pleistocene Epoch between roughly 90,000 and 10,000 years ago. At the higher elevations the Upper Grande Ronde Valley was occupied by the westernmost glacier that originated from the Anthony Lakes cirque complex. Studies by Pogue et al., (N.d.) and Geraghty (N.d.) show that valley glaciers advanced from the top of the Grande Ronde River Valley downstream for a distance of approximately 2 miles in two pro-glacial episodes. Ferns et al. (2010) discusses evidence of glacial advances typically in the form of till that forms lateral moraines along the Grande Ronde River in the headwater areas. Following the cool and wet Pleistocene Epoch, the climate in Eastern Oregon became relatively warmer and drier. As glaciers retreated and levels of precipitation decreased, overall discharge and sediment supply also decreased allowing the Grande Ronde River to erode and redistribute alluvial material downstream forming small sections of terrace along the valley margin. Infrequent mass wasting episodes associated with fire, earthquakes, landslides and large floods also shaped the valley margins by forming small alluvial fans. The fans are generally comprised of gravels and sand with cobble.

The geology and processes associated with the changing climate during and following the last ice age resulted in a valley that contains relatively wider valley segments separated by narrow canyon reaches. For this report the classification of degree of confinement was done by comparing the width of the active channel to the Federal Emergency Management Agency's (FEMA) 100-year floodplain as described by the Oregon Watershed Enhancement Board (OWEB) (1999) (Table 5).

Table 5. Confinement classification based on the Oregon Watershed Assessment Manual (OWEB 1999).

Condition	Floodplain Width
Unconfined	Greater than 4 times the bankfull width
Moderately Confined	Greater than 2 times but less than 4 times the bankfull width
Confined	Less than 2 times the bankfull width

FEMA floodplain mapping is at a very coarse scale and field observation of geomorphic landforms such as alluvial fans and younger terraces were also considered for the confinement classification. Table 6 is a summary of the location, length, and confinement classification of the reaches within the assessment area.

Table 6. Summary of the reaches identified on the Upper Grande Ronde River.

Reach	Confinement Classification	Upstream River Mile	Downstream River Mile	Total Length (mi)
Reach 1	Confined	164.2	156.05	8.15
Starkey	Confined – Moderately Confined	156.05	151.8	4.25
Reach 2	Confined	151.8	146.05	5.5
Birdtrack/Longley	Unconfined	146.05	143.3	2.75
Reach 3	Confined	143.3	141.8	1.5
Hampton	Moderately Confined	141.8	140.65	1.15
Reach 4	Confined	140.65	137.3	3.35
Hilgard	Moderately Confined	137.73	136.3	1.43
Reach 5	Confined	136.3	133.65	2.65

Geomorphic Reaches

Four response reaches separated by narrow canyon sections were identified as areas of interest for reach level investigations due to their geomorphic response potential (Figure 7). From upstream to downstream the reaches for this report are Starkey, Birdtrack/Longley, Hampton, and Hilgard.

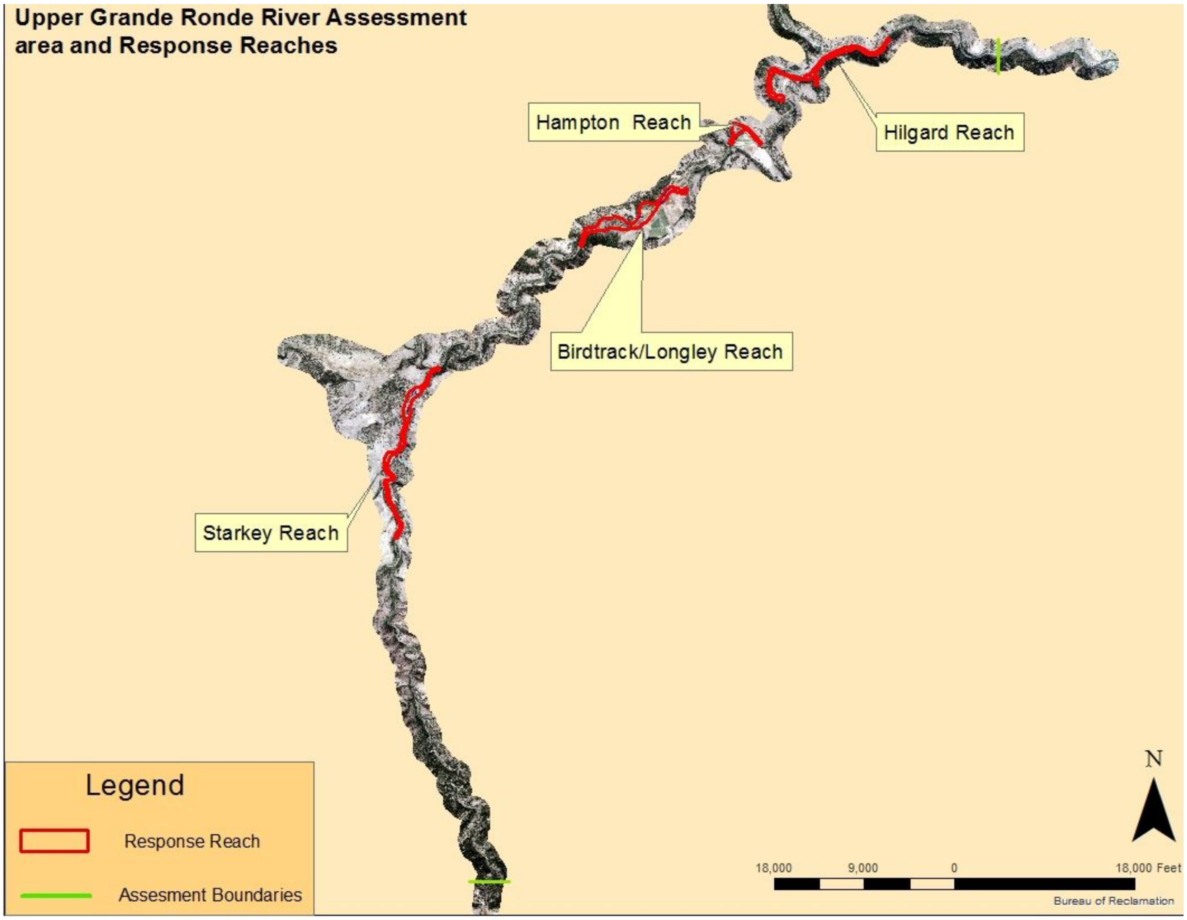

Figure 7. Map showing the four response reaches on the Upper Grande Ronde River.

For the remainder of this report the historical and current forms and processes as well as target conditions will be discussed for the Starkey, Birdtrack/Longley, and Hampton reach. The Hilgard reach will be discussed in less detail than the response reaches as a concurrent geomorphic, hydrologic, and hydraulic assessment is being conducted within that reach.

Historical Reach

Forms represent physical conditions on the landscape and in the river. Large-scale forms include the geometry, gradient, and composition of the valley and channel, which largely define the overall character of the channel. Smaller-scale forms include instream structures, bedforms, and channel shapes that add heterogeneity to the channel, and habitat for fish.

Channel Planform and Bedform

Channel Planform

Within all four of the response reaches the historic channel planform (the longitudinal shape or pattern of the channel when viewed from above) was a product of physical process including hydraulic discharge and sediment transport regime, and physical conditions including density and age of riparian vegetation, river bed and bank, and valley confinement (Beechie et al. 2006). For this report valley confinement is defined as the ratio of the FEMA 100-year floodplain width compared to the current interpreted bankfull width.

An estimate of the historic sinuosity can be made by looking at current as well as recent historical meander wavelengths and amplitudes and drawing a hypothetical channel centerline with similar average planform features. This method can produce a slightly exaggerated estimate as the hypothetical channel centerline does not account for straight sections that would have naturally occurred at any given time with the channel migration progression. The local straight sections could have been the result of multiple valley characteristics including local variation confinement from terraces, alluvial fans, and other natural constrictions as well as local gradient.

By using this method, the hypothetical channel sinuosity calculated for the channel in the Starkey reach is 1.27. Therefore, a reasonable estimate for historical overall average sinuosity in the Starkey reach ranges between 1.1 and 1.2. The channel would have been predominantly single thread at base flow. As seasonal flows increased from baseflow, activated back bar channels within the estimated bankfull channel width would have created split flow conditions across unvegetated lateral and point bars. At bankfull conditions, the channel would again have been predominantly single thread with most of the lateral and point bars completely inundated.

Within the Birdtrack/Longley reach using the same technique of applying the existing average meander, wave length and amplitude gives a hypothetical sinuosity of 1.46. A reasonable estimate of historical average channel sinuosity within the Birdtrack/Longley reach would range between 1.1 and 1.3. Similar to the Starkey reach, the channel would have been predominantly single thread at base flow. As seasonal flows occurred, activated side channels within the estimated bankfull channel width would have created split flow conditions across unvegetated lateral and point bars. At bankfull conditions, the channel would have been predominantly single thread with most of the lateral and point bars completely inundated.

The same methods applied in the Hampton reach gave a result of a hypothetical sinuosity of 1.26. A reasonable estimate of historical sinuosity within the Hampton reach is 1.1 to 1.2. The channel would have historically been predominantly single thread at base flow. During seasonally high flow there would have been sections of side channel activated creating occurrences of split flow around vegetated islands.

The historic sinuosity in the Hilgard reach was likely very similar to the current sinuosity. The level of confinement by bedrock and valley walls would have not allowed for significantly greater meander bend amplitudes to have existed. An estimate of the historical sinuosity for the Hilgard reach is 1.1 to 1.2.

Within the Starkey and Birdtrack/Longley reaches, the historic bedform was likely predominantly pool riffle with some plane bed sections with long deep runs. Pools and subsequent riffles would have occurred along the outside of meander bends due to helical flow (Figure 8) (Reclamation 2013). With helical flow, the circular momentum of moving water causes it to bulge against the outside of a bend, forcing downward and downstream flow to relieve the pressure. The downward helical or corkscrew flow vectors in combination with an erodible alluvial bank and bed in the response reaches resulted in localized bend scour. The scouring effects of helical flow break down shortly downstream of the bend where the eroded sediment is subsequently deposited forming a lateral bar in the channel opposite the eroded bend, and/or riffle with relatively shallow water depth across the crest. This helical flow pattern results in increased planform sinuosity with pool bedforms at the scour locations in the curves and riffle bedforms in the depositional areas in between.

The historic bedform within the Hampton reach was likely riffle-run, with the runs being fairly long and potentially deep. The conditions that differ between the Hampton and the Birdtrack/Longley reach are the degree of confinement in the Hampton reach by the alluvial terrace along the left bank throughout the entire reach and the toe of the hillslope along the right bank in the downstream half of the reach. Confined, straight channels lack the ability to develop and maintain the helical flow patterns and associated sinuosity and pool-riffle bedform described above.

Within the Hilgard reach, the historic bedform was likely also predominantly riffle run. Bedrock control in the upstream end and over all degree of confinement by the valley walls would have contributed to that bedform.

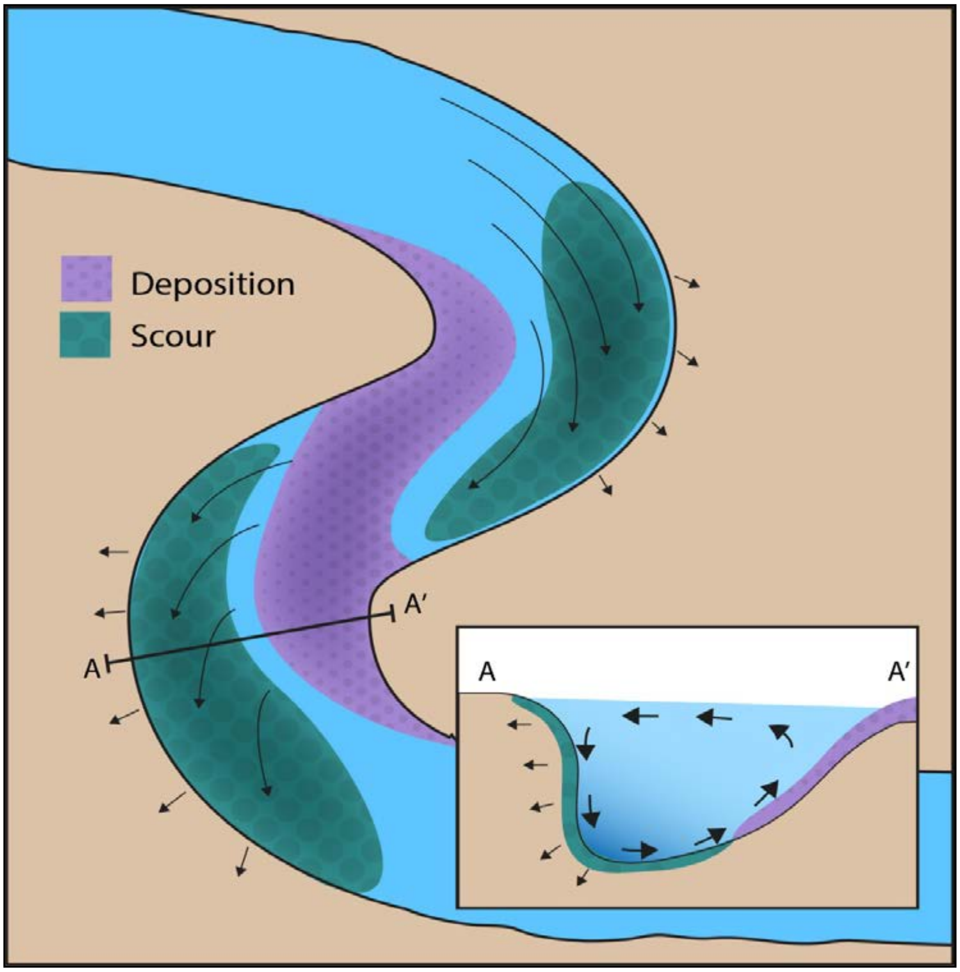

Figure 8. Simplified diagram illustrating helical flow resulting from flow pasing around bends in the river. As flow enters a bend, its momentum pushes more volume toward the outside of the bend resulting in a slight bulge (increased water surface elevation) along the outside of the bend. This added pressure along the outside of the bend is relieved downward, initiating a spiral-shaped flow path around the bend. The downward flow at the outside of the bend increases scours meanwhile upward flow downstream of the bend increases deposition. The result is a pool-riffle sequence with pools generally located at the outside of each bend and riffles located between bends (photo published by Reclamation 2013).

Although it is impossible to know the actual number of historic pools in the four response reaches, it can be roughly estimated by assuming each bend formed a pool through helical scour as described above. An estimate of pool abundance can be made by dividing the total length of the reach by the average historic meander wavelength and multiplying by two to account for two bends, and therefore, two pools per meander wavelength. Another method to estimate the historic number of pools is based on the empirically measured relationship between pool spacing and wetted channel width described by Bisson et al. (2006).

In the Starkey reach, measurements from aerial photos reveal an approximately average meander wavelength of 947 feet. The Starkey reach channel length is approximately

22,440 feet long, resulting in an estimated 23.7 wavelengths and roughly 47 total pools or approximately 11.1 pools per mile. Results using the method described by Bisson et al. (2006) ranged between 11 and 15 pools per mile. Along with pools forming in association with meander bends, it is very likely that a few additional pools would have also formed between bends from scour associated with instream obstructions such as logjams. With that acknowledged, it is estimated that the number of pools per mile ranged between 11 and 15 within the historic Starkey reach.

