Lower Peshastin Creek

Tributary and Reach Assessment

Wenatchee Subbasin, Chelan County, WA

Provided for:

Yakama Nation Fisheries Program
P.O. Box 15, Fort Road
Toppenish, WA 98948

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1 INTRODUCTION AND BACKGROUND

1.1 Overview

This assessment evaluates aquatic habitat conditions in lower Peshastin Creek and identifies strategies to restore and preserve salmonid habitat and natural river processes. The Peshastin Creek Basin is located on the east slope of the Cascade Mountains in Central Washington. Peshastin Creek is a tributary to the Wenatchee River and flows into the Wenatchee River at river mile 18. The study area encompasses the lower 9.3 miles of Peshastin Creek. The assessment also includes an evaluation of conditions in the contributing watershed that influence habitat and physical processes in the study area.

Peshastin Creek supports populations of salmonids that are currently listed under the Endangered Species Act (ESA), including spring Chinook salmon, summer steelhead, and bull trout. Habitat for these species has been impacted by anthropogenic activities throughout the basin. Specific goals of this assessment include:

- Address critical aquatic habitat impairments limiting the productivity of local salmonid populations.
- Protect and restore the dynamic landscape processes that support sustainable riparian and salmonid habitat.
- Improve and protect water quality to promote salmonid recovery.
- Coordinate efforts with local landowners, resource managers, and other stakeholders in order to establish collaborative efforts that contribute to the success of restoration strategies.

1.2 Background

Salmonid use of lower Peshastin Creek includes spring Chinook salmon, summer run steelhead, coho, bull trout, cutthroat trout, and resident rainbow trout. Human-induced changes to aquatic habitat have affected the key parameters used by federal agencies to evaluate the viability of salmonid populations; known collectively as the “viable salmonid population” (VSP) parameters: *abundance, productivity, diversity, and spatial structure* (UCSRB 2007). Failure to meet viability (i.e. VSP) criteria resulted in the listing of species under the ESA in the late 1990s. Upper Columbia River (UCR) steelhead trout and spring Chinook salmon were listed as Endangered in 1997 and 1999, respectively (UCSRB 2007). UCR steelhead has since been upgraded to Threatened. Bull trout were listed as Threatened under the ESA in 1999 (UCSRB 2007).

Aquatic habitat in lower Peshastin Creek has been impacted by a number of historical and on-going land-use activities within the river corridor and in the contributing watershed. These changes have affected stream channels, riparian areas, floodplains, and the physical processes that create and maintain the habitat conditions to which aquatic species have adapted to over time. Road building, in particular the construction of Highway 97 in 1956, has altered the river corridor through channel straightening, levee construction, bank armoring, and vegetation clearing. Agricultural and residential development has disconnected riparian areas and floodplains due to vegetation clearing, filling and grading, and construction of levees. Water withdrawals for agriculture reduce summertime flow levels in the downstream portion of the study area. Impacts in the contributing watershed, including mining, timber harvest, and road building, have also impacted aquatic habitat within the study area.

1.3 Habitat Restoration and Preservation Objectives

The Upper Columbia Spring Chinook Salmon and Steelhead Recovery Plan (Recovery Plan, UCSRB 2007) states that recovery of species viability will require reducing threats to the long-term persistence of fish populations, maintaining widely distributed and connected fish populations across diverse habitats of their native ranges, and preserving genetic diversity and life-history characteristics. The Recovery Plan calls for recovery actions within all of the "Hs" that affect salmon throughout their life history; namely Harvest, Hatchery, Hydropower, and Habitat. This Peshastin Creek Assessment addresses the Habitat component of the Recovery Plan, with a focus on the lower 8.4 miles of the Peshastin Creek corridor.

The following habitat restoration and preservation objectives were set forth in the Recovery Plan (UCSRB 2007). These objectives apply to spring Chinook, steelhead, and bull trout habitat and are consistent with the Subbasin Plan (NPPC 2004), the watershed plan (WRIA 45 Planning Unit 2006), and the Biological Strategy (UCRTT 2008). The objectives are intended to reduce threats to the habitat needs of the listed species. Objectives that apply to areas outside the study area or that are outside the scope of this plan are not included. A list of regional objectives (applicable to all streams in the Recovery Planning area) is followed by a list of specific objectives for the Peshastin Creek Basin. These objectives provided a framework and guidance for the watershed analyses and ultimate selection of specific restoration and preservation activities conducted as part of this assessment and included in this report.

