Mid-Columbia Fisheries Enhancement Group

Salmon habitat assessment for conservation planning on the Lower White Salmon River, Washington

By Jill M. Hardiman and M. Brady Allen

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Figures

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Tables

Conversion Factors

Inch/Pound to SI

Multiply	By	To obtain
	Length	
mile (mi)	1.609	kilometer (km)
	Area	
Acre	4,047	square meter (m^2)
Acre	0.004047	square kilometer (km^2)
square mile (mi^2)	2.590	square kilometer (km^2)
	Flow rate	
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
	Hydraulic gradient	
foot per mile (ft/mi)	0.1894	meter per kilometer (m/km)

SI to Inch/Pound

Multiply	By	To obtain
	Length	
kilometer (km)	0.6214	mile (mi)
	Area	
square meter (m^2)	0.0002471	acre
square kilometer (km^2)	247.1	acre
square kilometer (km^2)	0.3861	square mile (mi^2)
	Flow rate	
cubic meter per second (m^3/s)	35.31	cubic foot per second (ft^3/s)
	Hydraulic gradient	
meter per kilometer (m/km)	5.27983	foot per mile (ft/mi)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

°F=(1.8×°C)+32

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:

°C=(°F-32)/1.8

Salmon habitat assessment for conservation planning for the Lower White Salmon River, Washington

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Abstract

In 2011, Condit Dam was removed from the White Salmon River, Washington. Since removal, there has been interest in assessing Pacific salmon habitat in the lower six miles of the White Salmon River for conservation planning. The study area for planning purposes is the area which was once inundated by Northwestern Lake prior to the removal of Condit Dam downstream to the confluence with the Columbia River. As part of efforts by the Mid-Columbia Fisheries Enhancement Group to conduct conservation planning, the U.S. Geological Survey (USGS) used current and historical habitat information to assist in the planning process. The USGS compiled existing georeferenced habitat data into a Geographic Information System to identify areas of high quality habitat for salmon, potential areas for restoration/improvement, and areas that could be threatened. The primary sources of georeferenced data for this project include a Lidar flight contracted by PacifiCorp, bathymetry from USGS, and fall Chinook salmon redd surveys from U.S. Fish and Wildlife Service and Washington Department of Fish and Wildlife. Redd observations provided support that the study area is a migratory corridor for salmon and steelhead and that the lowest two to three miles had the highest concentration of documented fall Chinook salmon redds. The study area has potential for restoration/conservation areas to improve/conserve salmon habitat.

Introduction

As of October 26, 2011 after the breaching of Condit Dam, the White Salmon River has become free-flowing. The Condit Hydroelectric Project was constructed in 1912 and 1913 at river mile (RM) 3.3 (river km 5.3) of the White Salmon River in Klickitat and Skamania Counties, Washington. The dam blocked fish passage for nearly a century prior to breaching. The dam removal was completed on September 14, 2012 and mitigation and restoration efforts are ongoing including re-vegetation of the newly exposed reservoir sediment. The White Salmon watershed is part of both of Washington State's Lower Columbia River (LCR) salmon recovery domain and the Middle Columbia River (MCR) Steelhead Recovery sub-domain, as well as the state's Water Resource Inventory Area (WRIA) 29b. Land use in the lower White Salmon River includes commercial timber, irrigated cropland, orchards, and residential. Additionally, this area is heavily used for recreation by both private and commercial interests (rafting, kayaking, fishing, and others), including an in-lieu boat launch for tribal fishing rights, and is part of the Columbia Gorge National Scenic Area. Approximately 27.7 miles of the White Salmon River are classified as Wild and Scenic, including the section from the town of BZ Corner (RM 12.4) to its confluence with Buck Creek at RM 5. The White Salmon River has historically supported steelhead trout, spring and fall Chinook, coho, and chum salmon runs (Lane and Lane Associates, 1981).

The removal of Condit Dam, has opened up access to anadromous species, and dramatically changed the habitat from a reservoir above Condit Dam to a free flowing river. The removal also resulted in new shorelines, steep banks, and exposed land area particulary in the region of the former Northwestern Lake (the reservoir formed by Condit Dam). Currently the river is in a state of flux, with sediment and gravel transport towards the lower sections and the confluence with the Columbia River, and changing gravel bars with each high water event. Furthermore, a newly formed delta has appeared at the mouth of the White Salmon river at the confluence with the Columbia River. The newly exposed lands and steep banks in the former Northwestern Lake area are under going restoration efforts such as re-vegetation and some completed bank stabilization efforts and large woody debris placements. The western shoreline in this region is used by cabin owners who lease their land from PacifiCorp. PacifiCorp is the primary land owner (500-600 acres) in the lower six river miles of the White Salmon River. The Mid-Columbia Fisheries Enhancement Group received a grant to initiate efforts to plan for salmon habitat protection in the lower six river miles of the White Salmon River. The primary objectives of the planning grant are to identify key habitat areas for salmonids that warrant protection, identify potential risks to these habitats, and involve stakeholders in discussions of salmon habitat protection strategies and issues. This report will focus on the results of the salmon habitat assessment conducted by the USGS.

The USGS and other agencies have provided habitat data and fish use information for this assessment. This work focused on compiling and summarizing existing data and presenting new data, such as the Lidar and orthophoto imagery provided by PacifiCorp from a flight conducted in August, 2013. Monitoring information and spatial information from various habitat surveys was reviewed and incorporated into a Geographic Information System (GIS). Spawning survey data summaries from 2012 were provided by US Fish and Wildlife Service (USFWS) and from 2013 and 2014 from Washngton Department of Fish and Wildlife (WDFW). Additionally, this habitat assessment will be made within the context of the various life history stages of the salmonids historically present in this system. This document will provide an overview of the status of the salmonid habitat based on this existing information and will identify data gaps or where additional information would better inform salmonid habitat needs.

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Study Area

The White Salmon River river drains approximately 386 square miles of Klickitat, Yakima, and Skamania Counties in south central Washington. The topography of the surrounding area is highly varied, including mountainous terrain, deeply incised canyons, rolling hills and low-gradient valley floors. The geographic area of interest is the lower six river miles of the White Salmon River (Figure 1) to the confluence with the Columbia River. The primary land owner in this area is currently PacifiCorp, according to Klickitat and Skamania county records. In general, the mainstem White Salmon River has good water quantity and quality. Peak flows in the mainstem reflect snowmelt runoff, increasing from an average daily flow of 644 ft^3/s during the fall to flows of 1,538 ft^3/s in the spring (Haring, 2003). Water temperatures remain cold, and river flow is maintained by cold springs and seeps coming from high-altitude snowmelt throughout the summer. With the removal of Condit Dam, the characteristics of the lower river are changing now that natural watershed processes of large woody debris and gravel recruitment to the lower reaches have been restored. The amount of time these watershed processes take to reach equilibrium is unknown. Furthermore, to date a large flood event has not occurred since the removal of Condit Dam. The lower river will likely be in a state of flux for the next few years as the river channel stabilizes and the riparian corridor re-establishes.