In the Birdtrack/Longley reach, measuring the average meander wavelength method resulted in an estimated 8.3 pools per mile. The Bisson method results estimated 8 to 10 pools per mile. Similar to the Starkey reach, is very likely that additional pools formed between bends from scour associated with instream obstructions (logjams) within the Birdtrack/Longley reach. A reasonable estimate of historic pools per mile within the reach is 8 to 10.

In the Hampton reach, the average wave length method resulted in an estimated 12.7 pools per mile. The Bisson method results indicated a range of between 11 and 15 pools per mile. However, these estimates are for a pool-riffle channel type and the channel in the Hampton reach is and likely was riffle run. This relatively straighter and more homogenous channel type would result in fewer pools. An estimate of historic pools in the Hampton reach ranges between 2 to 3.5 pools per mile.

The Hilgard reach is similar to the Hampton reach with a probable riffle run bedform due to bedrock control and straight planform. An estimate of historic pools in the Hampton reach is between 3.5 to 4.5 pools per mile.

Channel Width-to-depth

As with number of historic pools per mile, it is impossible to know historic width-to-depth ratios. Although no quantitative data exists it is hypothesized that historic width-to-depth ratios in the response reaches were lower than current condition due to changes in response to anthropogenic activities. This is based in part on observations of existing channel and floodplain conditions including lack of floodplain connectivity at annual high flows and "bankfull" flow recurrence intervals. Additionally, it is known that the channel was artificially confined in some locations by railroad, road, and bridge building activities as well as hydraulically simplified through the removal of large instream obstructions (wood and boulders). These activities would have affected the sediment transport competency and capacity of the river. Competency refers to the maximum grain size a stream is capable of transporting, while sediment capacity refers to the volume of sediment transported by a stream. Decreased hydraulic roughness and increased velocity and depth would have created increased shear stress within the channel, leading to increased sediment mobilization and transport. This would have initially lowered the bed of the channel and increased the width of the channel until a new channel geometry that was relatively stable at the altered (increased) hydraulic conditions was created. Observations of the Upper Grande Ronde River indicate that much of the channel bottom in the relatively unconfined reaches is bedrock. This lends further support to the conclusion that the channel has been artificially incised.

Floodplain and Off-channel Character

Floodplain connection (inundation) occurs when instream flow conveyance is exceeded, and water overflows the banks. Alluvial channels are formed within a balance between erosion and deposition, trending toward a channel geometry that is capable of conveying bankfull flows. In the more arid climate of eastern Oregon, bankfull flow has been calculated to be a discharge with a recurrence interval of approximately 1.4 to 1.5 years (Castro and Jackson 2001). Well-connected floodplains of alluvial channels are inundated or “connected” to their channels at and above this bankfull discharge.

The historic floodplain likely varied locally within each reach but was predominantly moderately to well connected. Variation in several local conditions including but not limited to channel gradient, local channel conveyance, sediment transport characteristics, the existence of large woody material (LWM) and downstream channel constrictions would have cumulatively provided local variation to frequency and depth of floodplain inundation within each reach. In some cases, channel spanning LWM accumulations would have aided in the floodplain inundation at or near bankfull flow by creating a backwater effect that would effectively raise local water levels allowing the water to more frequently overtop the bank. In other locations, accumulations of sediment could have had the same effect on bankfull discharge. The increased natural confinement by valley walls at the downstream end of each of the reaches may also have created a backwater effect during high flow events.

Evidence of connected floodplains typically include topographic features on the landscape including historic channel scars, overflow and side channels, and other low-lying depressions in the floodplain as well as relatively higher elevation natural levees and sediment splays. Some of the low-lying features sustained a downstream connection as alcoves, some became wetlands, and others remained connected at upstream and downstream ends at flows forming side channels. In most cases, the side channels would have been intermittent and activated at a range of seasonal flow conditions rather than being active year round. Alcoves could have developed on the downstream end of those side channels by processes described below.

Alcoves are off-channel, wetted areas with one (typically downstream) connection to the mainstem. Flow through the alcove during low-water periods is typically the result of hyporheic (local groundwater) conditions during lower flow conditions. Most alcoves formed by the following process: 1) from multiple episodes of overbank flooding where flood water flowing across the floodplain returns back into the channel as concentrated flow capable of scouring and head-cutting into the floodplain, or 2) channel migration and avulsion creating oxbow ponds and wetlands that are periodically connected to the main channel, and 3) maturation of side channels through sediment deposition within the channel (typically from the upstream end). Alcoves are present in each of the response reaches, but are the most prevalent in the Birdtrack/Longley and local sections of the Starkey reach.

Avulsion is the abrupt movement of an active channel to a new location in the river valley. This process usually occurs in response to cumulative deposition and infilling of the active channel by sediment or woody material causing the stream to rapidly erode a new channel or reoccupy a formerly abandoned channel. Avulsions occurred infrequently where either sediment or debris accumulations within the channel were bypassed for a more direct path through the floodplain or across a point bar often in response to a large flood. Similarly, avulsion may also have occurred at a meander bend cutoff wherein a looping bend would have been pinched off or plugged at the neck, abandoning the bend, and straightening the channel pattern. In the Starkey reach, there are local areas where the channel locations show some variance when comparing the historical aerial photos. Whether or not it is true avulsion is unknown. In the Birdtrack/Longley reach, there is potential for channel avulsion to occur in the future, but there is no indication that it has occurred over the time span of the historical photos set. Overall, evidence suggests that the occurrence of channel avulsion within the response reaches is low.

Side channels formed in the same manner as alcoves, but were able to maintain an upstream surface connection by locally breaching the bank upstream or by localized scour at the site of the side channel inlet often created by a logjam or other instream obstruction. It is unlikely that perennial side channels persisted for more than a few years without a corresponding logjam or other obstruction to maintain the inlet and prevent the mainstem from migrating away from the inlet. Three types of side channels were likely prevalent in the reaches of the Upper Grande Ronde: 1) floodplain channels that conveyed primarily high flow through the vegetated floodplain, 2) back bar channels that conveyed seasonal flow across the back of an unvegetated bar or around an island, and 3) split flow around vegetated islands. The second and third types of side channel typically occur within the active channel.

The dominant historic side-channel type in the Starkey reach was likely a seasonal channel that conveyed flow across the back of an unvegetated bar. Due to the overall narrow floodplain in the Starkey reach, these side channel types were activated as seasonal flows increased from low flow. In the locally unconfined section from RM 153.3 downstream to RM 152.3, floodplain side channels that conveyed higher flow through the vegetated floodplain would have existed but were likely active for only short periods of time during greater than bankfull flow conditions. Both types of intermittent side channels would have been maintained by LWM that had accumulated on point and lateral bars that helped to split flow into the side-channel area. Channel avulsion may have taken place in the unconfined section of the reach due to accumulations of sediment and/or LWM in the mainstem of the channel.

Within the Birdtrack/Longley reach, the historic off-channel floodplain was likely well connected. In the unconfined upper and mid-section of the reach, both types of intermittent side channels would have been present. In the downstream end increased degree of confinement would have contributed to greater instances of back bar channels that were likely activated at flows above base flow but less than bankfull and stayed wetted for longer periods of time.

In the Hampton reach, the most prevalent type of side channel would have been overflow channels that activated at seasonal flows that created split flow around vegetated island conditions at RM 141.5 and 141.1. Additional side channel type included some back bar channels in the upstream section of the reach near RM 141.7

Within the Hilgard reach, back bar channels and potentially a few split flows around vegetated island channels would have likely existed at the confluences of Rock Creek at RM 138.3 and Five Points Creek at RM 137.7 due to the sediment input from those tributaries. Floodplain channels that conveyed primarily high flow through the vegetated floodplain would have been rare if present at all due to the confined nature of the reach.

Large Woody Material and Instream Obstructions

Instream obstructions can force flow to move laterally, concentrate flow initiating local scour, and/or constrict the flow to create a local backwater effect. All of these effects have the potential to locally alter the channel planform and/or bedform. Obstructions represent any object that blocks flow, but most commonly consist of bedrock outcrops, or large pieces of wood or rock embedded into the bed or banks of the active channel. Large wood is defined in this report as any piece of wood greater than 12 inch diameter and 30 feet long. Woody material tends to rack or collect against instream obstructions such as large wood key members. The accumulation of woody material around one or more key members is considered a logjam. Logjams typically consist of a key member, secondary members, and additional racked members.

- Key member = typically a very large piece of LWM providing anchoring and structural stability to the logjam. It is this piece (or these pieces) upon which secondary and racked members are connected to maintain a persistent logjam. The key members are often embedded into the bed or bank of the channel.
- Secondary member = typically consists of LWM pinned against a key member or other structural element (boulder, live vegetation, etc.) contributing to the size and structure of the logjam. Secondary members are generally fairly stable within the logjam.

- Racked member = typically smaller wood and small woody material that is pinned against the key and secondary members providing little to no structural support, but enhancing cover and increasing surface area and frictional component to the logjam as a whole.

Prior to Euro-American settlement and associated logging practices that included the clearing of structure from the river, the Upper Grande Ronde River likely contained many individual pieces of LWM and multiple logjams. Large logjams can affect the local hydraulics to provide variation to bedform from local scour and deposition. If large enough the logjam could activate intermittent side channels. The following rough estimates of number of logjams that may have existed along the Upper Grand Ronde River are derived by using the estimated number of historic meander bends and assuming logjams formed along the outsides of at least 60 to 80 percent of those bends and at the apex of mid-channel bars.

Estimated historic logjams in the Starkey reach ranged between 5 and 7 logjams and an average of up to 20 additional pieces of LWM per mile (Fox 2001). Estimated historic logjams in the Birdtrack/Longley and Hampton reaches ranged between 4 and 6 jams with an average of between 10 and 15 additional pieces of LWM per mile. The Hampton reach may have had between 3 and 5 logjams per mile with an additional 15 to 18 pieces of large wood per mile. In the Hilgard reach, the straight planform would have contributed to a low number of logjams per mile, but additional woody material could have been provided by Five Points Creek and Rock Creek, and logjams may have existed at the head of islands. The estimate for logjams in the Hilgard reach is 1.5 to 3.0 logjams per mile with an additional 15 to 18 pieces of large wood per mile.

In addition to wood, large boulders also obstruct flow influencing channel form. Boulders have been delivered to the channel and floodplain over the past several thousand years through colluvial processes associated with rock spall near the valley margin.

Riparian Conditions

Although no direct evidence of pre-Euro-American settlement riparian conditions exist today, it is likely that historic vegetation conditions in all three of the response reaches on the Upper Grande Ronde River included significantly greater densities of riparian vegetation in the well-connected floodplain areas. In addition, a greater variety of appropriate species and range of age class that include large diameter old-growth trees would have been present. Seed dispersal from floods, wind, and other natural means of propagation following disturbances enabled establishment of diverse upland and riparian communities. Prominent historic riparian vegetation likely included cottonwood, willow, river birch and alder, with Ponderosa pine and Douglas fir dominating upland areas. Wetland vegetation including grasses, rushes and sedges would have occupied low-lying areas formed by channel migration or flood scour.

Beaver Activity

Historic beaver population levels are unknown for the Upper Grande Ronde River (NPCC 2004). Beaver activity and beaver dams in particular could have played a vital role in maintaining and diversifying historic off-channel habitat. Where beaver activity was prevalent within the response reaches on the Upper Grande Ronde River, the impacts could have included large low velocity off-channel areas. Beaver activity and dams would have played a vital role in maintaining and diversifying off-channel habitat and riparian conditions. Beaver activity would have promoted a network of ponds and/or wetlands connected by single or multiple transportation routes that resulted in floodplain complexity. Beaver dams would have also provided increased sediment retention, increased groundwater recharge and retention which may have increased in-channel flow at low flow conditions. The off-channel wetland complexes associated with beaver activity typically would have provided increased total area of available fish habitat. Beaver dams likely also contributed to reduced water velocities, attenuated peak flows, and increased area of riparian vegetation (Pollock, Heim, and Werner 2003).

Historic processes and forms for the response reaches are summarized below in Table 7.

Table 7. Historical conditions and forms of the Starkey reach on the Upper Grande Ronde River.

Form	Historical Condition	Process(es) Creating/Maintaining Form
River bed and banks		
Starkey	River alluvium (gravel cobbles), hillslope colluvium (coarse rock)	Deposition of river alluvium; back water effect from downstream constrictions; input by infrequent hillslope disturbances such as debris flows following fires, severe thunderstorms and earthquakes.
Birdtrack/Longley	River alluvium (gravel cobbles), hillslope colluvium (coarse rock)	Deposition of river alluvium; back water effect from downstream constrictions; input by infrequent hillslope disturbances such as debris flows following fires, severe thunderstorms and earthquakes.
Hampton	River alluvium (gravel cobbles), hillslope colluvium (coarse rock)	Deposition of river alluvium; back water effect from downstream constrictions; input by infrequent hillslope disturbances such as debris flows following fires, severe thunderstorms and earthquakes.
Hilgard	River alluvium (gravel cobbles), hillslope colluvium (coarse rock)	Local deposition of river alluvium from tributaries; input by infrequent hillslope disturbances such as debris flows following fires, severe thunderstorms and earthquakes.
Sinuosity		
Starkey	1. 1 to 1.2	Colluvium and bedrock created areas of erosion resistance; channel obstructions drove local bank erosion and meander formation; episodic avulsions resulted from sediment accumulation in the downstream end of the reach.
Birdtrack/Longley	1.1 to 1.3	Colluvium and bedrock created areas of erosion

Form	Historical Condition	Process(es) Creating/Maintaining Form
		resistance along the left bank; channel obstructions drove local bank erosion and meander formation.
Hampton	1.1 to 1.2	Colluvium and bedrock created areas of erosion resistance along the left bank; right bank is bound by older alluvial terrace; downstream half runs along a fault.
Hilgard	1.1 to 1.2	Bedrock and valley walls created areas of erosion resistance.
Channel Morphology		
Starkey	Pool riffle	Local scour and deposition along outside of meander bends; LWM accumulations; forcing agents (bedrock/colluvium).
Birdtrack/Longley	Pool riffle	Local scour and deposition along outside of meander bends; LWM accumulations; forcing agents (bedrock/colluvium).
Hampton	Riffle run	LWM accumulations; forcing agents (Colluvium, faulting).
Hilgard	Riffle run	LWM accumulations; forcing agents (bedrock) confinement.
Large Pools (>20m^2 and 1m deep)		
Starkey	11 to 15 per mile	Channel meandering, constrictions from large instream obstructions (LWM) forced flow convergence from bedrock/bar development; bend scour.
Birdtrack/Longley	8 to 10 per mile	Channel meandering, constrictions from large instream obstructions (LWM) forced flow convergence from bedrock/bar development; bend scour.
Hampton	2 to 3.5 per mile	Constrictions from large instream obstructions (LWM) forced flow convergence from bedrock/bar development; bend scour.
Hilgard	3.5 to 4.5 per mile	Constrictions from large instream obstructions (LWM) bedrock control; straight planform.
Floodplain connection		
Starkey	Frequent flooding	Deposition, LWM, backwater conditions from downstream constriction.
Birdtrack/Longley	Frequent flooding	Deposition, LWM, and unconfined valley; backwater conditions from downstream constriction.
Hampton	Frequent flooding	Deposition, LWM, backwater conditions from downstream constriction.
Hilgard	Frequent flooding	Deposition at confluences, LWM, and unconfined valley; backwater conditions from downstream constriction.