1.3.1 Short-Term Objectives

- Protect existing areas where high ecological integrity and natural ecosystem processes persist.
- Restore connectivity (access) throughout the historic range where feasible and practical for each listed species.
- Protect and restore water quality where feasible and practical within natural constraints.
- Increase habitat diversity in the short term by adding instream structures (e.g., LWD, rocks, etc.) where appropriate.
- Protect and restore riparian habitat along spawning and rearing streams and identify long-term opportunities for riparian habitat enhancement.

- Protect and restore floodplain function and reconnection, off-channel habitat, and channel migration processes where appropriate and identify long-term opportunities for enhancing these conditions.
- Restore natural sediment delivery processes by improving road network, restoring natural floodplain connectivity, riparian health, natural bank erosion, and wood recruitment.

1.3.2 Long-Term Objectives

- Protect areas with high ecological integrity and natural ecosystem processes.
- Maintain connectivity through the range of the listed species where feasible and practical.

1.3.3 Restoration Objectives Specific to the Peshastin Creek Basin

- Re-establish connectivity throughout the assessment unit by removing, replacing, or fixing artificial barriers.
- Reduce water temperatures by increasing stream flows and restoring riparian vegetation along the stream.
- Increase habitat diversity and quantity by restoring riparian vegetation, adding instream structures and large woody debris, and reconnecting side channels and the floodplain with the stream.

1.4 Description of Study Area

The study area includes the lower Peshastin Creek river channel and floodplain from the mouth to river mile 9.3 (Figure 1). The Peshastin Creek river valley is generally wide and unconfined throughout the lower 9.3 miles to the confluence with the Wenatchee River with the exception of an approximately mile-long bedrock canyon at RM 5.0 and discrete locations of valley constrictions. The total catchment area is 136 miles^2. The largest tributary to Peshastin Creek is Ingalls Creek, which drains the Alpine Lakes Wilderness and flows into Peshastin Creek at RM 9.2. Other major tributaries include Hansel (RM 8.6), Allen (RM 7.35), Camas (RM 6.1), and Mill (RM 5.0) creeks with several tributaries draining the upper Peshastin Creek catchment and smaller tributaries draining side canyons of the lower Peshastin Creek river valley. The predominant land cover in the Peshastin Creek catchment is forest (69%) with grasslands (18.2%), shrubland (5.9%), rural residential/resource land use (4%), and a small amount of commercial agriculture comprising the remainder of the catchment area (USFS 1999). The upper portion of the basin has been heavily impacted by timber and mining activities, with agricultural and residential activities comprising the lower portion of the drainage. The channel shares the valley bottom with State Highway 97, a two-lane road constructed in 1956 and extending up the valley bottom to Blewett Pass.