Species of Interest

Historical fish production in the White Salmon River included five Endangered Species Act (ESA) listed Evolutionarily Significant Unit (ESU)/Distinct Population Segment (DPS) salmonid populations (Table 1). The White Salmon River supported runs of MCR steelhead up to the falls at RM 16 and into Buck, Spring, Indian, and Rattlesnake creeks (NPCC 2004). Based on spawning habitat accessibility and historical information, biologists assume that spring Chinook, coho, and chum salmon

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were present in the watershed (Lane and Lane Associates, 1981; NMFS 2013). Husum Falls, at RM 7.6, was considered likely to be a barrier for fall Chinook salmon migration and a partial barrier for steelhead and coho salmon (NPCC 2004). Salmon and steelhead production was reduced significantly with the construction of Condit Dam, which blocked access to most of the historical range of spring and fall Chinook salmon, steelhead, and coho salmon populations. Currently, the MCR steelhead population in the White Salmon River is considered functionally extirpated (ICTRT 2008) and also the LCR spring Chinook salmon and coho salmon and the CR chum salmon are considered extirpated (Myers et al. 2006). The National Marine Fisheries Service (NMFS) has developed a recovery plan for the ESA listed species in the White Salmon River (NMFS 2013).

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Table 1. Endangered Species Act listed Evolutionarily Significant Unit/Distinct Population Segment salmonids in the White Salmon River. LCR is Lower Columbia River, CR is Columbia River, MCR is Middle Columbia River.

Species	ESU/DPS	Status	Federal Register Notice	
Chinook Salmon (*Oncorhynchus tshawytscha*)	LCR Chinook salmon	Threatened	70 FR 37160	6/28/2005
Coho salmon (*O. kisutch*)	LCR coho salmon	Threatened	70 FR 37160	6/28/2005
Chum salmon (*O. keta*)	CR chum salmon	Threatened	70 FR 37160	6/28/2005
Steelhead (*O. mykiss*)	MCR steelhead	Threatened	71 FR 834	1/5/2006
Bull trout (*Salvelinus confluentus*)	CR bull trout	Threatened	63 FR 31647	6/10/1998
Critical Habitat Designation	LCR Chinook salmon, CR chum salmon, LCR coho salmon, MCR steelhead		70 FR 52630	9/2/2005
Critical Habitat Designation	CR bull trout		75 FR 2269	1/14/2010

Data Compilation

Habitat Data

Data sets were compiled from a Lidar flight conducted by PacifiCorp in August 2013. The USGS used the Lidar data to create a digital elevation model (DEM) of the new river channel and surrounding area of the Lower White Salmon River (Figure 2). This data was also used to create data sets of stream bank slope (Figure 3), and water surface elevation in the river channel (Figure 4). The water surface elevation data was used to delineate smaller reaches based on past Ecosystem Diagnosis and Treatment (EDT) model analysis (Allen and Connolly 2004), changes in slopes, tributary confluences, and changes in habitat types, (i.e. pool, riffle, run; Table 2). PacifiCorp also shared digital orthophotogramatic imagery taken during this time, which the USGS incorporated into the GIS and used to provide reference maps and create data layers, such as documentation of large woody derbis (LWD) placement.

The USGS previoulsy collected detailed habitat information from the mouth of the White Salmon River to one mile upstream both pre- and post-dam removal, which will be published as a separate manuscript (Hatten et al. *In Review*). This information was incorporated into the GIS and includes bathymetric surveys, substrate information, and a 2D River hydrodynamic model. This information was used to compare the movement of gravel bar beds from 2012 to 2013 and illustrate the dynamic nature of the river as it is finding equilibrium post Condit Dam removal (Figure 5). The detailed nature of this data also allowed for associating redd locations in 2012 with the habitat data- such as velocity, depth, and substrate. One general conclusion of this report was improved salmon habitat in the lowest river mile due to increased gravel recruitment, favorable velocities and depths for spawning (Hatten et al. *In Review*).

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Table 2. Table describing the reach divisions for salmon habitat assessment for the Lower White Salmon River including designated reach name, river mile location, length and percent slope.

Reach name	Description	White Salmon River miles	Length (ft)	Slope (%)
WS1	Confluence to end of Bonneville influence	0 – 1.1	6,255	0.2
WS2	End of Bonneville influence to powerhouse	1.1 – 2.2	5,746	0.7
WS3	Powerhouse to steelhead falls	2.2 – 2.6	2,130	1.1
WS4	Steelhead falls to Mouth of Mill Creek	2.6 – 4.2	8,251	1.2
WS5	Mouth of Mill Creek to mouth of Buck Creek	4.2 – 5.2	5,172	0.7
WS6	Mouth of Buck Creek to end of Study area (Lidar data set)	5.2 – 5.7	2,284	0.7
M1	Mill Creek mouth to PacifiCorp property line		1,906	4.4
B1	Buck Creek mouth to PacifiCorp property line		715	4.3

Fish Use

The USGS collected data on the lower White Salmon River fish species composition prior to Condit Dam removal using a rotary screw trap at river km 1.5 from 2006 to 2009 (Allen and Connolly, 2011). They captured juvenile salmonids during their outmigration from March to June, with the following conclusions:

- Fall Chinook salmon were captured in the highest numbers (n=18,640), and were composed of two stocks: tule and upriver bright. Almost all captured fall Chinook salmon were age-0, with only 16 (0.09 percent) being age-1or older.
- Tule fall Chinook salmon, the native stock, generally out-migrated from mid-March through early April. The tule stock was the more abundant fall Chinook salmon subspecies, comprising 85 percent of those captured in the trap.
- Upriver bright fall Chinook salmon comprised 15 percent of the Chinook salmon catch and generally out-migrated from late May to early June. However, during WDFW spawning surveys

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in 2013, the upriver bright fall Chinook were constistently more abundant than tule fall Chinook salmon.

- Coho salmon and steelhead trout were captured by the rotary screw trap in all years. Coho salmon were caught in low numbers (n=661) and 69 percent were age-0 fish. Steelhead were slightly more abundant (n=679) than coho salmon and 84 percent were age-1 or older fish.