Form	Historical Condition	Process(es) Creating/Maintaining Form
Side channel type		
Starkey	Back channel bars throughout the reach; occasional split flow around vegetated island; side channels through vegetated floodplain in the locally unconfined sections.	Frequent floodplain back bars during seasonal flow, some split flow condition maintained by LWM; beaver activity maintained off-channel habitat; rare perennial upstream connections maintained by scour from logjams.
Birdtrack/Longley	Both back channel bars and side channels through vegetated floodplain in the upstream third of the reach; back channel bars concentrated in the downstream third.	Frequent floodplain inundation concentrated in topographic lows created scour and head cuts into the floodplain; beaver activity maintained off-channel habitat; rare perennial upstream connections maintained by scour from logjams.
Hampton	Predominantly split flow around vegetated island, some back bar side channels.	Frequent inundation concentrated in intermittent side channels; beaver activity maintained off-channel habitat; rare perennial upstream connections maintained by scour from logjams.
Hilgard	Predominantly back bar with a few split flow around vegetated islands; few floodplain side channels.	Frequent floodplain back bars during seasonal flow, some split flow condition maintained by LWM rare perennial upstream connections maintained by scour from logjams.
LWM		
Starkey	5 to 7 logjams per mile; 20 pieces per mile	LWM recruited from episodic mass failures and/or from bank erosion or windfall; Individual pieces deposited on bars, lodged against instream structures, or pinned against the bank; logjams required large instream structure (boulder and/or key member) for recruitment and retention of multiple pieces.
Birdtrack/Longley	5 to 10 logjams per mile; 20 pieces per mile	LWM recruited from episodic mass failures and/or from bank erosion or windfall; Individual pieces deposited on bars, lodged against instream structures, or pinned against the bank; logjams required large instream structure (boulder and/or key member) for recruitment and retention of multiple pieces.
Hampton	3 to 5 logjams per mile; 15 to 18 pieces per mile	LWM recruited from episodic mass failures and/or from bank erosion or windfall; Individual pieces deposited on bars, lodged against instream structures, or pinned against the bank; logjams required large instream structure (boulder and/or key member) for recruitment and retention of multiple pieces.
Hilgard	1.5 to 3.0 logjams per mile; 15 to 18; pieces of large wood per mile.	LWM recruited from episodic mass failures and/or from bank erosion or windfall; Individual pieces deposited on bars, lodged against instream structures, or pinned against the bank; logjams required large instream structure (boulder and/or key member) for recruitment and retention of multiple pieces.

Historical Process

In an alluvial system, channel processes are continually working to maintain a relatively stable condition by adjusting numerous variables which are mutually interdependent: hydrology, sediment transport, channel migration, LWM recruitment, and riparian conditions, among others. As one process changes the others respond to maintain quasi-equilibrium. The response time for adjustment depends both on the degree of change (disturbance) and the inherent condition of the river system. In alluvial response reaches, the response time required for natural processes to adjust to changes in form or process is relatively short. As a result, despite episodic disturbances the natural processes inherent to the system continually maintain a relatively stable yet diverse riverine environment.

Hydrology

Glaciers advanced and retreated at least twice at the higher elevations of the Upper Grande Ronde River watershed during the last ice age resulting in variable and potentially extreme hydrologic response that initially formed the Upper Grande Ronde River Valley. In the roughly 10,000 years since the last glaciers melted, the modern climate has been marked by a relatively consistent and mild temperature and precipitation (Houghten et al. 2001) resulting in a relatively consistent hydrologic regime dominated by seasonal snow melt.

Historically under a seasonal, snowmelt-dominated hydrologic regime, within the response reaches, the mainstem of the Upper Grande Ronde River functioned similar to many unconfined alluvial channels by conveying modest flows within its banks but frequently spilling water onto its floodplain during high-water periods and building or reworking floodplain through seasonal deposition. Evidence of a historically well-connected floodplain is present in the varied but up to 4 feet thick layer of silt and sand observed along sections of bank within all three reaches suggesting hundreds of years of flood deposition. The consistent climate of the past several thousand years supports a historic hydrologic regime very similar to the modern regime whereby channel forming flow is estimated to be around the 1.4 to 1.5-year recurrence interval discharge (Castro and Jackson 2001). At this discharge bedload was mobilized, bed scour and bank erosion occurred, and floodplain interaction initiated, all of which combined to help shape the historic and modern channel form of the three response reaches.

Sediment Transport

Sediment transport can generally be separated into two categories: competency and capacity. Competency refers to the maximum grain size a stream is capable of transporting. Sediment capacity refers to the volume of sediment transported by a stream and is dependent on the channel competency and sediment supply.

Historically, competency in the relatively straight channel within the four response reaches was controlled largely by hydrology and gradient. Floods mobilized sediment comprised of cobble, gravel, and fines. In the locally unconfined channel segment within any reach, as discharge increased to flood stage, overbank flow initiated. Energy and flow volume were dissipated on the floodplain during large floods where the maximum instream competency was in the cobble size range. In other words, the sediment transport competency could not increase beyond cobble grain sizes because the channel was not steep and deep enough, and energy and finer sediments from big floods were dissipated on the floodplain rather than focused between the banks.

Capacity was also controlled largely by hydrology and gradient with the added component of sediment supply. Most bedload sediment was supplied from local scour (bend scour and contraction scour) and local bank erosion while most suspended sediment was supplied from hillslope erosion (sheetwash) and bank erosion. Infrequent mass wasting associated with landslides and rock spall introduced a wide range of grain sizes and sediment volumes of which most cobble and smaller sediment has been subsequently reworked by the channel. Larger boulders have not been mobilized by the channel and represent obstructions providing local hydraulic roughness.

Suspended sediment (mainly sand and silt) was primarily deposited on the floodplain or washed downstream. As sediment-laden floodwaters spilled over the banks, the depth, velocity, and therefore transport capacity of these flows decreased proportionally to their distance from the river bank resulting in preferential sediment deposition in the shallow, high-friction zone directly adjacent the banks. While suspended sediment was deposited on the floodplain most bedload was deposited as bars and riffles generally after short distances of transport. The overall sediment transport capacity (suspended and bedload) depended on the duration of the transport flow. As with modern flows, in the snow-melt dominated system, the highest flow spring runoff historically lasted between 1 and 3 weeks on average with the majority of sediment transport occurring during this time frame.

Historically, the sediment transport regime within all of the response reaches within the Upper Grande Ronde River Valley was over all in balance. Within each reach there would have been sections that were primarily transport and others that were depositional.

Within the Starkey reach, the upstream sections would have been predominantly transport sections due to the confined-to-moderately confined conditions. The section from RM 153.3 downstream to RM 152.3 would have been an area of deposition due to the unconfined conditions. Backwater conditions that would have been caused by the natural constriction by valley walls at higher flows at the downstream end of the reach would have contributed to the depositional area in the downstream end of the Starkey reach.

Within the Birdtrack/Longley reach, the sediment regime was also likely in balance overall trending toward transport limited. Sediment would have commonly been reworked to change bar shape and location.

The Hampton reach was also likely in sediment balance, with some sediment being deposited/reworked in the upstream end.

The Hilgard reach was likely in balance. In the upstream section the historic transport regime was likely transport due to the bedrock control. The area of the confluence with Rock Creek at RM 138.4 downstream to RM 138.0 would have been an area of deposition and reworking of sediment, with the remainder if the reach generally being in balance.

Channel Migration

Streams that have a bankfull width of less than 50 to 65 feet typically tend to not migrate across the floodplain (Beechie et al. 2006). Streams above this width threshold that have a natural sinuosity of less than 1.5 due to physical confinement or constraints may locally migrate laterally but do so at overall low rates. Riparian vegetation, bedrock, geologic terraces and alluvial fans, and certain types of valley fill materials may all contribute to low migration rates.

Historical channel migration in the Starkey reach was relatively low due to the comparatively straight planform resulting from the combination of confinement by bedrock valley walls and/or terraces and probable historic channel width. Increased root mass from dense mature riparian vegetation and natural physical constraints would have increased bank stability and reduced rates of lateral migration. The channel segment from around RM 153.3 to RM 152.3 in the downstream section of the reach may have had higher instances of channel avulsion due to the natural accumulation of woody material and sediment, but average historic channel migration rates were likely less than a foot per year based on typical migration rates of straight channels (Beechie et al. 2006).

Within the Birdtrack/Longley reach, average historic channel migration rates were also likely low. The historic bankfull channel width was likely wide enough to support lateral migration, but the average migration rate for a stream with a straight planform is around 89 years to move one channel width laterally (Beechie et al. 2006). As within the Starkey reach, increased root mass from dense mature riparian vegetation would have increased bank stability. Local sections of bank where bedrock outcroppings and/or terraces existed would have also increased local levels of erosion resistance. Historic channel migration rates likely ranged between 1.5 feet to less than 1 foot per year within the Birdtrack/Longley reach.

In the Hampton reach, historic migration rates were also low due to relatively straight channel planform and local physical constraints that include terraces and bedrock. In addition, the downstream half of the reach the planform (and location) is likely controlled by a fault that the river runs along. Historic channel migration rates within the Hampton reach were likely significantly less than 1 foot per year.

Channel migration rates in the Hilgard reach were also likely less than a foot per year due to erosion resistant material (bedrock) and the overall confinement by valley walls.

LWM Recruitment and Retention

Under conditions that vary across individual river systems that can include but are not limited to degree of erodible bed and/or banks, range of channel slopes, and sizes ranges of substrate, LWM has the potential to significantly influence channel form and process at multiple scales. At the reach scale, large wood can effectively increase pool frequency, increase hydraulic roughness and channel competence, and alter sediment transport by reducing bed-surface grain size (Montgomery et al. 2003). At the channel unit scale, wood can affect the size and type of pools, bars and steps in coarse grained channels (Montgomery et al. 2003). Wood can also affect channel geometry and planform by localized redirection of flow (Naimen et al. 2002; Montgomery et al. 2003). Processes of wood delivery to streams range from those that provide predictable inputs over long periods of time, to rare episodic events that generate large amounts of wood in a short period of time (Naimen et al. 2002)

Historic delivery of LWM to each of the four response reaches on the Upper Grande Ronde River was from two sources with each one having different mechanisms. The first source is from upstream by mechanisms that typically include episodic disturbances such debris flows, landslides, avalanches, and avulsions. Once incorporated into the stream, the woody material could be transported downstream and into the reach by fluvial processes. The second source was from within the reach. Mechanisms for local delivery typically include wind throw and mortality of trees along the bank related to stand development and succession (Naimen et al. 2002) as well as trees that were undercut by bank erosion and channel migration.

Under historic conditions the retention of LWM depended both on the size of the wood and the local shape of the channel in each of the focus reaches. Large logs with root wads would have deposited onto riffles where water depth was insufficient for the LWM to pass. Subsequent deposition on the lee side of the root wad would have buried various amounts of the LWM. LWM was also lodged against the bank by flow in certain areas. This would have commonly occurred at the head of islands, along the outside of bends where existing vegetation or windfall captured mobile wood as it passed by, or where flow passed onto the floodplain either at a side channel or floodway.

Riparian Disturbance and Succession

Riparian disturbance took place frequently over a large portion of the reaches historically. Flooding accompanied by silt/sand deposition occurred annually on low elevation portions of the floodplain. Localized channel migration eroded portions of the floodplain and created new floodplain from point bar deposition. Channel avulsions episodically cut through the floodplain creating new channels and abandoning the old channel paths or creating new side channels. Additional disturbances to the riparian vegetation also included fire that burned the vegetation; debris flows that deposited alluvial sediment from the valley slopes onto the floodplain and into the channel; and ice flows that potentially scoured bank vegetation and/or dammed the channel temporarily increasing flood effects. Logjams may have also temporarily dammed portions of the channel creating backwater conditions increasing flood effects. All of these processes would have resulted in the formation of a diverse, multi-species, and multi-age class riparian zone.

Existing Conditions

Existing conditions are the forms and processes currently shaping the four response reaches within the assessment area on the Upper Grande Ronde River. Data collected to assess existing conditions included detailed light detecting and ranging (LiDAR) imagery and aerial photos with spot checks in the field to ground truth. Hydrologic and hydraulic analyses were not completed for this effort.

Existing Forms

The primary defining characteristic forms are described below for the responses reaches.

Channel Dimensions

Representative bankfull channel widths were calculated using remote analysis techniques in ArcGIS. Channel widths were measured by digitizing the 2012 active channel including the wetted channel and predominantly unvegetated gravel bars and then measuring the width. For this effort, channel cross sections were not measured in the field; therefore, width-to-depth ratios are not included in this description. Channel gradient was calculated from elevations at the top and bottom of each reach based on the digital elevation models generated from the 2013 LiDAR data. To varying degrees within each response reach, width-to-depth ratios are higher than what would be expected. The increased in the channel width-to-depth is a result of the river responding to anthropogenic impacts that includes the alteration or removal of riparian vegetation along the banks associated with early logging practices and the clearing of in-channel LWM associated with splash dam logging to transport the harvested timber. In rivers where LWM has been removed, the effects include reduced hydraulic roughness, reorganized and simplified bed topography, and increased bedload transport rates due to an increase in shear stress and increased transport capacity, and the coarsening of bed material (Montgomery et al. 2003). In reaches where LWM plays a significant role in creating/maintaining the bed morphology, removal of LWM can allow the morphology to evolve to plane bed or even scour to bedrock, if present. If the cohesion of the bank material has been reduced due to loss of riparian vegetation root mass, channel widening could potentially occur as a result of the smaller material contained in the banks being mobilized before the more coarse material of the bed. Table 8 summarizes the average channel within the response reaches.

Table 8. The average unvegetated channel width within each of the response reaches on the Upper Grande Ronde River.

Reach	Average channel width (feet)
Starkey	68
Birdtrack/Longley	98
Hampton	119
Hilgard	96

Within the Starkey reach, active channel widths ranged between 50 and 95 feet. In the Birdtrack/Longley reach, the active channel widths ranged between 77 and 134 feet. The Hampton reach had the widest active channel with widths ranging between 105 and 135 feet. In the Hilgard reach the active channel widths typically ranged between 64 and 94 feet.

Channel Planform

Based on GIS analysis of dividing the channel center length by valley length measured on the 2012 aerial photographs, the average sinuosity within all three of the response reaches is less than 1.5 which classifies all three reaches as straight (Beechie et al. 2006). Table 9 summarizes the overall average sinuosity of the response reaches on the Upper Grande Ronde River.

Table 9. The overall average sinuosity of each of the response reaches on the Upper Grande Ronde River.

Reach	Sinuosity
Starkey	1.09
Birdtrack/Longley	1.21
Hampton	1.05
Hilgard	1.02

Historic Channel Migration Zone

The historic channel migration zone (HCMZ) was delineated from a 75-year span of aerial photos series from 1937, 1946/47, 1956/57, 1964, and 2012 that were collected, scanned and ortho-rectified as part of this assessment effort. The HCMZ is the combination of all areas the channel occupied in those aerial photos. The channel area was delineated as described in the channel dimension section above. This limited interpretation of the HCMZ is accurate depending on timescale but difficult to substantiate over a defined period of time and therefore introduces the potential for a wide range of interpretation and potential misuse. Rather than speculating on the timing of the activation of each channel, this report has identified the historic channel migration zone as only that area having been occupied by the active channel (mainstem and side channels) within the record of historic aerial photos previously noted. It should be noted that the time period encompasses conditions after most of the anthropogenic disturbances had occurred. The width of the HCMZ is the minimum width of area that one would expect the channel to occupy though lateral migration and/or avulsion. Table 10 shows the average width of the HCMZ within the Starkey, Birdtrack/Longley, and Hampton reaches. The width of the HCMZ for the Hilgard reach was not calculated for this draft.