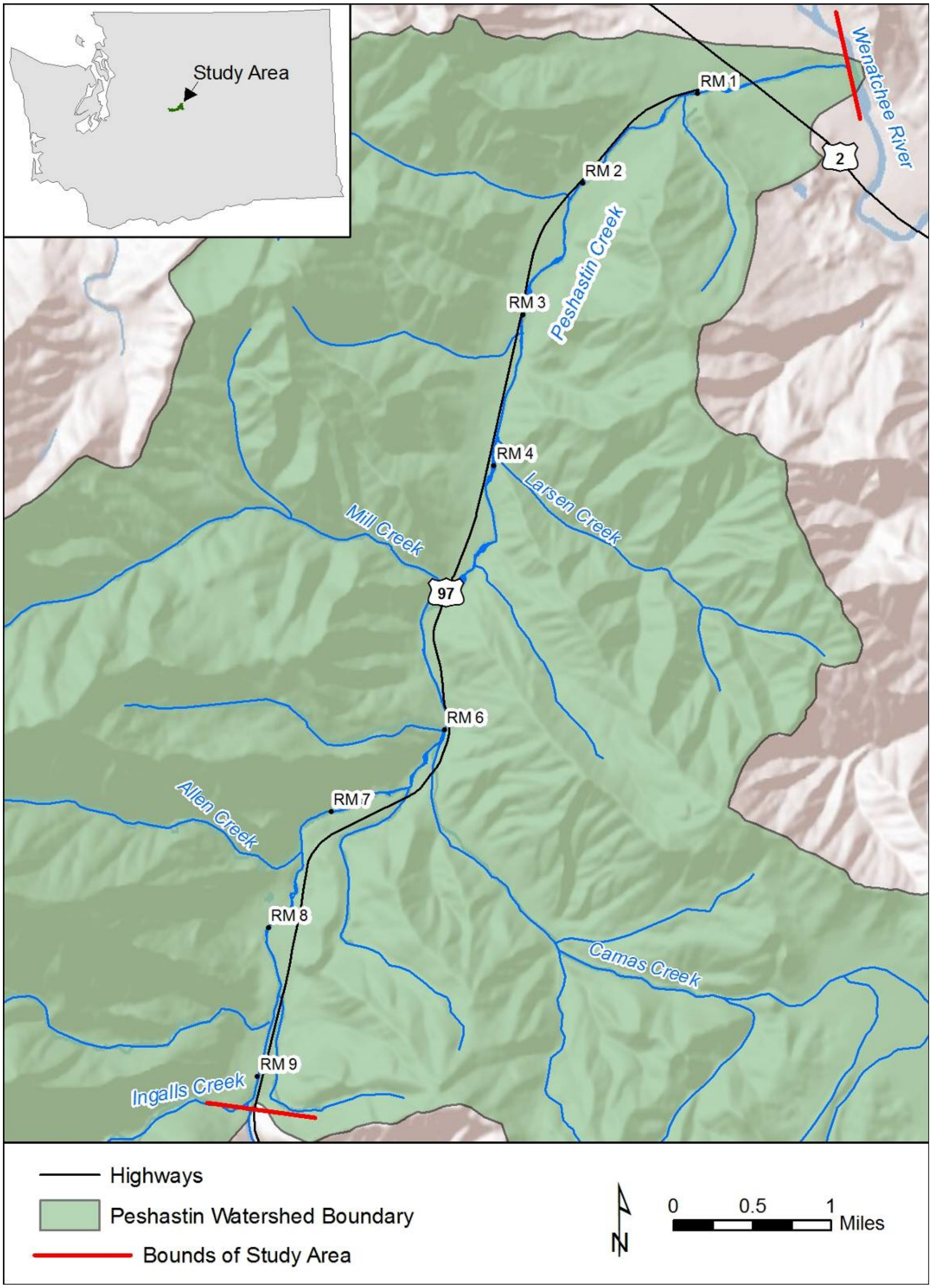


Figure 1. Lower Peshastin Creek Basin. The study area extends from the mouth to river mile (RM) 9.3.

1.5 Approach and Report Organization

This assessment includes two primary components: (1) Tributary Assessment, and (2) Reach Assessment.

The Tributary Assessment evaluates basin- and reach-scale conditions in the Peshastin Creek Basin and is intended to provide context to the Reach Assessment. The Tributary Assessment includes topics covering multiple disciplines. These topics are presented as separate sections in this report; including 1) data sources/existing information, 2) historical human alterations, 3) biological overview, 4) stream habitat assessment, 5) water quality overview, 6) hydrology, 7) geomorphology/geology, and 8) Reach Ecosystem Indicator (REI) results. These sections include either existing or newly collected information, or both. Some information, particularly with respect to historical and current geomorphology, was developed previously by the Bureau of Reclamation (USBR). These data were obtained from the USBR and were further developed into the assessment products included in this report.

The Reach Assessment is a finer scale assessment that evaluates geomorphic processes and land-use impacts at the reach- and subreach-scales between river miles 0 and 9.3. The Reach Assessment also identifies specific opportunities for accomplishing habitat restoration and preservation. The Reach Assessment begins with an introduction and methods section, which is then followed by reach-specific sections that describe geomorphic processes, habitat impairments, project opportunities, and feasibility constraints to restoration.

2 TRIBUTARY ASSESSMENT

2.1 Existing Data Sources

Federal, state, and local government agencies, conservation districts, tribes, and contracted consultants have conducted studies and collected data that is relevant to the Wenatchee River Basin and the Peshastin Creek Subbasin. This information was compiled and reviewed and was utilized throughout the course of this assessment. Existing relevant studies, and the entities associated with them, are included below in Table 1.

Table 1. List of existing information pertinent to the physical and biological assessment of Peshastin Creek.