The USGS also electrofished when water levels in the White Salmon River declined in late summer, along the river margins in 2006–09 at three sites (approximately RM 0.9, 1.4, and 2.6). Age-0 steelhead were the most abundant fish captured (n=565, 62 percent), followed by age-0 coho salmon (n=222, 24 percent). There were no age-1and few age-0 Chinook salmon collected while electrofishing (n=40, 4 percent). The only age-1 salmonids captured while electrofishing were steelhead (n=84, 9 percent; Allen and Connolly, 2011). This composition likely has changed since the removal of Condit Dam, however, a more recent survey for juvenile distribution and composition has not been done. Thus, this past work provides evidence of early salmonid life history stages rearing in and outmigrating from the lower river (Allen and Connolly, 2011).

Spawning surveys have been conducted by USFWS in 2012 and WDFW in 2013 and 2014 during the fall months of Chinook salmon runs. For a complete description of survey methodology for the 2012 survey, see Engle et al. 2013. The 2013 survey methodology will be available at a later date in an annual report from WDFW (Jeremy Wilson, WDFW, pers. comm) and the 2014 survey was just recently completed. At the time of writing this report, the 2013 and 2014 data is unpublished. During the 2012 survey, three main reaches were surveyed below Husum falls to the confluence with the Columbia River, during weekly surveys from September 20 to November 15. Not all reaches were surveyed every week. Redd surveys were conducted from inflatable rafts and all redd observations were recorded and marked on maps for digitizing and enumeration into a GIS. From the 2012 effort, the

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USGS was able to obtain GPS points of redd locations and incorporate these into a GIS (Figure 6). During the 2013 survey, GPS points were collected on Spring Chinook salmon redds only as they were in a lower abundance than the tule fall Chinook and the bright fall Chinook salmon runs. These were collected from August 19 to November 26 during weekly survey efforts (Figure 6). Individual GPS points were not collected for the fall Chinook and bright salmon runs due to the higher abundance of spawners and redds and the high occurrence of superimposition in the lowest river miles.

Steelhead spawning surveys have been conducted by the Yakama Nation in the tributaries but not within the mainstem White Salmon study area. The lack of information on mainstem spawning potential for steelhead and coho salmon are considered data gaps for this area. However, we do know that steelhead/rainbow trout redds have been observed in tributaries upstream of the former reservoir, mainly in Buck Creek and Rattlesnake Creek. There is also evidence of steelhead occurring up to BZ falls and even big brother falls (RM 15.5; Joe Zendt, Yakama Nations Fisheries, pers. comm), both above Husum falls indicating this is not a passage barrier for steelhead.

Fish Habitat Criteria by Life History Stage

Habitat preferences of the salmonid species of interest and life history stages have been well documented in the literature. A table summary has been provided in Appendix D of an Interfluve report (2013) with a brief summary provided here. In general, prior to spawning, adult salmonids prefer to hold in deep pools with cover (e.g., LWD, boulders, shadows, depth) near spawning areas, with a variety of suitable substrate types, and with temperatures ranging from 3.3 to 19.4°C (Bell 1986). Typical Chinook and coho salmon spawning habitat occurs in water depths greater than 18-24 cm, with velocities between 30-91 (cm/s), with substrate in the size range of 1.3 to 10.2 cm (Thompson 1972), and fines less than 20%. The water temperature ranges from 4.4 to 14.0°C and is not limiting in the White Salmon River, nor is dissolved oxygen a limiting factor. These conditions are similar to those

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needed for steelhead, with the exception of a slightly narrower velocity range of 40-91 (cm/s), broader substrate range of 0.6 to 10.2 cm, and a narrower temperature range of 4 to 10°C (Bell 1986). Incubation temperatures typically fall in the same range as the spawning criteria as well as the other habitat conditions, including limited scour or high flow events during this period. Habitat preferences of rearing and out-migrating juvenile salmonids include lower velocities, 0-40 (cm/s), shallower depths (~15 cm), smaller substrate (0.4 to 1.6 cm; Garland et al. 2002), cobble embeddedness less than 20% (NMFS 1996), and access to cover. Juveniles are often found along stream margins in the slower moving water, shallower depths, with adequate cover (e.g. vegetation, woody debris).

Reach Ranking Methodology

Individual reaches were ranked numerically based on fish use and/or habitat information as available for individual life-history stages. The most complete data sets we have for fish use after fish passage was restored are the 2012 and 2013Chinook salmon redd surveys. The number of redds/mile was estimated for each reach and the reach with the highest redd density was ranked as a one, and next highest a two, etc. The 2013 redd survey data , is still preliminary (unpublished at the time of writing this), however the summarized results presented here represent the general patterns of redd distributions and that is unlikely to change. Due to the lack of information about fish use for the various salmonid species and life history stages, ranking of these were applied in more a descriptive manner based on available habitat data and fish life-stage preference as described in the habitat criteria section.

Results

Habitat Description

The mainstem lower White Salmon River including the former Northwestern Lake area up to the confluence with Buck Creek is mostly confined through a basalt canyon or by steep embankments.

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There is little habitat complexity with floodplain interaction, LWD, backwaters, eddies, or sandbars throughout the entire study area. The present instream habitat complexity is is made up of overhanging bedrock shelves, boulders, and sparse LWD and is considered moderate. Bedrock cliffs line the river throughout the majority of the lower White Salmon River, below the former site of Condit Dam and in some areas bedrock creates waterfalls, such as Steelhead Falls at RM 2.6. We georeferenced and incorporated into the GIS database 11 natural and man-made LWD jams within the study area. This will be a base line reference to future changes in the fish habitat.

The general habitat types within the study reach are largely riffles, runs, with some cascades and pools. On average, the gradient of the water surface elevation ranges from 0.2 to 1.1 percent of slope in the individual reaches of the lower six river miles. Upstream of the former Northwestern Lake, river gradients generally range between 2 and 11percent (Haring 2003). Prior to the release of sediment behind the dam, the gradient of the lowermost mile of the White Salmon River was influenced by the backwater effect of the Columbia River's Bonneville Pool, which is impounded by Bonneville Dam, and the water in the lowermost half mile was more than 9-m deep (J. Hatten, USGS, pers. comm). The outflow of silt, sand and gravel from dam breaching aggraded the lower river by about 1.5 m (Wilcox et al. 2014). The sediment filled pools throughout the lower river, created gravel bars, and created a small delta at the Columbia River confluence. Currently the lowermost 0.3 mile of the White Salmon River continues to be influenced by Bonneville Pool and is only 2 m deep (J. Hatten, USGS, pers. comm).