Table 10. The average width of the HCMZ in the Starkey, Birdtrack/Longley, and Hampton reaches.

Reach of interest	Average HCMZ Width (feet)
Starkey	132
Birdtrack/Longley	225
Hampton	149

Within the Starkey reach the HCMZ varied between 100 and 310 feet. In the Birdtrack/Longley reach the HCMZ varied between 123 and 472 feet. The Hampton reach varied between 116 and 227 feet.

Bed Composition and Form

The bed of the river is described by its average gradient and, on a finer-scale, by its grain-size distribution, armoring, and representative bedforms.

The channel gradient in each of the responses reaches is less than 1 percent. The Starkey reach has the overall average highest gradient. The Birdtrack/Longley, Hampton, and Hilgard reaches have similarly low channel gradients (Table 11).

Bed composition within each of the response reaches is dominated by gravel and cobble with sand. There are also sections of boulder-sized colluvium in all three of the response reaches where the river is located near the valley wall (Table 11).

Table 11. Summary of average channel bed gradient and material.

Reach	Gradient (percent)	Bed material
Starkey	0.7	Gravel and cobble with sand; local section of boulder sized colluvium
Birdtrack/Longley	0.5	Cobble and gravel with sand, small sections of boulder sized colluvium.
Hampton	0.3	Gravel and cobble with sand; small sections of boulder sized colluvium.
Hilgard	0.4	Gravel and cobble with sand; small sections of boulder sized colluvium.

Bedform is defined as any deviation from a flatbed generated by streamflow on the bed of an alluvial channel (Bates and Jackson 1984). As with historical conditions, in all three reaches scour pools exist at some bends and at channel constrictions and obstructions that create local hydraulic roughness and cause local scour. Depositional bars were observed along the insides of most bends; relatively few mid-channel bars formed behind obstructions (LWM) or downstream of low-radius bends with significant bend scour pools (deposition of sediment scoured from the bend).

The existing bedform within the Starkey reach is characterized by long, relatively deep runs separated by shallow riffles. There are local sections of pool riffle bedform scattered throughout the reach. The number of existing pools was not identified as the entire reach was not field inspected for this reconnaissance level assessment. An evaluation of the 2012 aerial photographs identified 11 locations with a small (average of 26 feet) radius of curvature and/or a constriction associated with bar formation, bedrock or LWM. Assuming pool scour is occurring at each of these locations the total number of pools per mile within the reach is probably 2.6 to 4. The actual degree of scour and resulting pool depth at these locations is unknown.

The existing bedform within the Birdtrack/Longley reach is similar to that of the Starkey reach and is characterized by long deep runs separated by shallow riffles. Local sections of pool riffle bedform are present within the reach. Using the same method to determine the number of pools per mile as describe in the previous paragraph, the number of pools ranges between 4 and 6 per mile.

In the Hampton reach the predominant bedform is plane bed, but local sections of pool riffle also exists. Two pools were observed which equates to 1.7 pools per mile.

Within the Hilgard reach the bedform varies. The bedform transitions from pool/run associated with bedrock in the upstream end to plane bed shallow riffle in the mid and lower sections. Three pools were also observed but the depth was not measured. The three pools equates to less than one pool per mile.

Bank Condition

Within the response reaches the banks range from vertical to gently sloped. Bank material includes alluvial gravel with sand and cobble overlain by a layer of floodplain silts and sands that varies in thickness (Figure 9). Within the Starkey and Birdtrack/Longley reaches where the channel is located along the edge of the valley, bedrock outcrops and/or colluvium comprise the left bank. In the Hampton reach, the right bank is a 2 to 3 foot terrace comprised of alluvial material while in the downstream half of the reach the left bank is comprised of coarse fill material used to construct the historic railroad grade along the toe of the hillslope.

Figure 9. Representative bank conditions within the upstream three response reaches on the Upper Grande Ronde River.

Forcing Agents

Forcing agents are accumulations of material including LWM, sediment, and colluvium and geologic/geomorphic forms such as alluvial fans, terraces and bedrock outcroppings. Forcing agents can effectively obstruct the channel and influence local physical conditions and channel form. Where forcing agents exist on both sides of the river, the resulting constriction narrows the effective width of the channel and floodplain forcing high flows through a comparatively narrow opening increasing shear and velocity during high flow.

The natural forcing agents within the Starkey reach include LWM, boulder-sized colluvium, and local sections of bedrock. A few LWM accumulations were noted at the heads of islands and bars. Several more single logs were noted predominantly at the heads of bars. In many instances those logs force lateral flow at seasonal flows that are above base flow but have less than 1.1 to 1.5 year recurrence interval. Sediment accumulations in the form of lateral and point bars can also concentrate flow at low flow which increases local low flow depths. Anthropogenic forcing agents in the Starkey reach include numerous instream structures such as boulder clusters, rock jetties, and small bank engineered logjams (ELJs). In one instance, a series of six small rock jetties originally placed along the toe of the left bank have been flanked by the stream and are now located near the middle of the channel (Figure 10). The angle of the jetties (pointing in the downstream direction) would have deflected the flow into the bank. This likely increased the local rate of bank retreat leading to the current bank position. Other constrictions include two bridges and sections of Highway 5, although Highway 5 may not have a large impact in the channel form and processes due to its proximity along the bedrock valley wall.

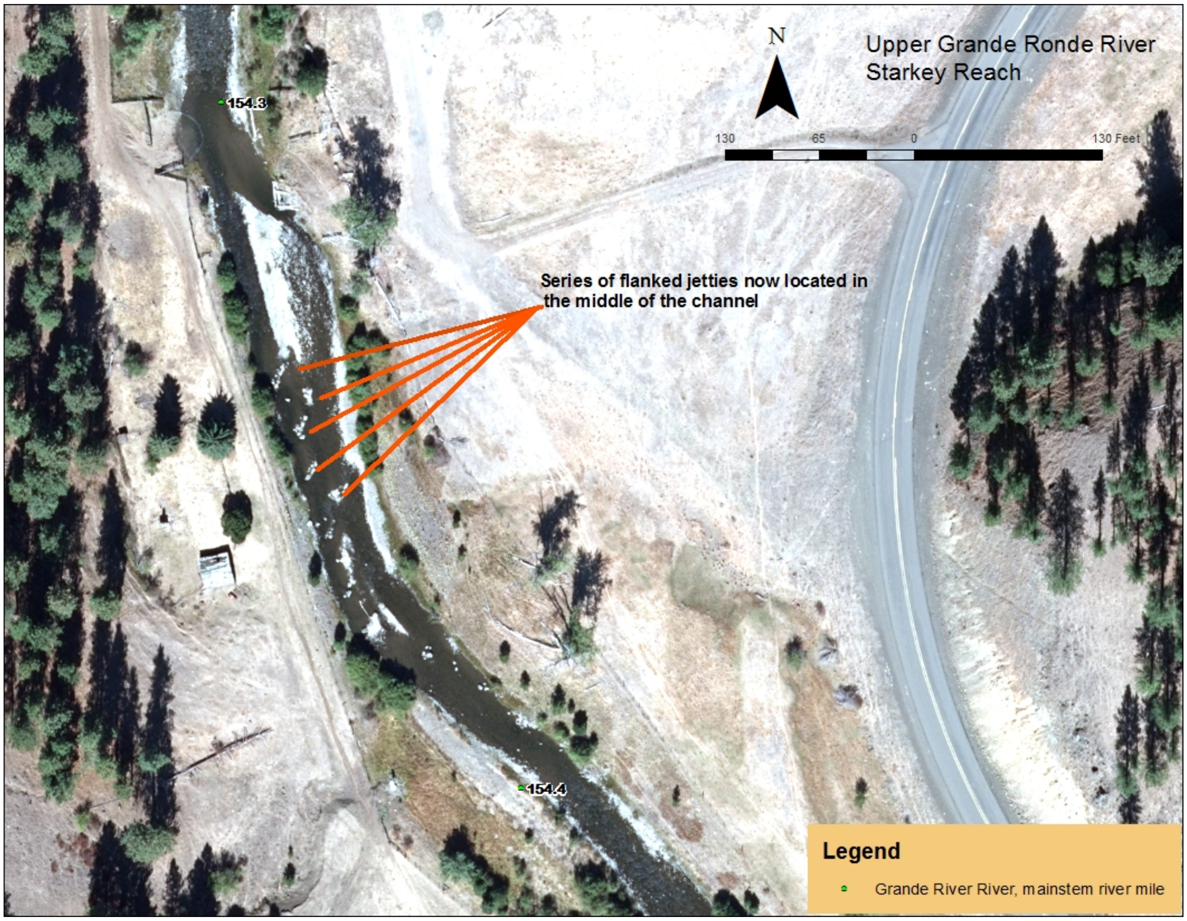

Figure 10. Series of bank jetties and instream boulder clusters within the Starkey reach on the Upper Grande Ronde River that have been flanked by the retreat of the left bank.

Within the Birdtrack/Longley reach very little LWM is present to act as a forcing agent. The river flows against bedrock and or colluvium associated with the left valley wall at several locations within the upstream section of the reach. In the downstream end of the reach from RM 143.8 to RM 143.3 the Bear Creek/Jordan Creek alluvial fan forms a 2 to 3-foot terrace that narrows the active floodplain. As within the Starkey reach, sediment accumulations in the form of lateral and point bars act to concentrate flow at low flow which increases local low flow depths. Anthropogenic forcing agents within the reach include several boulder clusters, vortex weirs, and rock/log barbs (Figure 11).

Figure 11. Instream rock structure in the Birdtrack/Longley reach.

The Hampton reach contains natural constrictions and forcing agents of bedrock and sediment accumulations that form lateral and point bars. As within the Starkey and Birdtrack/Longley reaches the bars act to concentrate flow at low flow which increases local low flow depths. The bars are large in the upstream section of the reach and decrease in size in the downstream direction.

Floodplain and Off-Channel Character

An edge of water delineation was produced in association with collecting LiDAR data in the spring of 2013. The flow at which the LiDAR data was collected had a recurrence interval of approximately 1 year at the gauge near Perry. The discharge and return interval of the flow associated with this edge of water delineation within each of the responses reaches are unknown; however, they presumably would correspond to a similar discharge as measured at the Perry gauge. This edge of water delineation shows the aerial extent of inundation but the depth of inundation unknown.

In the Starkey reach, there are various natural off-channel features visible in the LiDAR imagery. At the flow associated with the edge of water data, there are some intermittent floodplain side channels, but the predominant side channel type is back bar side channels within the active channel width (Figure 12). Most of the activated floodplain side channels were connected at the upstream and downstream ends. Others were connected at the downstream end providing alcove habitat. Additional hydrologic and hydraulic analysis is needed to estimate the area of floodplain that is inundated and/or the length of side channel that is activated at a range flows.

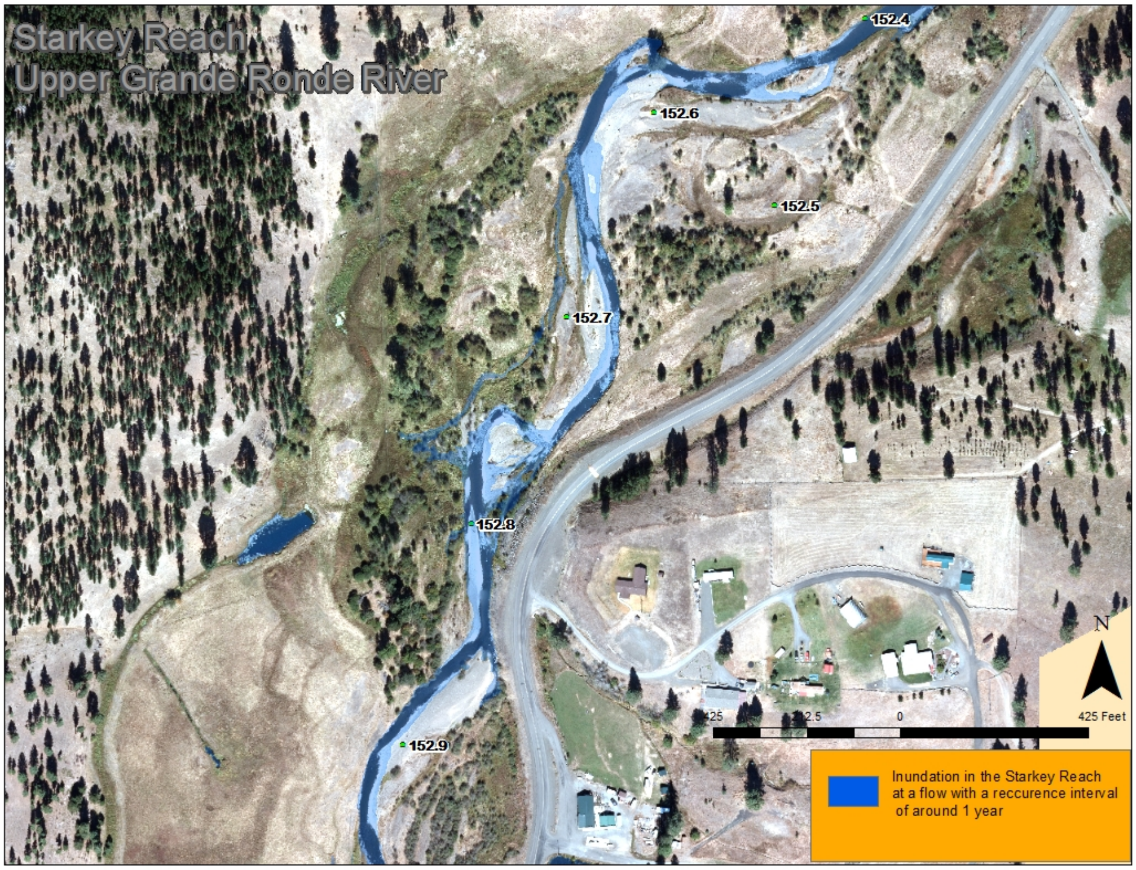

Figure 12. Activation of an intermittent side channel within the Starkey reach during a flow with a return interval of approximately 1 year.

Anthropogenic features in the floodplain of the Starkey reach include several sites where a section of levee or historic railroad grade that acts as a levee are located along the active channel and within the floodplain. The sections of levee that are located in the floodplain away from the current channel are typically associated with one or both banks of 1937 and 1946/1947 channels. The total combined length of levee and/or historic railroad grade is over 7,000 feet. The levees likely have little effect on the local channel migration rates but may prohibit activation of the 1937 and 1946/47 channel scars as current overflow and side channels at higher flow.

In the Birdtrack/Longley reach, approximately 11 acres of off-channel floodplain was inundated at the flow with a recurrence interval of approximately 1 year. The lineal side channel distance of that area is estimated to be roughly 5,000 feet. Similar to the Starkey reach, the activated floodplain side channels within the Birdtrack/Longley reach had upstream and downstream connections (Figure 13). There were also several bar side channels within the active channel, particularly in the upstream end of the reach (Figure 13). Additional hydrologic and hydraulic analysis is needed to estimate the area of floodplain that is inundated and/or the length of side channel that is activated at a range flows.