Sponsoring Agencies and Contracted Entities	Study Report, or Associated Data Set
US Bureau of Reclamation	
	Nason Creek Tributary Assessment, Chelan County Washington 2008
	2006 Aerial Photographs
	2006 LiDAR
	1998 Aerial Photographs
	Historical channel GIS layers
	Human infrastructure GIS layers
	Surficial Geology GIS layers
	Glacial Features GIS layers
	Floodplain Area GIS layers
Federal Emergency Management Agency	
	Flood Insurance Study Chelan County Washington Unincorporated Area 2004
Mid-Columbia Fishery Resource Office (US Fish & Wildlife Service)	
	Analysis of Fish Populations in Icicle Creek, Trout Creek, Jack Creek, Peshastin Creek, Ingalls Creek, and Negro Creek, Washington 1997
U.S. Dept. of Energy Bonneville Power Administration Division of Fish and Wildlife	
Prepared by US Forest Service	Integrated Status and Effectiveness Monitoring Program: U.S. Forest Service Fish Abundance and Steelhead Redd Surveys Annual Report 2007
Prepared by US Forest Service	Integrated Status and Effectiveness Monitoring Program: U.S. Forest Service Fish Abundance and Steelhead Redd Surveys

Sponsoring Agencies and Contracted Entities	Study Report, or Associated Data Set
	Annual Report 2008
Prepared by UA Fish and Wildlife Service	Peshastin Creek Smolt Monitoring Program Annual Report 2004
Prepared by Yakama Nation Fisheries Resource Management	Mid-Columbia Coho Reintroduction Feasibility Study Annual Report 2008
United States Forest Service	
	The Integrated Status and Effectiveness Monitoring Program 2008 Annual Report
	Wenatchee River Subbasin Temperature Monitoring Report 2008
	Annual Report Fish Population and Effectiveness Monitoring Project 2006
	Ingalls Creek Survey for Migratory Bull Trout Barriers 2005
	Fish Population Component of Wenatchee Basin Integrated Monitoring, Okanogan-Wenatchee National Forest 2005
	Annual Report Wenatchee Integrated Monitoring Fish Population Sampling 2004
	Peshastin Watershed Assessment 1999
	Peshastin Creek Stream Survey Report 1998
	Ingalls Creek Stream Survey Report 1995
	Mill Creek Stream Survey Report 1994
	Sediment Sampling Report 1993
	Peshastin Creek Stream Survey Report 1992
	Scotty Creek Stream Survey Report 1992
	Shaser Creek Stream Survey Report 1992
	Tronsen Creek Stream Survey Report 1992
	Negro Creek Stream Survey Report 1990
	Ruby Creek Stream Survey Report 1990
Northwest Power and Conservation Council	
Prepared by Chelan County and Yakama Nation	Wenatchee Subbasin Plan
Upper Columbia Salmon Recovery Board	
	Upper Columbia River Spring Chinook Salmon and Steelhead Recovery Plan 2007

Sponsoring Agencies and Contracted Entities	Study Report, or Associated Data Set
Washington Department of Fish and Wildlife	
	Integrated Status and Effectiveness Monitoring Program Expansion of Existing Smolt Trapping Program and Steelhead Spawner Surveys 2004
WA State Department of Ecology	
	Streamflow gaging data 2003-2008
	Irrigation withdrawal data 2002-2003
	Flow Summary for Gaging Stations on the Wenatchee River and Selected Tributaries 2005
	Wenatchee River Temperature Total Maximum Daily Load Study
Washington State Conservation Commission	
	Salmon, Steelhead, and Bull Trout Habitat Limiting Factors for WRIA 45 and portions of WRIA 40 within Chelan County (Squilchuck, Stemilt and Colockum drainages)
Chelan County Natural Resource Department	
Prepared by EES Consulting, Inc.	Final Technical Report Lower Wenatchee River PHABSIM Studies 2005
Prepared by Anchor Environmental, L.L.C.; EES Consulting, Inc.	Peshastin Subbasin Needs and Alternatives Study 2007
Prepared by Golder Associates, Inc.	Multi-Purpose Water Storage Assessment in the Wenatchee River Watershed 2006
Prepared by EES Consulting, Inc.	Channel thalweg longitudinal profile 2007
Cascadia Conservation District	
	Temperature Data

2.2 Human Alterations

Human alterations in the Peshastin Creek Basin have had wide-ranging effects on watershed and stream-scale processes and have resulted in significant changes to river form, function, and aquatic habitat conditions. This section summarizes the primary human alterations that have occurred throughout the basin since the time of European Settlement. This overview is intended to provide context for the evaluation of stream and habitat conditions within the lower Peshastin Creek study area (river mile 0 to 9.3).

2.2.1 Timeline of Human Disturbance

European settlement of the Peshastin Creek Basin began in earnest with the discovery of gold around 1860 (Andonaegui 2001). Activities such as logging, permanent settlement, irrigation diversion, road building, and agricultural activities supported the mining industry and proliferated as a result of it. By the turn of the century, much of the valley bottom of Peshastin Creek, particularly within the study area, had already been cleared (USFS 1999). These activities, and others, have continued until contemporary times, and have continued to impact streams and habitat conditions in numerous ways. Included below (Table 2) is an historical timeline of land-use, development, and other human alterations within the Peshastin Creek Basin.