The Underwood Conservation District performed vegetation surveys as part of their Anadromous Fish Passage Inventory assessment (Plummer and Zuckerman , 2012). They noted that vegetation composition shifts throughout the 16.9 miles of potentially anadromous habitat on the mainstem of the White Salmon River. Throughout the entire river corridor, mature trees shade the river with a canopy cover ranging from 5 to 35 percent. The relatively low canopy cover was due to steep

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bedrock banks and narrow canopied tree species that line the banks. Downstream of the former Condit Dam site, there are rocky slopes and cliffs dominated by Oregon white oak, as well as sections consisting mainly of Douglas-fir, big leaf maple, red alder and some Western red cedar; with vine maple, hazelnut and Oregon ash dominant in the subcanopy (Plummer and Zuckerman , 2012). Upstream of the former dam site, the riparian habitat is dense with Douglas-fir, Western red cedar, black cottonwood, red alder, big leaf maple, vine maple, oceanspray, willows, horsetail and Douglas spirea. Currently re-vegetation projects are underway in the area of the former Northwestern Lake, lead by PacifiCorp and Yakama Nation Fisheries.

Fish Use/Redd Suveys

During 2012, the USFWS was able to conduct limited redd surveys due to dam removal operations ,weather, and river condions. The reach from RM 7.6 to RM 0.0 was surveyed only three times. The results of the Chinook salmon redd surveys in 2012 indicated the maximum densityof use to be the lowermost two river miles (Figure 6). However, redds were observed thoughout the study area including in the former reservoir, just upstream of the Northwestern bridge, and upstream of the study area to Husum Falls (Engle et al., 2013). This indicated that the entire lower six river miles were used as a migration corridor for adults to access upper spawning areas and for juveniles as they rear and out-migrate. The distribution of spawning fall Chinook salmon adults in 2012 suggested the White Salmon River was suitable for spawning including new spawning habitat in the former reservoir.

Results from 2013 Chinook salmon redd surveys conducted by WDFW were more extensive and were consistent with the results from the 2012 redd surveys (Figure 6). The highest numbers of redds were from RM 2.1 downstream to a couple hundred yards above the confluence with the Columbia River. As in the previous year, a handful of fall Chinook salmon were observed spawning above the former Condit Dam site (RM 3.27), including some near the Buck Creek confluence (RM 4.90), the "castle" house (~RM 5.5), and up to the area just below Rattlesnake rapid (just below Husum, ~RM 7.6; Figure 7). Over half of the spawning spring Chinook salmon were observed above the former Condit Dam site. Most of the spring Chinook salmon redds that were above the former Condit site were 100-200 yards below Rattlesnake Creek confluence with a few redds near the "castle" house. The bulk of the spawning occurred downstream of Steelhead Falls (RM 2.6), with the highest concentration from the USFWS raceways (RM 1.3) down to the mouth (Jeremy Wilson, WDFW pers. comm).

During 2014, WDFW continued to do spawning surveys with preliminary results summarized here. For the spring Chinook salmon spawner estimates were two to three times what was observed in 2013(Jeremy Wilson, WDFW pers. comm). The tule fall Chinook salmon estimates also were higher than those observed during 2013. There was an increased use of the habitat above the former Condit Dam site by the spring Chinook salmon while the tule fall Chinook salmon were primarily observed using the reaches below Steelhead falls. Also, spring Chinook salmon were observed in Spring Creek in 2014, which is a tributary upstream of the former reservoir at RM 6.6 (Greg Morris, Yakama Nations Fisheries, pers. comm).

Information about the timing of adult fish spawning can be summarized from WDFW's 2013 unpublished results, indicating spawning from September until early December (Jeremy Wilson personnel communication). This spawning activity is focused in the lowest two river miles. Spring Chinook salmon likely hold in deeper pools in the White Salmon River beginning in May, and fall Chinook begin staging for spawning in late August. Bi-modal peak outmigration periods of fall Chinook salmon fry was found to occur during mid-March to early April and again in late May to early June at RM 1 from 2006 to 2009 (Allen and Connolly, 2011). Although this study occurred prior to Condit Dam removal, this is likely still the outmigration timing post removal.

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Reach Ranking

Critical spawning habitat areas were identified based on the spatial information provided from redd locations and the reaches within the study area were given a rank, which identified the lower numbers as areas that had the highest Chinook salmon spawning density (Table 3). In the process of developing conservation planning, the lowest two miles had the highest density for spawning and would be given the highest priority for protection. Without additional salmonid use information since removal of Condit Dam, we are left to rely on historical data and habitat suitability assumptions to rank reaches for the other species and life history stages. With the assumption that juvenile salmonids will likely be rearing near and downstream of the reaches with the highest densities of redds, the lowest two miles would also rank highest for juvenile rearing. Juvenile rearing would also likely be higher in the reaches with lower gradients, such as reaches 1, 2, 5, and 6 (Table 2) since the preferred rearing velocities are lower than the preferred spawning velocities. Juveniles would use more of the shallower habitats within these reaches with suitable cover along the river shoreline margins.

Table 3. Reach prioritization for White Salmon River based on redd data from 2012 and 2013. Prioritization ranking was assigned a 1 for the highest density of redds from surveys by USFWS in 2012 and WDFW in 2013, and was sequential after that. For 2012 ranking was based on all observed redds from September to November. The 2013 ranking is from surveys from August to December for Chinook salmon.

			Prioritization Ranking	
Reach name	Description	White Salmon River miles	Redd 2012	Redd 2013
WS1	Confluence to end of Bonneville influence	0 – 1.1	2	1
WS2	End of Bonneville influence to powerhouse	1.1 – 2.2	1	2
WS3	Powerhouse to steelhead falls	2.2 – 2.6	6	3
WS4	Steelhead falls to Mouth of Mill Creek	2.6 – 4.2	5	4
WS5	Mouth of Mill Creek to mouth of Buck Creek	4.2 – 5.2	3	4
WS6	Mouth of Buck Creek to end of Study area (Lidar data set)	5.2 – 5.7	4	4

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Discussion

The return of fish passage to the White Salmon River has opened up many more miles of habitat for anadromous species. The management plan for the first five years is to allow for natural re-colonization of salmonids to this river (NMFS, 2013). Natural resource managers are continuing to collect data of fish use through spawner and carcass surveys in 2014 and 2015. This region is in the public eye for recreational use, business use (rafting companies), private land owner access, public access, and the potential future changes of the land in the study area. The high level of interest in this area was evident at public meetings (May 17, and November 15, 2014) to discuss fish habitat assessment and land development suitability for the study area. The information presented here is the first step since removal of Condit Dam towards understanding the baseline salmon use and habitat conditions in the former reservoir down to the confluence with the Columbia River.