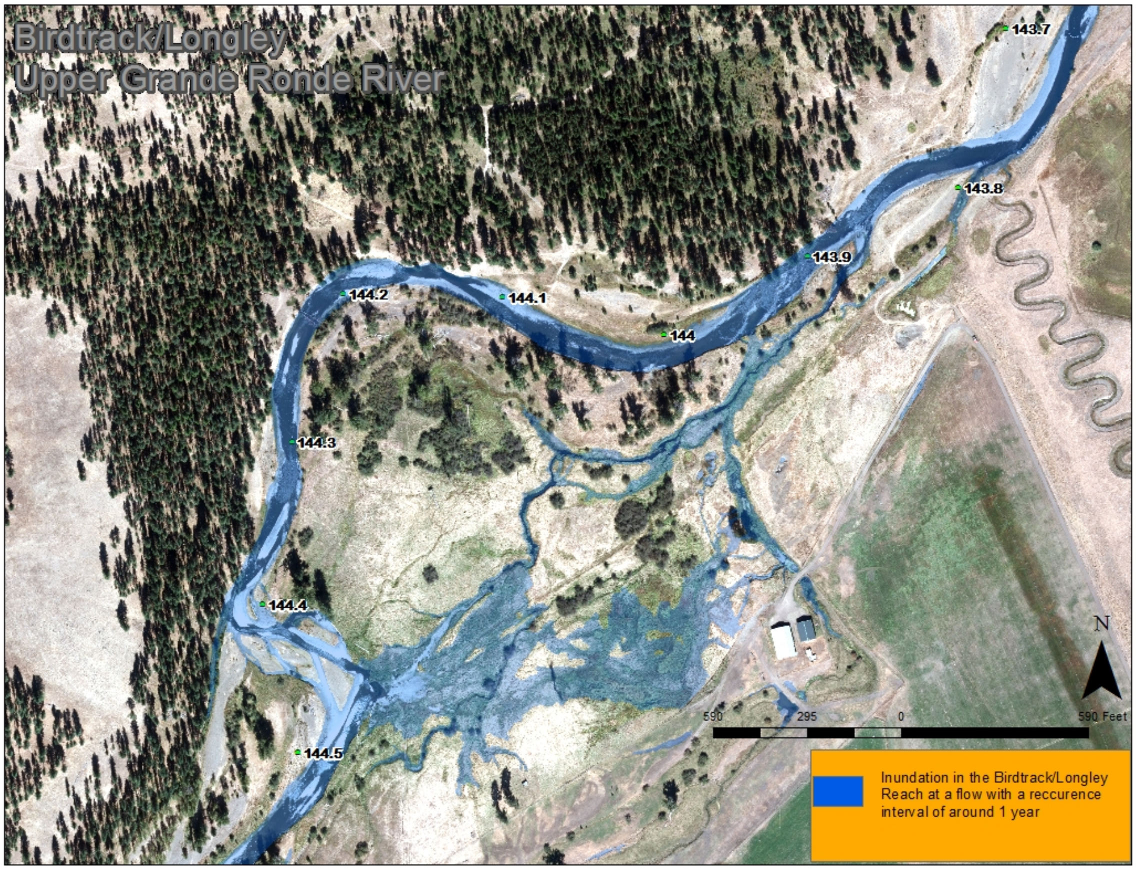

Figure 13. Floodplain inundation associated with flow with a recurrence interval of approximately 1 year within the Birdtrack/Longley reach.

The most prevalent anthropogenic feature within the floodplain in the Birdtrack/Longley reach is over 9,500 feet of non-continuous historic railroad grade. A section of the railroad grade has been removed, allowing inundation of the floodplain noted in Figure 13 (Childs 2013).

In the Hampton reach, the predominant side channel type was split flow channels around vegetated islands. These side channels occur within the active channel width at RM 141.5 and RM 141.15. Some back of bar type side channels were observed during a flow with the approximate 1-year recurrence interval near the top of the reach (Figure 14).

Figure 14. Activation of intermittent side channels in the Hampton reach at RM 141.5 and 141.15 during a flow with a recurrence interval of approximately 1 year.

Anthropogenic features located within the reach include the historic railroad that is present along the left bank. The total length of the historic railroad grade is over 4,000 feet. In the upstream section of the reach roughly 1,300 feet of the railroad grade disconnects floodplain and an existing wetland complex. In the downstream end of the reach the historic railroad grade likely has little effect due to its proximity along the toe of the valley wall.

Within the Hilgard reach, both back bar and split flows occur during a flow with approximately 1 year recurrence interval from RM 138.3 downstream to RM 138.1 in the vicinity of the confluence with Rock Creek.

Riparian Conditions

For this report, the existing riparian vegetation condition within the response reaches was evaluated by analyzing NLCD imagery with GIS software to classify the vegetation type within 30-meters of the digitized edge of the 2012 channel.

Within the Starkey reach, riparian vegetation consists of grasses and shrubs with willow, alder, and Cottonwood trees along the channel, and coniferous trees on the hillside and terraces. Vegetation densities range from locally dense to completely removed with approximately 50 to 60 percent of the riparian vegetation within a 30-meter wide zone in the floodplain being impacted in the Starkey, Birdtrack/Longley, and Hampton reaches. Although no active logging or riparian vegetation clearing is known to be occurring now, recovery of the riparian vegetation is slow due to grazing of domestic livestock and wild animals and current land use practices of the riparian corridor on private land.

In the Starkey reach, approximately 57 percent of the vegetation within the 30-meter belt width has been altered. Table 12 provides the summary of classification and percent area of the 30-meter belt width in the Starkey reach.

Table 12. A summary of the vegetation within the 30-meter belt width in the Starkey reach.

Vegetation Type	Acres	Percent
Developed (residential/cleared)	7.6	7.5
Barren	1.7	1.7
Evergreen Forest	10.3	10.2
Mixed Forest	26.8	26.4
Shrub/Scrub	7.2	7.5
Grassland/Herbaceous	41.8	41.2
Pasture/Hay	6.0	5.9
Total	101.5	100

In the Birdtrack/Longley reach, vegetation within the 30-meter belt width is varied. The right bank in the upstream section is the Birdtrack Park area. The vegetation consists of low density medium-aged coniferous trees and old cottonwoods. The understory is predominantly grassland with patches of willows and other shrubs. Downstream of the park the vegetation along the right bank is predominantly grassland and used for pasture. There are a few thin patches of cottonwood trees or other hardwood with grass and willow and/or herbaceous understory. The majority of the 30-meter belt width along the left bank is hillside. The vegetation is predominantly grassland with scattered medium-aged coniferous trees. Occasionally a small patch of willow or other shrub exists along the toe of the slope. Approximately 58 percent of the vegetation within the 30-meter belt width has been altered in the Birdtrack/Longley reach. Table 13 provides the summary of classification and percent area of the 30-meter belt width in the Birdtrack/Longley reach.

Table 13. A summary of the vegetation within the 30-meter belt width of the Birdtrack/Longley reach.

Vegetation type	Acres	Percent
Developed (residential/cleared)	0.6	0.9
Barren	0.5	0.6
Evergreen Forest	16.5	23.3
Mixed Forest	3.3	4.7
Shrub/Scrub	9.7	13.6
Grassland/Herbaceous	40.5	57.0
Total	71.1	100

In the Hampton reach, the dominant vegetation type within the 30-meter belt width is grassland and nearly all of the right floodplain is in active agricultural use. In the upstream end of the reach the left bank contains patches of medium aged cotton wood with some willows and shrubs. In the mid-section of the reach the left bank is comprised of hillslope that is predominantly grass covered with a few coniferous trees. In the downstream end of the reach is a section of medium aged cottonwoods with an understory of willow grass and herbaceous plants along the left bank. Approximately 62 percent of the vegetation within the 30-meter belt width has been altered in the Hampton reach. Table 14 provides the summary of classification and percent area of the 30-meter belt width in the Hampton reach.

Table 14. A summary of the vegetation within the 30-meter belt width in the Hampton reach.

Vegetation type	Acres	Percent
Developed, Open Space	0.6	2.7
Barren	0.1	0.5
Evergreen Forest	2.1	9.5
Mixed Forest	3.9	17.5
Shrub/Scrub	2.4	10.6
Grassland/Herbaceous	8.6	38.1
Pasture/Hay	4.8	21.2
Total	22.5	100

A summary of the vegetation within the 30-meter belt width of the Hilgard was not performed for this draft.

Existing Physical Processes

The physical forms present in the focus reaches of the Upper Grande Ronde River are created and maintained by physical processes which can include hydrology, sediment transport, channel migration, LWM recruitment and retention, riparian disturbance, and succession.

Hydrology

As with historic conditions, existing hydrologic inputs in the Grande Ronde River subbasin are dominated by surface runoff, and peak runoff is dominated by snowmelt, with the largest floods being associated with spring runoff and rain-on-snow events. The topography of the Upper Grande Ronde River basin above the assessment area is steep and likely yields relatively short lag times between precipitation and runoff. In some locations, but particularly in the Starkey reach, the construction of roads has altered the surface runoff pattern. The roads act as a dam trapping surface runoff water that subsequently forms an artificial wetland in low lying areas.

Effective or ‘channel forming’ flow is defined as that discharge that transports the largest cumulative volume of sediment over the long term. In other words, while a single large flood may move a very large volume of sediment, many smaller floods may cumulatively move substantially more sediment by inducing local bank erosion, bed scour, and subsequent deposition and generally result in the reworking of bed material. While the effective discharge has not been measured for the Upper Grande Ronde River, previous work by Castro and Jackson (2001) indicates that the bankfull discharge is likely around the 1.4 to 1.5 year flood.

Sediment Transport

All four of the response reaches in the Upper Grande Ronde River vary in transport competency and capacity. Similar to historic conditions, within all 4 response reaches the sediment transport competency is such that high flow mobilizes sediment comprised of cobble, gravel, and fines. Energy and flow volume are currently dissipated on the floodplain during large floods. Maximum instream competency maintained within the stream is in the cobble size range. The sediment is generally reworked within the reach rather than being transported for any significant distance.

Capacity is currently controlled largely by hydrology and gradient with the added component of sediment supply. Reach-scale sources include local scour (bend scour and contraction scour) and local bank erosion while finer sediment is supplied from hillslope erosion (sheetwash) at the watershed scale. Current levels of sediment transport capacity are likely greater than historic levels due to changes in the local channel geometry that includes incision and widening due to reasons previously described in the channel dimension discussion in the existing form section.

Anchor Ice

During low flows in the winter months, anchor ice can form on the Upper Grande Ronde River which has the potential to disturb the bed and banks of the river and alter the sediment transport competency and capacity. Anchor ice forms when the air temperature is well below freezing and the water temperatures quickly drop to the freezing point. Turbulent heat exchange prevents ice formation at the water surface, but the relatively calm water occupying the interstitial space between grains of cobbles and boulders on the river bed enables tiny platelets of ice called frazil ice to coagulate and attach, creating a progressively larger ice surface which grows into blocks of anchor ice (Hammar and Shen 1995). Anchor ice can become large enough that the combination of shear and buoyancy can dislodge the ice from the bed, often disturbing the bed in the process. Anchor ice is less frequently formed in deeper, less turbulent, and/or warmer water. Current conditions of predominantly plane bed with shallow riffles, particularly in the confined reaches as well as local sections of each of the response reaches promote the formation of anchor ice. In addition to anchor ice, surface ice also forms on the Upper Grande Ronde River in areas of low water velocity, particularly along the banks. Surface ice accumulation can be significant to the point of creating ice dams. Ice dams can create local overbank conditions that “raft” ice up onto the tops of the river banks, creating disturbance to the banks and floodplain. When the ice dams break, mobilized ice flow can disturb the bed and cause damage to the banks, riparian vegetation, and infrastructure such as bridges.

Channel Migration

Meander bend channel migration occurs through erosion of the outside bank of a bend coupled with concurrent deposition of sediment along the inside bank of the same bend. This process results in the lateral movement of the channel, while maintaining relatively consistent channel shape and width. The area of the most pronounced migration usually occurs where the flow converges against the outer bank near the downstream end of a bend, resulting in simultaneous lateral and downstream migration of the bend. Erosion resistant material such as bedrock or colluvium can reduce or stop lateral migration or transfer migration upstream or downstream. In these instances, down valley meander bend migrations rates may also increase.

Local migration rates in the focus reaches of the Upper Grande Ronde River were calculated in ArcGIS by digitizing the wetted channel width from the time series of aerial photographs. At locations where migration was occurring, the distance between bank locations was measured and divided by the number of years between photos to determine the average distance per year. Within the focus reaches, the lateral and down valley migration rate is relatively high at a few specific locations but is consistently low at the reach scale. The low migration rates are due primarily to the relatively straight channel planform, lack of hydraulic roughness and erosion resistant materials including bedrock and coarse alluvium.

In the Starkey reach, average channel migration rates are low (less than 1 foot per year), but there are two local instances of down valley meander bend migration, one located at RM 152.9 and the other at RN 152.6 (Figure 15). The average downstream migration rate at these two locations is approximately 6 feet per year. In the same area lateral migration rates are greater than the rest of the reach as well, likely due to locally greater rates of sediment accumulation (Figure 15). There are also at least two instances where locally increased channel migration rates based on channel location are likely the result of the relocation of a short section of channel to accommodate for road construction.

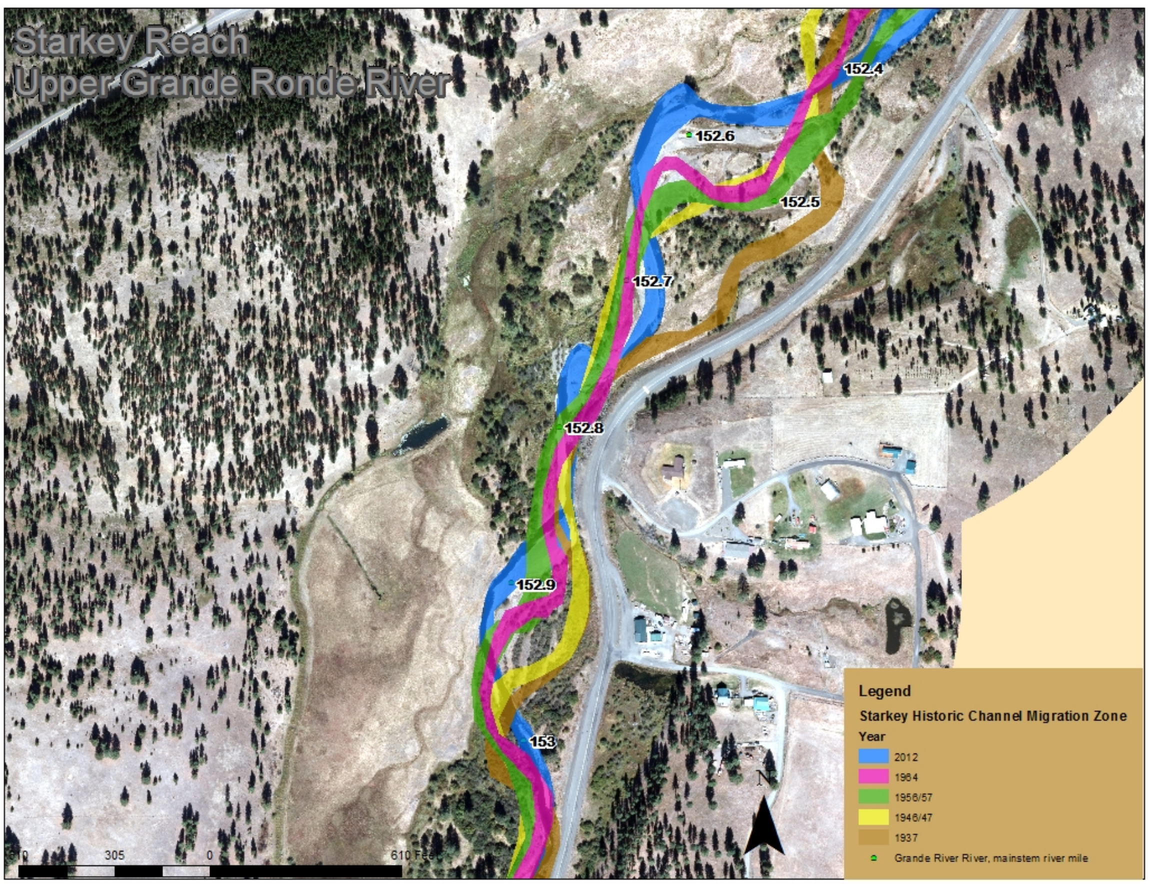

Figure 15. Channel delineations by year showing downstream meander migration at RM 152.9 and local increased rates of lateral migration due to increased sediment accumulation at RM 152.6-152.5.