Table 2. Historical timeline of human alteration within the Peshastin Creek Basin. Adapted from USFS (1999).

Date	Event	Activity
1860s	Gold discovered in Peshastin Creek	Placer mining in streams and along banks.
1874	First quartz lode claim filed	The first quartz lode claim was filed at Culver Gulch. Subsequent hard rock mining claims also filed in the Negro Creek drainage.
1879	Roading	A wagon road was constructed over the Wentachee divide connecting the Peshastin Mining District to commerce in Cle Elum
Late 1800s	Logging	A lot of timber removed to support mining operations (buildings, mine shoring, ore tracks, wood-fed furnaces, flume construction)
1890s 1900s	Flume construction/water diversions	After timber resources dwindled, flumes were constructed along the canyons to carry water to the mill which powered the stamp mills. The water in the flume was also used to sluice the crushed ore in mercury.
1893	Town of Blewett established	A community of 200-300 people was built up around the mineral exploration. The town was located at the mouth of Culver Gulch.
1894	Irrigation	Construction started on Peshastin Ditch ~2 miles above the mouth of Peshastin Creek on the eastern bank.
1896	Construction of cynide plant	A small cynide plant was erected at the mouth of Culver Gulch for the purpose of treating the trailings. Dams were built to catch the slimes from this process.
1898	Wagon road	The wagon road was completed north to Peshastin linking the Kittitas and Wenatchee Valleys.
By 1902	Land clearing	Lower Peshastin had already been cleared of four foot diameter pines for agricultural development. Conversion of riparian areas to orchards.
1915	Road building	A route was sought over Blewett Pass connecting to Snoqualmie Pass. By 1918, Model T's were crossing the pass. Road location sometimes channelized Peshastin Creek, resulting in abandoned flood plains.
1916	Grazing	All lands in the watershed open to grazing. Sheep were driven through Camas land.

Date	Event	Activity
1920	Peshastin Irrigation District formed	Six existing ditch companies (5 of which withdraw from Peshastin Creek) joined and purchased 40% of the water diverted by the Icicle Irrigation District to augment an inadequate supply.
1920s 1930s	Logging	Horses were used to pull logs out of the woods, either directly to a mill or to a wagon. It was not economically feasible to haul logs for more than a few miles so mill sites were often moved.
1925	Mill Creek Allotment	Used continuously by cattle and sometimes in conjunction with sheep, which were used in the more inaccessible areas and upper Allen Creek.
1936 - Present	Logging	The use of trucks to haul logs began. More expansive road networks and logging sites became accessible.
1956	Highway 97	The present day Blewett Pass Highway (Swauk Pass) is laid out and constructed. The location resulted in abandoned floodplains and channelized many sections of Peshastin and Tronsen Creeks.
1977	Municipal water supply	Developed on Allen Creek for the Valley Hi Community
1986 - 1992	Aerial photos	Aerial photos reveal continued urban encroachment and timber extraction in the watershed.

2.2.2 Land Ownership and Land Use

Most of the basin area (76%) is in federal ownership as part of the Wenatchee National Forest and Alpine Lakes Wilderness. Federal lands dominate the middle and upper portions of the basin. There is a checkerboard pattern of private and federal lands in the upper Peshastin Creek drainage and portions of the lower watershed. Private lands make up approximately 17% of the basin (Andonaegui 2001). Longview Fibre Company (a forest products company) is the dominant private landholder in the basin. Private lands are located primarily in the lower elevation portions of the basin and along the lower Peshastin Creek stream corridor. Current land use on private lands includes forestry (94.8%), residential (4%), and some commercial agriculture (WRIA 45 Planning Unit 2006). Though agriculture comprises a small portion of the total land use in the basin, irrigation demands have a significant impact on late summer flows in the downstream 4 miles. Flow withdrawals affect stream temperatures, habitat capacity, and fish passage.

The sections below provide additional detail on land uses and the associated impacts to stream habitat in the study area.