The lower White Salmon River continues to be used by salmon for spawning and rearing downstream of the former Condit Dam site and salmon are using the newly accessible habitat upstream of the dam site as well. The general trend for the last three years of spawning surveys is increased numbers of returning Chinook salmon and increased redd locations. The highest numbers of redd locations are in the lowest two miles of the river. Since dam removal, the habitat in this area has become even more suitable for spawning with an overall decrease in pool depth from 9 meters to 2 meters and increased gravel recruitment suitable for spawning habitat and a decrease in the percent of fine substrates (Hatten et al. *In Review*). This study focused on the lower 6 RM, however observations of redd locations above the study area, is continued evidence of range expansion of spawning habitat and fish use where river velocities, depths, and substrate are suitable.

A major limitation of this assessment is that no new habitat or fish surveys were done as part of this study, thus this work focused on summarizing existing information with an emphasis on the

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available spatial data sets. New habitat surveys should be conducted to monitor changes in substrate (i.e. gravel recruitment, fines distribution), pool numbers and depths, riparian cover, etc.. Also, a watershed approach may better represent fish use in the lower river considering the information of fish use above the former reservoir. Data gaps currently exist for recent (post-dam removal) juvenile salmonid composition, rearing and out-migration timing. More comprehensive spawning surveys including steelhead, coho salmon, lamprey, bull trout and other species are needed. The stocks that are recolonizing the river are unknown, other than the fall Chinook salmon, thus more comprehensive surveys including a genetic component would be beneficial. Additionally, surveys targeting invasive species within the White Salmon river would be prudent for early detection and potential control of unwanted species. In general, the river ecosystems are properly functioning and the habitat conditions are very suitable for salmonids, and water quality (temperature, dissolved oxygen) and quantity are not limiting in the mainstem White Salmon River. Also, fish habitat conditions are likely to improve as ecosystem processes come to an equilibrium and are enhanced with improvements to the riparian corridor with the re-vegetation projects underway and some of the LWD placements.

There are also potential threats to the salmon habitat through future development such as roads, buildings, septic tanks, and increased surface or ground water withdrawals. Other potential threats are increased fish harassment, redd disturbance (potential damaging of eggs), riparian erosion and vegetation clearing, and trash from an increase in recreational use in the lower reaches, now that new access was gained by a continuous, free-flowing stretch of river allowing for boaters, rafters, and fishermen to float to the mouth of the river. This connectivity can also allow for potential increase in likelihood of invasive species establishment throughout the river corridor. The region would be well served by conservation planning efforts and strategies that address conservation alternatives for protection of critical salmon habitat while addressing community issues and uses.

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Figures

Figure 1. Study Area, lower six river miles of the White Salmon River, from Buck Creek to the confluence with the Columbia River. Inset of location in Washington. The yellow outlines indicates property owned by PacifiCorp.

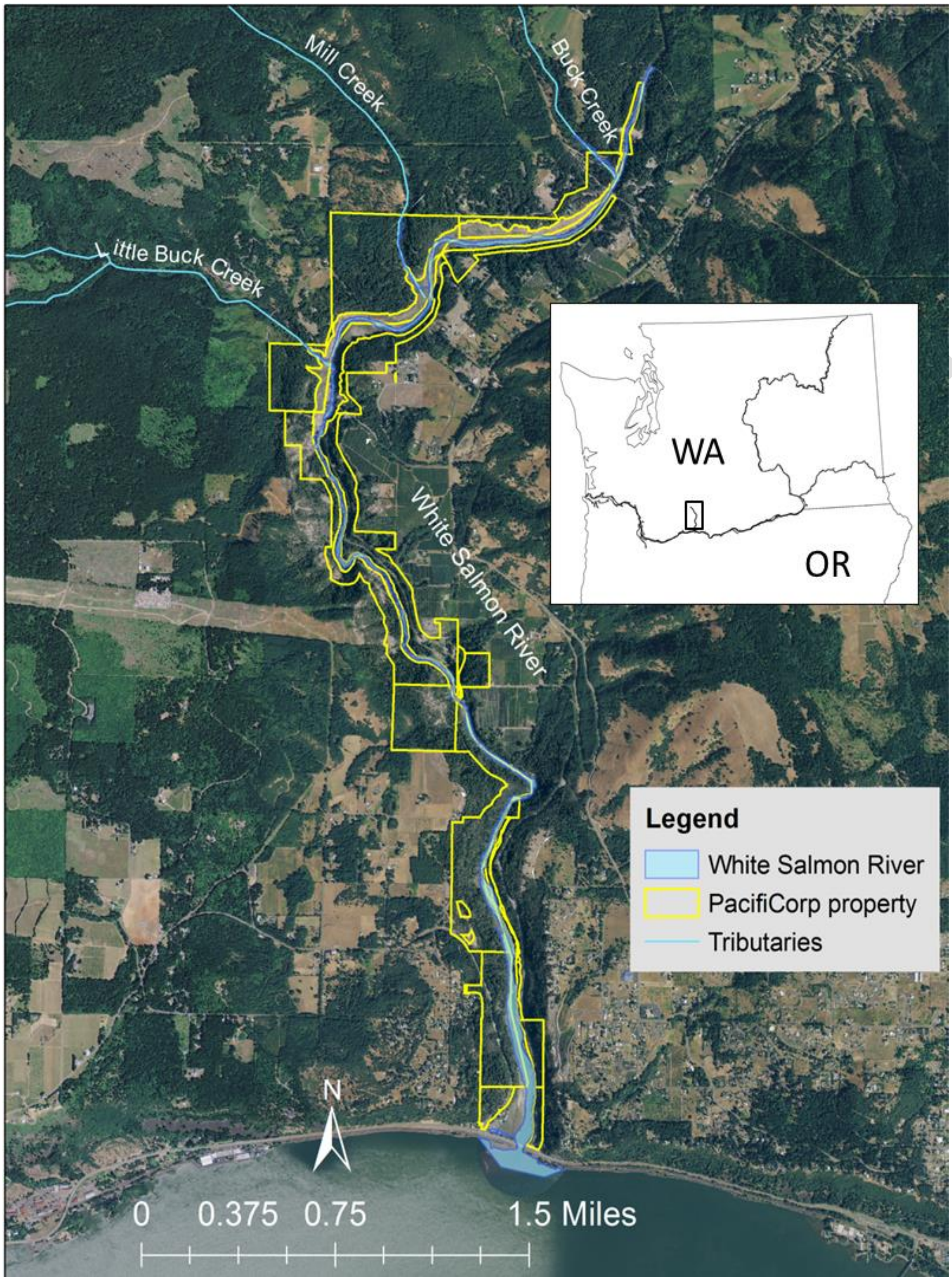

Figure 2. Digital elevation model of study area on the White Salmon River, Washington from Lidar flight conducted in August 2013.