The Birdtrack/Longley reach also exhibits examples of lateral and down valley migration. Maximum down valley rates were as high as 20 feet per year, and appear to be the result of a combination of non-erodible bedrock along the left bank and a lack of vegetation along the right bank. There was one local instance of lateral migration occurring for a distance of over 400 feet in the time span of 75 years which equates to nearly 6 feet per year (Figure 16). Average rates of channel migration at locations where lateral migration is occurring range between 1.5 to 2 feet per year. Similar to the Starkey reach, the predominant migration rate is about a foot per year and takes place in a relatively narrow HCMZ width.

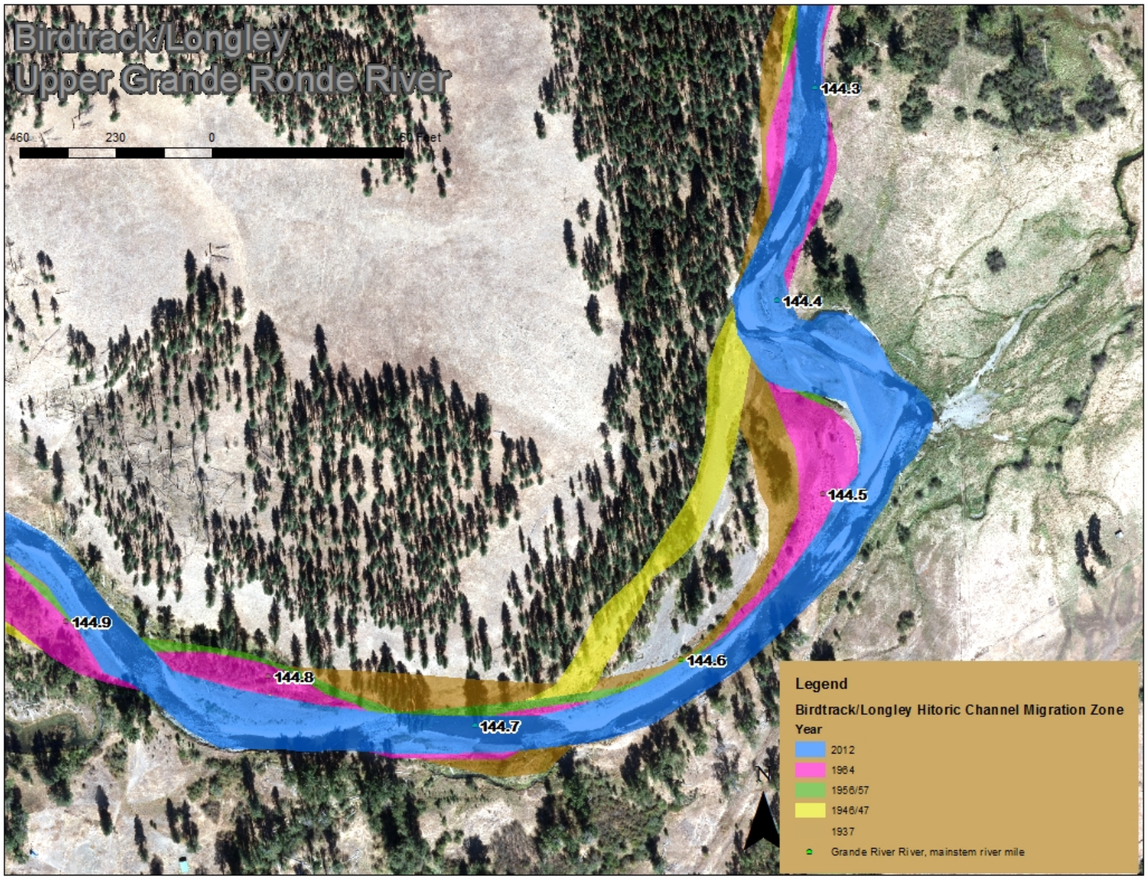

Figure 16. Local lateral migration in the Birdtrack/Longley reach.

The Hampton and Hilgard reaches exhibited the lowest rates of channel migration with reach-scale averages less than 1 foot per year and local maximum rates of about a foot per year.

Riparian Disturbance and Succession

Riparian vegetation influences other processes largely based on the type, density, and age of vegetation within the riparian corridor. Succession is dependent on disturbance which is common in all of the response reaches. Frequent natural disturbance may include local floodplain scour, deposition, fires, and local instances of channel migration and avulsion.

These disturbances can result in a diverse species mix and age. In the response reaches, these natural disturbances occur to some degree but the dominant disturbance is the alteration and/or complete removal of riparian vegetation by past logging and agricultural practices. The cleared riparian conditions are maintained through current land use practices that include agricultural use and grazing.

LWM Recruitment and Retention

Many streams in the northwest evolved with significant inputs of large wood, which has the ability to force channel response by altering instream hydraulics, sediment routing and storage, channel dynamics and processes and channel morphology across scales ranging from site to watershed (Montgomery et al. 2003). A common trend in the northwest is the reduced availability of large wood in the river over the past century. In addition to the clearing of large wood from within the active stream channel, timber harvests and riparian clearing for development have removed upland and riparian trees. This has reduced the number of available large-diameter trees that may form key members for instream LWM accumulations, and significantly reduced or eliminated the source for large wood.

Under current conditions, LWM recruitment in the response reaches depends on delivery from the same sources and mechanisms as described in the historic process section. It is the amount of LWM available to incorporate into the system that has been reduced by approximately 50 to 60 percent in the response reaches due to the logging of the valley floor and upland areas. This in turn reduces the potential for logjam formation and overall average number of logs per jam is reduced.

Within the Starkey reach, LWM retention was observed to be most commonly associated with lateral bars and split flow. In most cases, the logs were single, but three small accumulations of 2 to 3 logs associated with lateral bars were observed in the 2012 aerial photographs within the reach.

In the Birdtrack/Longley reach, fewer pieces of LWM were observed than in the Starkey reach. Those pieces that were distinguishable in the 2012 aerial photographs are associated with point bars.

No pieces of LWM were noted in the 2012 aerial photographs within the Hampton or Hilgard reaches.

Changes from Historical Conditions

Within all the response reaches existing processes and physical conditions differ from estimated historical processes and physical conditions. The most significant differences are channel geometry (width and depth), channel morphology (bedform) and instream LWM, and riparian conditions. Change to channel geometry and morphology has resulted from the loss of instream structure and cover primarily associated with instream clearing and splash dam logging, and local anthropogenic confinement. Availability, recruitment, and retention of LWM have also been greatly reduced through the clearing of riparian vegetation and the maintenance of the cleared riparian area.

Trends

The processes and conditions described in this report appear to be trending toward improvement at various rates in each unconfined reach. In general, the time scale that it would take to note significant improvements associated with rehabilitative efforts varies between the various conditions and processes. For example, the riparian conditions would likely require many decades before significant improvements will be noticed following planting actions due to the time required for the plantings to grow to sufficient size and density. Actions taken to increase hydraulic roughness and narrow the effective channel width will result in noticeable change in channel geometry, planform, and morphology within a much shorter time scale.

Anticipated changes to future physical habitat if no action is taken to deviate from existing trends include: 1) minor increased area of riparian vegetation and overall age, 2) persistence of high channel width-to-depth ratio, 3) limited off-channel habitat formation, 4) limited LWM recruitment and logjam formation, and 5) effects from global climate change including more precipitation in the form of rainfall rather than snow accumulation, and overall warmer drier summers.

Riparian Vegetation

Riparian vegetation will continue to age where it is not kept cleared. Logging within the riparian area no longer occurs and historic clearing and splashing of timber is not anticipated to return. However, private land is still managed and maintained for agricultural uses including livestock grazing and grass/hay production. It is unlikely that existing areas where the riparian vegetation has been altered or removed will be planted with native vegetation without a change in land use and management, and support of local habitat improvement agencies and groups. All planting efforts should consider temporary fencing and/or easements to ensure establishment of mature vegetation.

Channel Width-to-Depth Ratios/Migration

Low gradient depositional areas would be expected to increase the instream variability and bedform complexity, which would lead to increased floodplain connectivity and decreased width-to-depth ratios over time. Simplified hydraulics in the existing channel will continue to promote the persistence of high width-to-depth ratios. By estimating historic rates and locations of channel migration, mapping bank conditions and surface geology, considering the average channel width and measuring meander traits including overall sinuosity, wavelength and amplitude, future channel migration characteristics can be anticipated. In general, migration rates are expected to continue to be relatively low with local sections of both lateral and downstream migration similar to current conditions.

Side Channel Formation

At flows with a recurrence interval of approximately 1 year, all of the response reaches contain significant back bar channel habitat within the active channel width. Floodplain side channels and split flow channels are also present within each of the response reaches. Although the rate of creation is not known, future formation of all three types of side channels is anticipated to continue to occur. Historic as well as recent channel migration in the Starkey and Birdtrack/Longley reaches resulted from the accumulation of sediment and or LWM combined with local sections of bank that are susceptible to erosion due to alteration or removal of riparian vegetation. Back bar, floodplain, and split flow side channels that were created from these areas of higher rates of channel migration are now activated at higher flows for differing lengths of time.

LWM Recruitment

The future recruitment of LWM depends on the availability of large wood and its ability to be retained within the reach. Improved riparian conditions with older and larger trees will increase the size of recruited woody material in the future (several decades from now), and with increased size comes improved retention as large trees are less easily transported by the river. Additionally, increased hydraulic diversity and side channel formation, if it occurs, creates enhanced LWM capture and retention. It is anticipated that LWM recruitment will continue along the existing trend of slowly increasing the total number of individual logs for several decades at which time sufficiently large size and volume of available logs will begin to more consistently form persistent logjams in addition to individual log structures.

Global Climate Change

Global climate models forecast that the climate of the Pacific Northwest will warm significantly during the 21st century, and related research shows that this warming will significantly alter streamflow patterns and water quality (Graves 2012). Current predictions include changes that result in reduced snow water equivalent, earlier peak flows, higher colder month flows, and lower warm month flows (Rheiheimer 2007). Potentially lower summer flows and increased summer water temperatures present the most significant negative impacts to the target fish species. With less potential water in the river, less snowmelt in the summer, and warmer summer temperatures, the potential for higher temperatures in a river that currently experiences seasonally high water temperatures is increased. The limiting factor of high summer water temperatures is likely to be intensified in the future.

Target Conditions

Target conditions represent the most appropriate physical characteristics that should guide future habitat improvement projects for a given reach. The difference between target conditions and historical conditions is that target conditions take into consideration existing conditions, constraints, and future trends. Critical to the development of target conditions is an understanding of the linkage between the physical characteristics of the channel and the biological needs of the species of concern. By better understanding this relationship, targeted conditions can be identified which will provide fish with the physical habitat necessary to overcome identified biological limiting factors.

Table 15 outlines the physical conditions generally preferred by steelhead and spring Chinook salmon during several different life stages as compiled by the U.S. Forest Service in Entiat, Washington. Although it is helpful to understand the physical conditions preferred by the species of concern, not all of these conditions may be appropriate for the Upper Grande Ronde River.

Table 15. Preferred general physical conditions preferred by spring/summer Chinook and steelhead (Reclamation 2011).

Preferred Habitat	Steelhead	Spring Chinook Salmon
Spawning Habitat		
Depth	1.8 feet (0.54 meters); 0.78 feet (<24 cm)	Minimum water depth limit= 1 foot (30 cm)
Velocity	2.3 feet/second (0.71 meters/second) 1.31 to 2.98 feet/second (40 to 91 cm/sec)	Optimal range=0.30 to 0.9 meters/second
Gravel size	1.28 inches (32.5 mm) 0.24 to 4.0 inches (0.6 to 10.2 cm)	Optimal substrate mixture=6 percent fines, 59 percent to 86 percent gravel (~15 cm in diameter), and 8 percent to 35 percent cobble >15cm Optimum spawning gravel size:21 percent for 0.3 to 1.25 cm; 41 percent for 1.25 to 6 cm; 24 percent for 6 to 10 cm; and 14 percent for 6 to 15 cm Mean spawning gravel size of 4.2 cm

Preferred Habitat	Steelhead	Spring Chinook Salmon
Water temperature	39.2°F; 4.0°C	Ranges between 4.4 to 18.0°C; >12.8°C increases mortality to spawning females
Other	Prefer protective cover	Prefer spawning in tailouts/glides
Egg incubation to emergence habitat		
Fine sediment (particles less than 1 mm)	< 20 percent fine sediment results in increased embryonic survival	< 20 percent fine sediment results in increased embryonic survival
Water temperature	5.0°C to 11.0°C	41-52°F; 5-11°C [d]= Highest rate for successful fertilization to emergence
Dissolved oxygen	≥50 percent survival of embryos achieved at 5 mg/L to 9 mg/L	≥8 mg/l at temperatures ≥7°C but ≤10°C and ≥12 mg/l at temperatures >10°C
Juvenile rearing habitat		
Groundwater	Groundwater provides cooler temperatures during the summer and warmer temperatures during the winter resulting in increased juvenile survival.	
Velocity	Less than 1.0 feet/second for holding; proximity of low-velocity water for holding to relatively high velocity water for feeding[r] Refugia from extreme high flows and extreme high velocity	
Large woody material	LWM increases the complexity of stream habitats by creating areas with different depths, velocities, substrate types, and amounts of cover. >20 pieces/ mile >12-inch diameter >35 feet length; and adequate sources of woody material recruitment in riparian areas	
Pools	As pool density (m^2/km) increases, smolt production increases (i.e., 2,000 (m^2/km) pool area resulted in ≈1,000 smolts/km and 3,000 pool area (m^2/km) resulted in between 2,000 and 3,000 smolts/km). Where streams are >3 m in wetted width at base flow, pools >1 m deep (holding pools) with good cover and cool water and a minor reduction of pool volume by fine sediment Pool to riffle ratio 1:1	
Temperature	10.0°C to 14°C	

Preferred Habitat	Steelhead		Spring Chinook Salmon	
Substrate Character and Embeddedness	Substrate is gravel or cobble with clears interstitial spaces reach embeddedness <20 percent			
Overhead Cover	Juveniles exhibit preference for habitats with overhead cover			
Adult holding habitat				
Pool Quality	Depth 1.0 to 1.4 meters; Deep habitats of intermediate size (200-1,200 m^2); Adults use pools with cover associated with flow (avg=9.3 cm/second). Cover associated with flows < 3 cm/s are avoided [h]; Low streambed substrate embeddedness (<35 percent).		Where streams are more than 3 m in wetted width at base flow, pools more than 1 m deep (holding pools) with good cover and cool water, minor reduction of pool volume by fine sediment	
Pool Frequency	channel width	# pools/mile	channel width	# pools/mile
	5 feet	184	5 feet	184
	10 feet	96	10 feet	96
	15 feet	70	15 feet	70
	20 feet	56	20 feet	56
	25 feet	47	25 feet	47
	50 feet	26	50 feet	26
	75 feet	23	75 feet	23
	100 feet	18	100 feet	18
Large Woody Debris	>20 pieces/ mile >12-inch diameter >35 foot length and adequate sources of woody debris recruitment in riparian areas		More than 20 pieces/mile More than 12-inch diameter, more than 35 feet long and adequate sources of woody debris recruitment in riparian areas	
Temperature	10.0°C to 14°C		10.0°C to 14°C	
Channel Condition and Dynamics				
Average Wetted Width/Maximum Depth Ratio in scour pools in a reach	≤10			
Streambank Condition	>80 percent of any stream reach has ≥90 percent stability,			

Target conditions in the three response reaches on the Upper Grande Ronde River are similar to existing conditions with the exception of targets including increase bed and channel form variability, instream structural complexity, riparian vegetation, and LWM recruitment. Essential for successful development of these target conditions is improved riparian conditions, increased hydraulic roughness, and actions to decrease width-to-depth ratio.