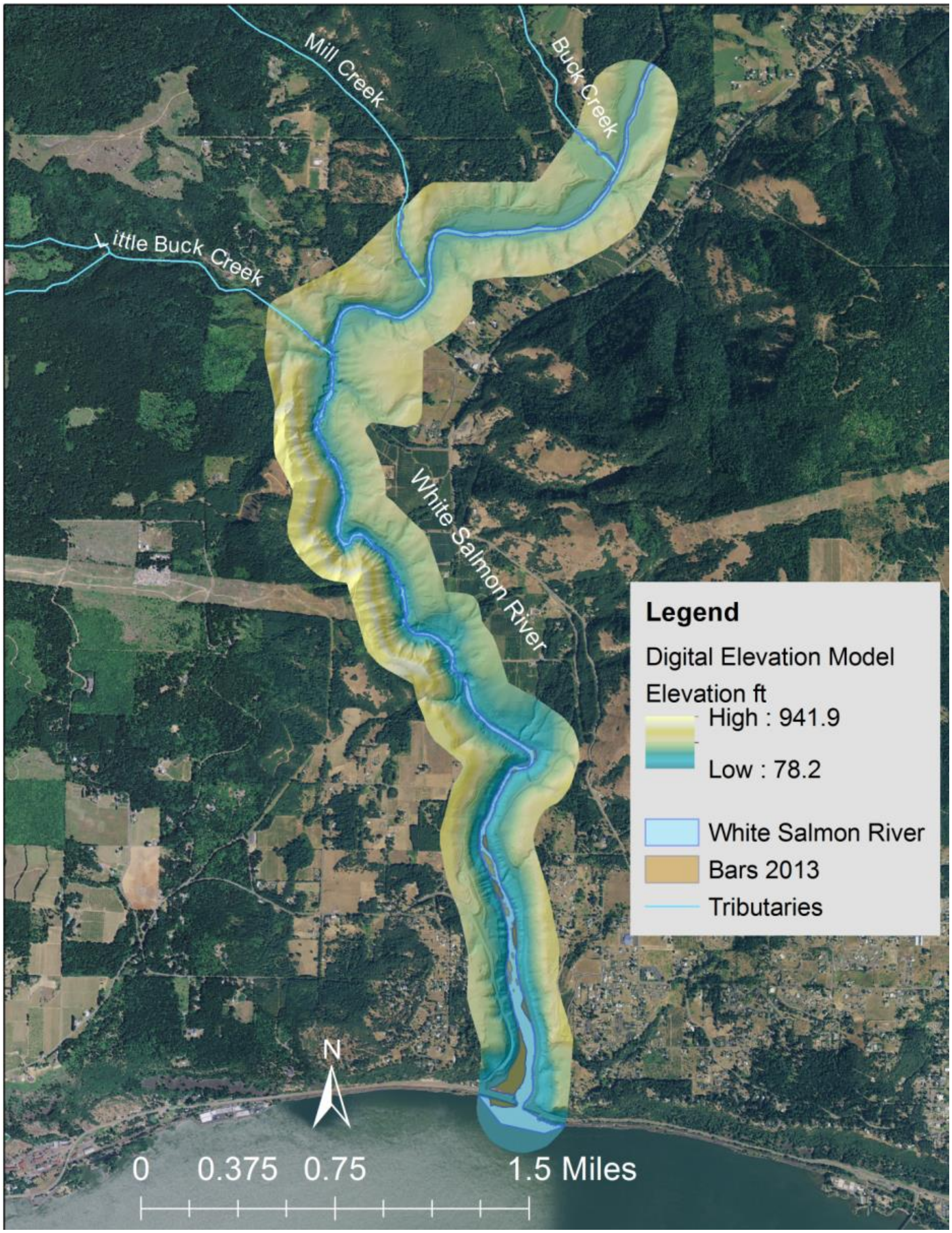

Figure 3. Near shore bank slope in degrees of the lower White Salmon River, Washington.