Bed and Banks

Target conditions for the bed and banks differ from the existing conditions in the response reaches. The target conditions include increased riparian vegetation to support overall bank stability, particularly in those locations where human structures have been installed and increased hydraulic roughness along banks that are currently susceptible to erosion due to loss of root mass.

Fine sediment (including sand-sized sediment and smaller) is currently considered a limiting factor. Although not observed to be a large problem, target conditions should be flexible to account for natural variations in fine sediment loading associated with periods of increased disturbance such as fire or local channel avulsion.

Channel Planform and Morphology (Bedform)

Target sinuosity is similar to past and existing conditions. Valley confinement, channel width, bed and bank material, and riparian vegetation condition will continue to drive overall channel migration rates. It is anticipated that future channel migration/avulsions will continue to occur at locations such as RM 152.5 to RM 152.6 in the Starkey reach and at RM 144.5 in the Birdtrack/Longley reach. At other locations within the Starkey and Birdtrack/Longley reaches where channel migration is occurring, it is expected that it will continue at roughly the same rates. However, overall channel migration rates are expected to remain low based on the typical migration rates associated with an overall straight planform (sinuosity of less than 1.5) in all four of the response reaches.

Target channel morphology (bedform) varies between each of the response reaches, but would be described in general terms as a shift to predominantly pool-riffle with sections of run with varied depth. In addition to increasing the number of large pools and subsequent riffles, efforts to narrow the effective width of the channel will help achieve target conditions by increasing the depth at pool locations due to reduced wetted widths.

Instream Structure and LWM

Target conditions for instream structure include increased hydraulic and bedform variability. This may be accomplished through placement of LWM structures. Increased LWM would increase the potential for the formation of large pools and subsequent deposition that would result in a predominantly forced pool-riffle channel type and bedform. Currently, the Starkey and Birdtrack/Longley reaches are dominated by long deep runs separated by shallow riffles. Sections of pool-riffle bedform exist in both reaches. In the Hampton reach, the dominant bedform is plane bed. The addition of LWM to the Hampton reach could force local pools and riffles. The increase of LWM in the Starkey and Birdtrack/Longley reaches could alter the existing long runs into a series of more complex and slightly smaller (but still considered “large”) pools, including pools in locations other than the outside of bends. Individual pieces would not necessarily create a forced morphology, but could provide local water velocity breaks and instream cover.

LWM and other instream structures will be most effective where they can interact with existing structure and features, including bedrock, side channels, and alcoves in order to amplify their cumulative effect. Logjams and other bank structures could be used to effectively narrow the width-to-depth ratio. Additionally, more instream structure will create habitat diversity, instream velocity breaks, and cover, all of which will address limiting factors. The LWM component of the instream structures should be maintained by the natural succession of riparian vegetation in a broad riparian corridor.

Target conditions for instream structure and LWM are similar to those estimated for historic conditions. The Starkey reach would have contained between 5 and 7 logjams per mile with an average of up to an additional 20 pieces of large wood per mile. The Birdtrack/Longley reach would have had between 4 and 6 of logjams per mile with up to 10 to 15 additional pieces if large wood per mile. The Hampton reach should have between 3 and 5 logjams per mile with an additional 15 to 18 pieces of large wood per mile.

Floodplain Connection

Floodplain connection has changed to varying degrees within each of the response reaches from historic conditions. Consistent over-widening and local incision of the steam allow for greater volumes of discharge to be contained within the banks. Target conditions include greater floodplain interaction at a wider range of flows. A potential target would be to address existing human obstructions such as levees that alter the location and timing of floodplain connection. In addition, there is potential to improve floodplain connection by increasing the frequency and duration of activation of historic side channels, particularly in the Starkey reach.

Off-Channel Habitat

Targets for conditions for off-channel habitat include a greater number of activated floodplain side channels particularly in the Birdtrack/Longley reach and the locally unconfined section of the Starkey reach. Hydrologic and hydraulic analysis is needed to estimate the boundaries of the active floodplain to see how and where floodplain side channels could be developed or reconnected.

Riparian Conditions

Target riparian conditions are a mosaic of species and ages in a broader area. The target riparian corridor width should roughly equal that of the floodplain, but taking other land use constraints into account, an appropriate target would be at least 30-meters (100 feet) from each bank or to the valley wall, whichever is less. The 30-meter width is based on tree height and the potential for LWM recruitment and shade. Beyond 100 feet from the bank, shade and LWM recruitment potential are relatively low. Without planting efforts and land use management changes, creation of these conditions through natural succession will likely take hundreds of years. Maintaining well-vegetated riparian areas where they exist and improving future riparian areas will promote LWM recruitment and retention, and provide shade and cover along the banks of the channel, alcoves, and side channels

A summary of constraints that are associated with stream and riparian rehabilitation efforts is shown in Table 16.

Table 16. Summary of constraints impacting habitat improvement on the Upper Grande Ronde River.

Constraint	Description
Floodplain clearing	Most of the valley bottom and floodplain have been converted from native vegetation to agricultural development and uses that include crop production and grazing. It is unlikely that all of this land can be reclaimed for native vegetation and floodplain connection, but easements could be collaboratively developed especially in areas of high habitat potential.
Climate change	The Upper Grande Ronde River is likely to experience larger peak floods, lower summer flows, and warmer summer water temperatures in the future as a result of climate change. Habitat actions should consider conditions that are likely to occur in the future to target conditions that will buffer endangered species from the changing conditions enabling them more time to adapt and evolve.
Funding, politics, and time	Habitat rehabilitation is a collaborative process that requires cooperation, time, and money. Without sufficient amounts of all three, habitat improvement is constrained.

Table 17 summarizes the differences between past, existing, and target conditions, including natural processes necessary to maintain target conditions and the limiting factors addressed.

Table 17. Summary of historical, existing, and target conditions within the four response reaches on the Upper Grande Ronde River.

Form	Historical Condition	Existing Condition	Target Condition	Process(es) Needed to Achieve Target Condition	Limiting Factor(s) Addressed
River bed and banks					
Starkey	River alluvium (gravel cobbles); hillslope colluvium and debris flow deposits (coarse rock);bedrock; LWM, and logjams	River alluvium (gravel cobble), hillslope colluvium and debris flow deposits (coarse rock), bedrock	River alluvium (gravel cobbles); hillslope colluvium and debris flow deposits, (coarse rock); bedrock; LWM and logjams	LWM placement, recruitment and retention to stabilize banks; mature riparian vegetation	Riparian Condition; Riparian vegetation/ LWM Recruitment; Channel Structure and Form; Bed and Channel Form/ Instream Structural Complexity
Birdtrack/Longley	River alluvium (gravel cobbles); hillslope colluvium and debris flow deposits (coarse rock); bedrock; LWM and logjams	River alluvium (gravel cobble), hillslope colluvium and debris flow deposits (coarse rock); bedrock	River alluvium (gravel cobbles); hillslope colluvium and debris flow deposits (coarse rock); bedrock; LWM and logjams	LWM placement, recruitment, and retention to stabilize banks; mature riparian vegetation	Riparian Condition; Riparian vegetation/ LWM Recruitment; Channel Structure and Form; Bed and Channel Form/ Instream Structural Complexity
Hampton	River alluvium (gravel cobbles); hillslope colluvium and debris flow deposits (coarse rock); bedrock; LWM and logjams	River alluvium (gravel cobble), hillslope colluvium and debris flow deposits (coarse rock); bedrock	River alluvium (gravel cobbles); hillslope colluvium and debris flow deposits (coarse rock); bedrock; LWM and logjams	LWM placement, recruitment, and retention to stabilize banks; mature riparian vegetation	Riparian Condition; Riparian vegetation/ LWM Recruitment; Channel Structure and Form; Bed and Channel Form/ Instream Structural Complexity

Form	Historical Condition	Existing Condition	Target Condition	Process(es) Needed to Achieve Target Condition	Limiting Factor(s) Addressed
Hilgard	River alluvium (gravel cobbles); hillslope colluvium and debris flow deposits (coarse rock); bedrock; LWM and logjams	River alluvium (gravel cobble), hillslope colluvium and debris flow deposits (coarse rock); bedrock	River alluvium (gravel cobbles); hillslope colluvium and debris flow deposits, (coarse rock); bedrock; LWM and logjams	LWM placement, recruitment and retention to stabilize banks; mature riparian vegetation	Riparian Condition; Riparian vegetation/ LWM Recruitment; Channel Structure and Form; Bed and Channel Form/ Instream Structural Complexity
Sinuosity					
Starkey	1.1 to 1.2	1.09	1.1 to 1.2	Local redirection of flow via hydraulic roughness elements and subsequent deposition.	Channel Structure and Form: Bed and Channel Form/ Instream Structural Complexity
Birdtrack/Longley	1.1 to 1.3	1.21	1.1 to 1.3	Local redirection of flow via hydraulic roughness elements and subsequent deposition.	Channel Structure and Form: Bed and Channel Form/ Instream Structural Complexity
Hampton	1.1 to 1.2	1.05	1.1 to 1.2	Local redirection of flow via hydraulic roughness elements and subsequent deposition.	Channel Structure and Form: Bed and Channel Form/ Instream Structural Complexity

Form	Historical Condition	Existing Condition	Target Condition	Process(es) Needed to Achieve Target Condition	Limiting Factor(s) Addressed
Hilgard	1.1 to 1.2	1.01	1.1 to 1.2	Local redirection of flow via hydraulic roughness elements and subsequent deposition.	Channel Structure and Form: Bed and Channel Form/ Instream Structural Complexity
Channel Morphology					
Starkey	Pool riffle with sections of long run	Predominantly riffle-run with section of pool riffle	Pool riffle with sections of long run	Local scour and deposition from increased hydraulic roughness	Channel Structure and Form: Bed and Channel Form and Instream Structural Complexity
Birdtrack/Longley	Pool riffle with sections of long run	Predominantly riffle-run with section of pool riffle	Pool riffle with sections of long run	Local scour and deposition from increased hydraulic roughness	Channel Structure and Form: Bed and Channel Form and Instream Structural Complexity
Hampton	Riffle-run with few pools	Plane bed with some pools	Riffle-run with few pools	Local scour and deposition from increased hydraulic roughness	Channel Structure and Form: Bed and Channel Form and Instream Structural Complexity
Hilgard	Riffle-run with few pools	Plane bed with some pools	Riffle-run with few pools	Local scour and deposition from increased hydraulic roughness	Channel Structure and Form: Bed and Channel Form and Instream Structural Complexity

Form	Historical Condition	Existing Condition	Target Condition	Process(es) Needed to Achieve Target Condition	Limiting Factor(s) Addressed
Large Pools (>20m^2 and 1m deep)					
Starkey	11 to 15 per mile	2.6 to 4 per mile	11 to 15 per mile	Increased localized scour from LWM or other forcing agent, decreased effective width	Channel structure and Form: Bed and Channel Form and Instream Structural Complexity
Birdtrack/Longley	11 to 14 per mile	4 to 6 per mile	11 to 14 per mile	Increased localized scour from LWM or other forcing agent, decreased effective width	Channel structure and Form: Bed and Channel Form and Instream Structural Complexity
Hampton	2 to 4 per mile	1 to 2 per mile	2 to 4 per mile	Increased localized scour from LWM or other forcing agent, decreased effective width	Channel structure and Form: Bed and Channel Form and Instream Structural Complexity
Hilgard	4 to 5 per mile	Less than 1 per mile	4 to 5 per mile	Increased localized scour from LWM or other forcing agent, decreased effective width	Channel structure and Form: Bed and Channel Form and Instream Structural Complexity
Floodplain connection					

Form	**Historical Condition**	**Existing Condition**	**Target Condition**	**Process(es) Needed to Achieve Target Condition**	**Limiting Factor(s) Addressed**
Starkey	Frequent flooding	Less frequent flooding	Frequent flooding	Remove/ breach anthropogenic barriers where applicable; initiate local deposition and reduce effective width via hydraulic roughness elements (LWM)	Water Quality: Temperature, Decreased Water Quantity, Sediment Conditions: Increased Sediment Quantity
Birdtrack/Longley	Frequent flooding	Less frequent flooding	Frequent flooding	Remove/ breach anthropogenic barriers where applicable; initiate local deposition and reduce effective width via hydraulic roughness elements (LWM)	Water Quality: Temperature, Decreased Water Quantity, Sediment Conditions: Increased Sediment Quantity
Hampton	Frequent flooding	Less frequent flooding	Frequent flooding	Initiate local deposition and reduce effective width via hydraulic roughness elements (LWM)	Water Quality: Temperature, Decreased Water Quantity, Sediment Conditions: Increased Sediment Quantity
Hilgard	Frequent flooding	Less frequent flooding	Frequent flooding	Remove/ breach anthropogenic barriers where applicable; initiate local deposition and reduce effective width via hydraulic roughness elements (LWM)	Water Quality: Temperature, Decreased Water Quantity, Sediment Conditions: Increased Sediment Quantity

Form	Historical Condition	Existing Condition	Target Condition	Process(es) Needed to Achieve Target Condition	Limiting Factor(s) Addressed
Side Channels					
Starkey	Back channel bars throughout the reach; occasional split flow around vegetated island; side channels through vegetated floodplain in the locally unconfined sections.	Back channel bars throughout the reach; occasional split flow around vegetated island; side channels through vegetated floodplain in the locally unconfined sections.	Increase in number and activation of floodplain side channels based on hydrologic and hydraulic analysis.	LWM recruitment and retention to initiate and maintain side channels and improve alcove connections; Breaching/ removal of levees where appropriate; decreased effective widths	Water Quality: Temperature, Decreased Water Quantity, Sediment Conditions: Increased Sediment Quantity
Birdtrack/Longley	Back channel bars and side channels through vegetated floodplain in the upstream third of the reach; back channel bars concentrated in the downstream third.	Back channel bars and side channels through vegetated floodplain in the upstream third of the reach; back channel bars concentrated in the downstream third.	Increase in floodplain side channels based on hydrologic and hydraulic analysis.	LWM recruitment and retention to initiate and maintain side channels and improve alcove connections; decreased effective widths	Water Quality: Temperature, Decreased Water Quantity, Sediment Conditions: Increased Sediment Quantity
Hampton	Predominantly split flow around vegetated island, some back bar side channels	Predominantly split flow around vegetated island, some back bar side channels	Increase in floodplain side channels based on future hydrologic and hydraulic analysis.	LWM recruitment and retention to initiate and maintain side channels and improve alcove connections; decreased effective widths	Water Quality: Temperature, Decreased Water Quantity, Sediment Conditions: Increased Sediment Quantity