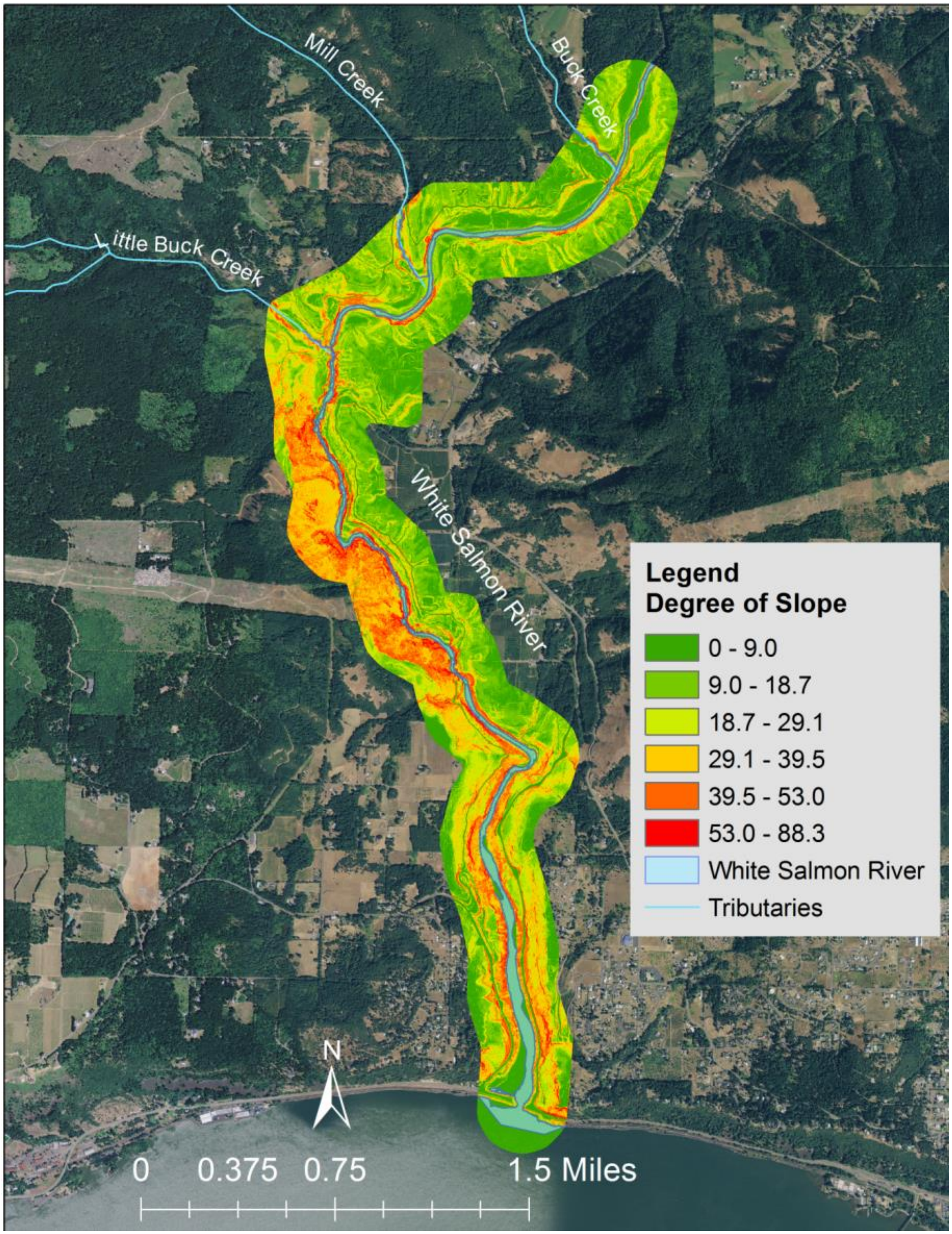

Figure 4. Water surface elevation and study area reach breaks of the lower White Salmon River, Washington.

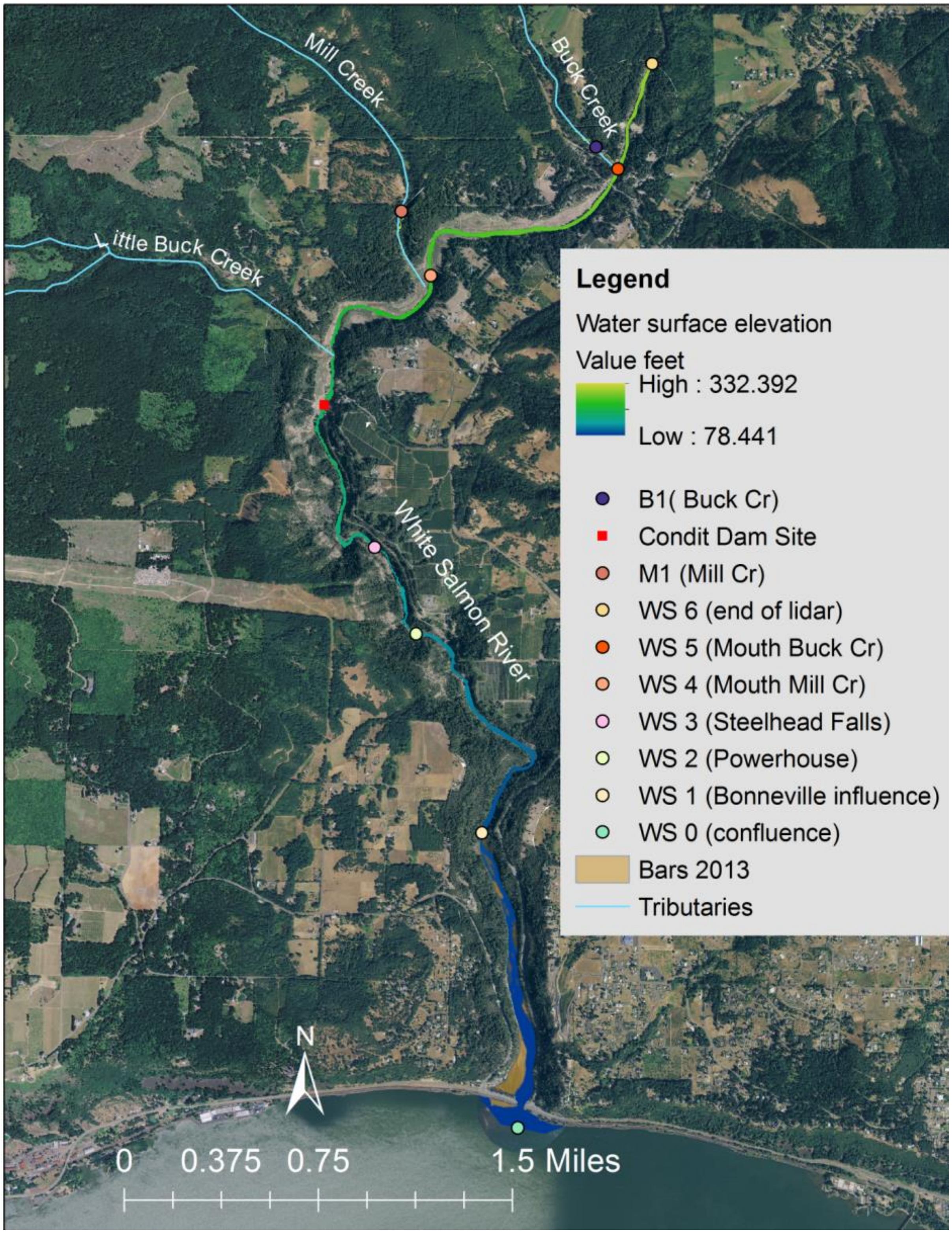

Figure 5. Map illustrating the change from 2012 to 2013 in gravel bar location and size in the first river mile of the White Salmon River, Washington.