Form	Historical Condition	Existing Condition	Target Condition	Process(es) Needed to Achieve Target Condition	Limiting Factor(s) Addressed
Hilgard	Predominantly back bar with a few split flow around vegetated islands; few floodplain side channels	Predominantly back bar with a few split flow around vegetated islands; few floodplain side channels	Increase in floodplain side channels based on hydrologic and hydraulic analysis.	LWM recruitment and retention to initiate and maintain side channels and improve alcove connections; decreased effective widths	Water Quality: Temperature, Decreased Water Quantity, Sediment Conditions: Increased Sediment Quantity
LWM					
Starkey	5 to 7 logjams per mile; 20 pieces per mile	0.7 logjams per mile; 6 pieces per mile	5 to 7 logjams per mile; 20 pieces per mile	LWM installation, recruitment, and retention	Channel Structure and Form: Bed and Channel Form and Instream Structural complexity
Birdtrack/Longley	5 to 10 logjams per mile; 20 pieces per mile	no logjams; 3 pieces per mile	5 to 10 logjams per mile; 20 pieces per mile	LWM installation, recruitment, and retention	Channel Structure and Form: Bed and Channel Form and Instream Structural complexity
Hampton	5 to 10 logjams per mile; 20 pieces per mile	No logjams; 0 pieces per mile	5 to 10 logjams per mile; 20 pieces per mile	LWM installation, recruitment, and retention	Channel Structure and Form: Bed and Channel Form and Instream Structural complexity
Hilgard	1.5 to 3.0 logjams per mile; 15 to 18 pieces of large wood per mile.	No logjams; 0 pieces per mile	1.5 to 3.0 logjams per mile;15 to 18; pieces of large wood per mile	LWM installation, recruitment, and retention	Channel Structure and Form: Bed and Channel Form and Instream Structural complexity

Form	Historical Condition	Existing Condition	Target Condition	Process(es) Needed to Achieve Target Condition	Limiting Factor(s) Addressed
Riparian condition					
Starkey	Dense, mixed-age trees and shrubs with wetlands spanning the valley bottom	Medium aged trees with an understory of grasses and herbaceous plants	Dense, mixed age trees and shrubs with wetlands; <10 acres disturbed	Land use management, riparian planting and succession	Riparian Condition: Riparian Vegetation and LWM Recruitment; Water Quality: Temperature
Birdtrack/Longley	Dense, mixed-age trees and shrubs with wetlands spanning the valley bottom	Medium aged trees with an understory of grasses and herbaceous plants	Dense, mixed age trees and shrubs with wetlands; <10 acres disturbed	Land use management, riparian planting and succession	Riparian Condition: Riparian Vegetation and LWM Recruitment; Water Quality: Temperature
Hampton	Dense, mixed-age trees and shrubs with wetlands spanning the valley bottom	Medium aged trees with an understory of grasses and herbaceous plants	Dense, mixed age trees and shrubs with wetlands; <10 acres disturbed	Land use management, riparian planting and succession	Riparian Condition: Riparian Vegetation and LWM Recruitment; Water Quality: Temperature
Hilgard	Dense, mixed-age trees and shrubs with wetlands spanning the valley bottom	Medium aged trees with an understory of grasses and herbaceous plants	Dense, mixed age trees and shrubs with wetlands; <10 acres disturbed	Land use management, riparian planting and succession	Riparian Condition: Riparian Vegetation and LWM Recruitment; Water Quality: Temperature

Potential Habitat Actions

Actions may be implemented in order to move the current trend more rapidly in the direction of achieving the targeted conditions and addressing the known limiting factors directly or through the potential channel process or geomorphic context of the reach.

Pertinent target conditions and potential habitat improvement actions have been summarized in Table 18.

Table 18. Summary of habitat improvement actions and their potential benefits to limiting factors for the four response reaches on the Upper Grande Ronde River.

Form	Target Condition	Habitat Improvement Action	Potential benefit to limiting factors (high, med, low)
River bed and banks			
Starkey	Increased roughness in plane bed or smooth-bank sections; increased age and variety of riparian vegetation sections	LWM and rock structure placement; riparian planting within easement	High
Birdtrack/Longley	Increased roughness in plane bed or smooth-bank sections; increased age and variety of riparian vegetation sections	LWM and rock structure placement; riparian planting within easement	High
Hampton	Increased roughness in plane bed or smooth-bank sections; increased age and variety of riparian vegetation sections	LWM and rock structure placement; riparian planting within easement	High
Hilgard	Increased roughness in plane bed or smooth-bank sections; increased age and variety of riparian vegetation sections	LWM and rock structure placement; riparian planting within easement	High
Channel Morphology			
Starkey	Pool riffle with section of long run	Increased hydraulic roughness elements; reduce effective widths	High
Birdtrack/Longley	Pool riffle with section of long run	Increased hydraulic roughness elements; reduce effective widths	High
Hampton	Riffle run with a few deep pools	Increased hydraulic roughness elements; reduce effective widths	High
Hilgard	Riffle run with a few deep pools	Increased hydraulic roughness elements; reduce effective widths	High
Large Pools (>20m^2 and 1m deep)			

Form	Target Condition	Habitat Improvement Action	Potential benefit to limiting factors (high, med, low)
Starkey	11 to 15 per mile	Increased hydraulic roughness elements, reduce effective widths	High
Birdtrack/Longley	11 to 14 per mile	Increased hydraulic roughness elements, reduce effective widths	High
Hampton	2 to 4 per mile	Increased hydraulic roughness elements, reduce effective widths	High
Hilgard	2 to 4 per mile	Increased hydraulic roughness elements, reduce effective widths	High
LWM			
Starkey	5 to 7 logjams per mile; 20 pieces per mile	LWM installation; mature riparian vegetation	High
Birdtrack/Longley	4 to 6 logjams per mile; 10 to 15 pieces per mile	LWM installation; mature riparian vegetation	High
Hampton	3 to 5 logjams per mile; 15 to 18 pieces per mile	LWM installation; mature riparian vegetation	High
Hilgard	2 to 3 logjams per mile; 15 to 18 pieces per mile	LWM installation; mature riparian vegetation	High
Riparian condition			
Starkey	Dense, mixed age trees and shrubs with wetlands; <10 acres disturbed	Riparian vegetation planting; land use management (fencing)	Low (short term) High (long term)
Birdtrack/Longley	Dense, mixed age trees and shrubs with wetlands; <10 acres disturbed	Riparian vegetation planting; land use management (fencing)	Low (short term) High (long term)
Hampton	Dense, mixed age trees and shrubs with wetlands; <10 acres disturbed	Riparian vegetation planting; land use management (fencing)	Low (short term) High (long term)
Hilgard	Dense, mixed age trees and shrubs with wetlands; ,10 acres disturbed	Riparian vegetation planting; land use management (fencing)	Low (short term) High (long term)

Next Steps

This reach assessment is intended to be used as one tool among many to help guide river process rehabilitation and habitat improvement in the four response reaches on the Upper Grande Ronde River. The actions outlined in this report represent appropriate actions for the river, but are not an exhaustive assessment of all possible actions that can be used to achieve habitat benefits.

- Step 1 = Identify physically appropriate actions (this and future site-specific assessments).
- Step 2 = Identify the physically appropriate actions that the greatest biological benefit (atlas process).
- Step 3 = Prioritize the physically appropriate actions based on social acceptability and individual landowner participatio (aponsor support and project development).

The potential habitat actions outlined in this report can be grouped in any number of ways or places to form projects. In some instances only one course of action may be appropriate, whereby project development is relatively simple. In other instances, multiple groupings may be appropriate requiring prioritization based on collaboration amongst project stakeholders. In either case, evaluating the proposed action(s) based on the findings of this assessment, the degree to which the proposed action will address limiting factors, and the goals and objectives of the project stakeholders will ensure the most appropriate suite of actions is developed. Throughout the entire project development, design, and implementation process, this Tributary Assessment can be used as a reference to verify whether or not project components are appropriate for the geomorphic character and trends prevalent in the Upper Grande Ronde River. Completed projects can be evaluated to determine the extent to which they helped achieve the identified target conditions. Shortcomings can be addressed through adaptive management of the project and in future project designs.

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Glossary

Term	Definition
action	Proposed protection and/or rehabilitation strategy to improve selected physical and ecological processes that may be limiting the productivity, abundance, spatial structure or diversity of the focal species. Examples include removing or modifying passage barriers to reconnect isolated habitat (i.e., tributaries), planting appropriate vegetation to reestablish or improve the riparian corridor along a stream that reconnects channel-floodplain processes, placement of large wood to improve habitat complexity, cover and increase biomass that reconnects isolated habitat units.
alluvial deposit	*alluvium*
alluvial fan	An outspread, gently sloping mass of alluvium deposited by a stream, esp. in an arid or semiarid region where a stream issues from a narrow canyon onto a plain or valley floor. Viewed from above, it has the shape of an open fan, the apex being at the valley mouth.
alluvium	A general term for detrital deposits made by streams on river beds, floodplains, and alluvial fans; esp. a deposit of silt or silty clay laid down during time of flood. The term applies to stream deposits of recent time. It does not include subaqueous sediments of seas and lakes.
anthropogenic	Caused by human activities.
avulsion	The rapid abandonment of a channel and the formation of a new river channel.
bedrock	The solid rock that underlies gravel, soil or other superficial material and is generally resistant to fluvial erosion over a span of several decades, but may erode over longer time periods.
cfs	Cubic feet per second; a measure of water flows
channel forming flow	Sometimes referred to as the effective flow or ordinary high water flow and often as the bankfull flow or discharge. For most streams, the channel forming flow is the flow that has a recurrence interval of approximately 1.5 years in the annual flood series. Most channel forming discharges range between 1.0 and 1.8 years. In some areas it could be lower or higher than this range. It is the flow that transports the most sediment for the least amount of energy, mobilizes and redistributes the annually transient bedload, and maintains long-term channel form.

Term	Definition
channel morphology	The physical dimension, shape, form, pattern, profile and structure of a stream channel.
channel planform	The two-dimensional longitudinal pattern of a river channel as viewed on the ground surface, aerial photograph or map.
channel units	Morphologically distinct areas within a channel segment that are on the order of at least one to many channel widths in length and are defined by distinct hydraulic and geomorphic conditions within the channel (i.e. pools, riffles, and runs). Channel unit locations and overall geometry are somewhat stage dependent as well as transient over time, and observers may yield inconsistent classifications. To minimize the inconsistencies, channel units are interpreted in the field based on the fluvial processes that created them during channel forming flows, then mapped in a geographic information system (GIS) to provide geospatial reference.
control	A natural or human feature that restrains a streams ability to move laterally and/or vertically.
degradation	Transition from a higher to lower level or quality. A general lowering of the earth's surface by erosion or transportation in running waters. Also refers to the quality (or loss) of functional elements within an ecosystem.
diversity	Genetic and phenotypic (life history traits, behavior, and morphology) variation within a population. Also refers to the relative abundance and connectivity of different types of physical conditions or habitat.
ecosystem	An ecologic system, composed of organisms and their environment. It is the result of interaction between biological, geochemical and geophysical systems.
extirpation	The loss of a local or regional population, with the species continuing to survive elsewhere.
fine sediment	Sand, silt and organic material that have a grain size of 6.4 mm or less.
floodplain	The portion of a river valley, adjacent to the channel, which is built of sediments deposited during the present regimen of the stream and is covered with water when the river overflows its banks at flood stages.
fluvial	Produced by the action of a river or stream. Also used to refer to something relating to or inhabiting a river or stream. Fish that migrate between rivers and streams are labeled "fluvial".

Term	Definition
fluvial process	A process related to the movement of flowing water that shape the surface of the earth through the erosion, transport, and deposition of sediment, soil particles, and organic debris.
geomorphic reach	An area containing the active channel and its floodplain bounded by vertical and/or lateral geologic controls, such as alluvial fans or bedrock outcrops, and frequently separated from other reaches by abrupt changes in channel slope and valley confinement. Within a geomorphic reach, similar fluvial processes govern channel planform and geometry resulting from streamflow and sediment transport.
geomorphology	The science that treats the general configuration of the earth's surface; specif. the study of the classification, description, nature, origin and development of landforms and their relationships to underlying structures, and the history of geologic changes as recorded by these surface changes.
GIS	Geographical information system. An organized collection of computer hardware, software, and geographic data designed to capture, store, update, manipulate, analyze, and display all forms of geographically referenced information.
gradient	Generalized change in elevation over a distance. For this report, reach gradient was estimated by valley gradient reported in percent (%) from 1:24,000 topography.
indicator	A variable used to forecast the value or change in the value of another variable; for example, using temperature, turbidity, and chemical contaminants or nutrients to measure water quality.
large woody material (LWM)	Large downed trees or parts of trees that are transported and deposited by the river during high flows and are often deposited on gravel bars or at the heads of side channels as flow velocity decreases. The trees can be downed through river erosion, wind, fire, landslides, debris flows, or human-induced activities. Generally refers to the woody material in the river channel and floodplain with a diameter of at least 20 inches and has a length greater than 35 feet in eastern Cascade streams (USFS 2006b).
limiting factor	Any factor in the environment that limits a population from achieving complete viability with respect to any Viable Salmonid Population (VSP) parameter.
riparian area	An area adjacent to a stream, wetland, or other body of water that is transitional between terrestrial and aquatic ecosystems. Riparian areas usually have distinctive soils and vegetation community/composition resulting from interaction with the water body and adjacent soils.

Term	Definition
river mile (RM)	Miles measured in the upstream direction beginning from the mouth of a river or its confluence with the next downstream river.
shear stress	The erosive energy associated with flowing water (ODEQ 2000).
side channel	A distinct channel with its own defined banks that is not part of the main channel, but appears to convey water perennially or seasonally/ephemerally. May also be referred to as a secondary channel.
sinuosity	Ratio of the length of the channel or thalweg to the down-valley distance of the reach of the channel. Channels with sinuosity of 1.5 or more are designated “meandering.”
subbasin	A subbasin represents the drainage area upslope of any point along a channel network (Montgomery and Bolton 2003). Downstream boundaries of subbasins are typically defined in this assessment at the location of a confluence between a tributary and mainstem channel. An example would be the Grande Ronde River subbasin.
terrace	A relatively stable, planar surface formed when the river abandons its floodplain. It often parallels the river channel, but is high enough above the channel that it rarely, if ever, is covered by over-bank river water and sediment. The deposits underlying the terrace surface are primarily alluvial, either channel or overbank deposits, or both. Because a terrace represents a former floodplain, it may be used to interpret the history of the river.
tributary	A stream feeding, joining, or flowing into a larger stream or lake (Neuendorf et al. 2005).
valley segment	An area of river within a watershed sometimes referred to as a subwatershed that is comprised of smaller geomorphic reaches. Within a valley segment, multiple floodplain types exist and may range between wide, highly complex floodplains with frequently accessed side channels to narrow and minimally complex floodplains with no side channels. Typical scales of a valley segment are on the order of a few to tens of miles in longitudinal length.
viable salmonid population	An independent population of Pacific salmon or steelhead trout that has a negligible risk of extinction over a 100-year time frame. Viability at the independent population scale is evaluated based on the parameters of abundance, productivity, spatial structure, and diversity (ICBTRT 2007).

Term	Definition
watershed	The area of land from which rainfall and/or snow melt drains into a stream or other water body. Watersheds are also sometimes referred to as drainage basins. Ridges of higher ground form the boundaries between watersheds. At these boundaries, rain falling on one side flows toward the low point of one watershed, while rain falling on the other side of the boundary flows toward the low point of a different watershed.