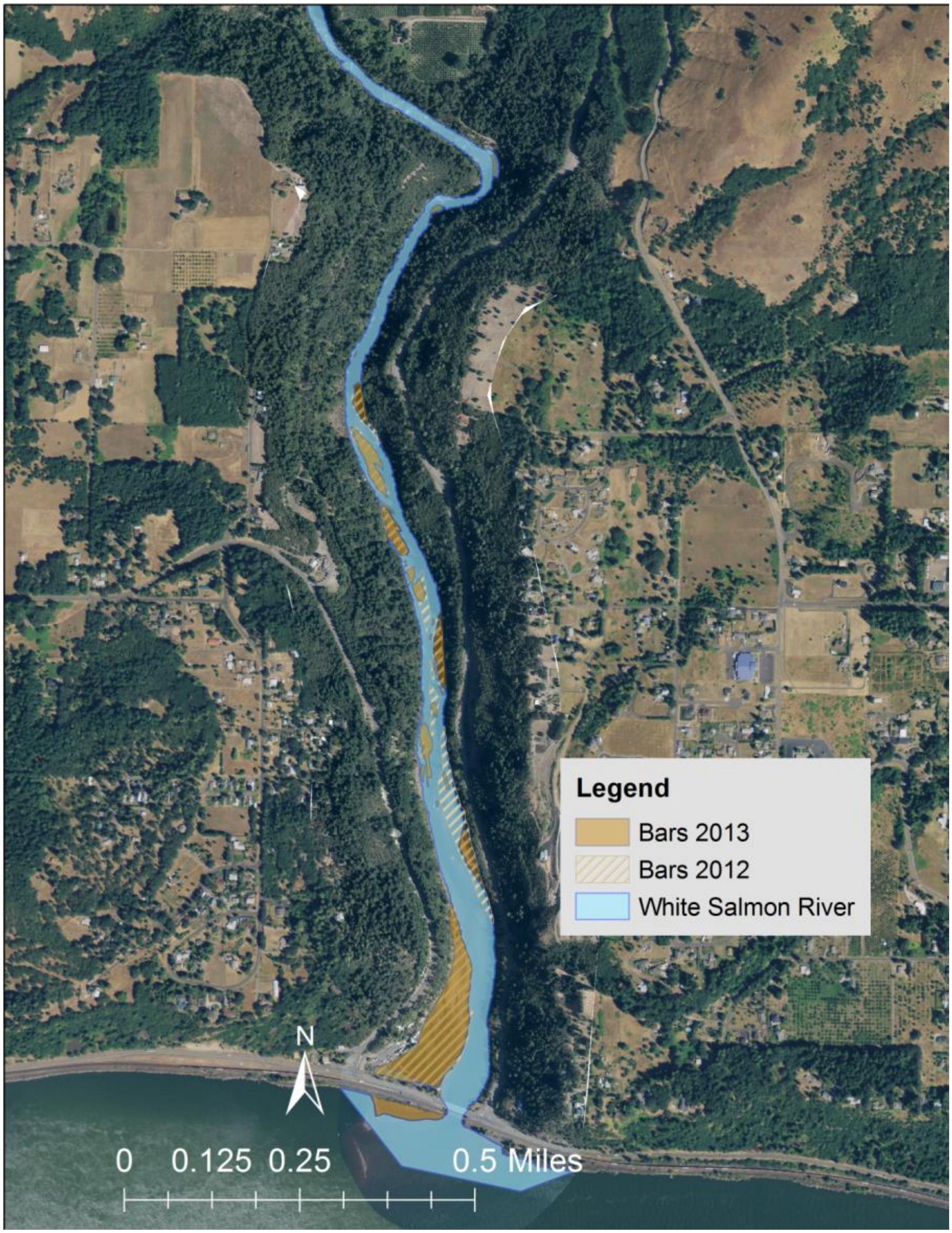

Figure 6. Chinook salmon redd survey results from U.S. Fish and Wildlife Service surveys during the fall of 2012 and from Washington Department of Fish and Wildlife surveys of spring Chinook redds in 2013 in the lower White Salmon River, Washington.

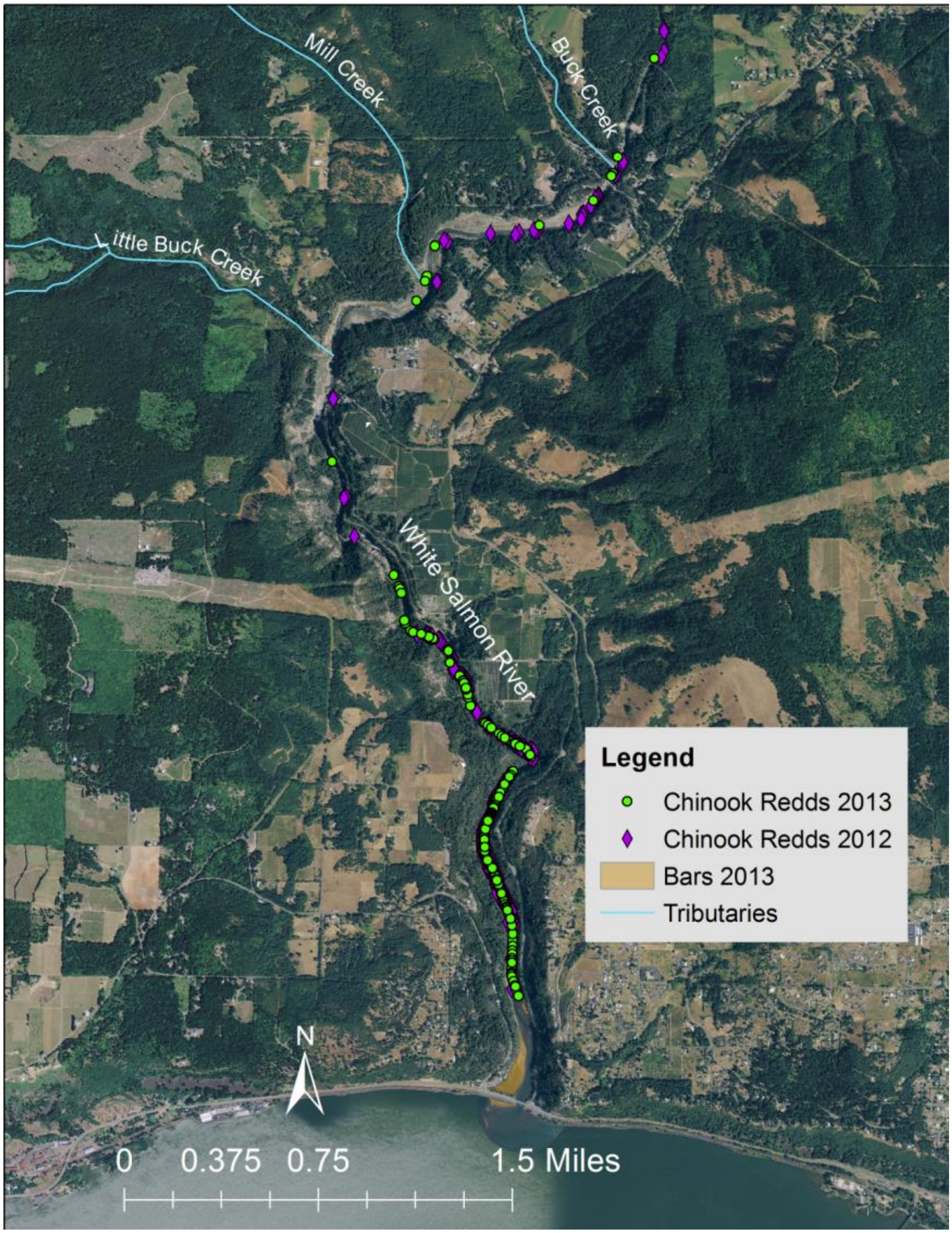

Figure 7. Chinook salmon redd survey results from U.S. Fish and Wildlife Service surveys during the fall of 2012 and from Washington Department of Fish and Wildlife surveys of spring Chinook redds in 2013 in the lower White Salmon River, Washington. Includes the study area (confluence up to Buck Creek) and upstream to Husum falls area.