Mining

Mining within the Peshastin Creek Basin includes placer and lode mining. Placer strikes first occurred in the 1850s and a brief gold rush followed. Placer and lode mining have continued over time and still occur today, primarily in mineralized areas in Negro, Culver, Shaser, and Scotty Creek areas. Placer mining still continues today on lower Peshastin Creek within the study area, but it is mainly of a recreational nature and is subject to permits and regulations designed to protect aquatic habitat (USFS 1999). Placer mining, which includes the mining of alluvial deposits for minerals, can have detrimental impacts on stream channels, riparian areas, and floodplains. Large-scale placer mining operations can significantly alter stream channels and can contribute large quantities of fine sediment to streams. The hydrologic impacts of mining are most apparent when a claim is being actively mined. Dredging and hydraulic mining can cause local incision and disconnect floodplains. Long-term effects of mining are largely water quality issues related to erosion, ore processing, and drainage from tailings piles. In addition to the direct effects of mining, roads and settlements associated with mining contribute to the overall impact (USFS 1999).

Timber Harvest

Timber harvest in the basin largely supported mining needs in the late 1800s, providing materials for the construction of town sites, mine shafts, cart tracks, and stamp mills. With advances in technology in the early 20th century, logging as an independent commercial activity increased between 1920 and 1940, pushing harvests into more remote and steep areas of the basin (USFS 1999). In addition to direct removal of trees, logging activities include construction of haul roads that can have large cumulative effects on hydrology. Logging activities can lead to erosion/mass wasting, changes in runoff patterns, and impacts to floodplains and riparian areas. Though harvest rates have decreased in the late 20th century, some logging still occurs in the basin.

Agriculture/Irrigation

Grazing and fruit production are the two primary agricultural activities that have taken place in the basin. Orchards and vineyards make up nearly 98% of the agricultural crop production in the basin (NPCC 2004). Orchards were planted in the valley bottom of Peshastin Creek as early as 1900 (USFS 1999). Orchards occur mainly along the historical floodplain of Peshastin Creek and adjacent terraces. Initial planting of orchards required the clearing and conversion of floodplains and riparian areas, and had a large impact on riparian vegetation that continues to this day. Riparian buffers adjacent to orchards on lower Peshastin Creek are very narrow and likely have a detrimental impact on riparian function. Fertilizers and pesticides used in orchard production are likely to negatively impact water quality.

Grazing has occurred throughout the basin since the late 1800s. Large sheep drives occurred in the early 1900s and intensive grazing pressure extended into the 1920s, 1930s and 1940s. Cattle have been grazed in the basin since 1925. Grazing decreased after the 1960s. Currently there is no grazing on federal land within the basin (USFS 1999). Grazing in upland areas affects soil compaction and vegetation composition, and can alter runoff patterns and degrade water quality. Grazing in riparian areas can increase streambank erosion, reduce native riparian vegetation, and degrade water quality.

Irrigation for agriculture began in the late 1800s and continues to be one of the biggest impacts to aquatic habitat in the study area. The largest irrigation withdrawal is the Peshastin Canal, which is operated by the Peshastin Irrigation District and withdraws water from Peshastin Creek near river mile 2.5. The Tandy Ditch at river mile 4.9 is the second largest irrigation diversion in the basin. Irrigation withdrawals may de-water portions of lower Peshastin Creek during drought years (Andonaegui 2001) and may contribute to temperature and fish passage impairments (Anchor Environmental and EES Consulting 2007).

Residential Development

Residential development has followed other land-use activities in the basin. The first mining claims on Peshastin Creek saw a community of 200 to 300 people established about 13 miles upstream of the mouth of Peshastin Creek near the mouth Culver Gulch by 1893 (USFS 1999). This town site is no longer inhabited, and most residential development is located in the lower portion of the basin. There is significant residential development along the lower 8.4 miles of Peshastin Creek within the study area. Numerous residences are located within 200 feet of the stream channel and many of these have landscaping that extends to the stream channel. Residential development and clearing/maintenance for views and lawns can negatively affect riparian vegetation and streambank conditions. The native, mature riparian forest community is often compromised in favor of exotic species and grass lawns. These impacts can reduce the availability of mature, native vegetation that is important to provide stream shade, bank stability, and a recruitment source for instream large woody debris. Residential uses may also contribute chemical contamination from pesticides, herbicides, and fertilizers used for landscaping. Streambanks along residential areas are frequently treated with bank armoring (e.g. rip-rap) to protect private property, and in some areas, trails and access points may increase erosion.

Road Building

Construction of roads is a by-product of almost every other anthropogenic activity in the basin. The road network in the basin is composed of paved surfaces, unimproved forest roads, skid trails, and other cleared and compacted surfaces. Roads increase the length of the effective drainage network contributing to Peshastin Creek, potentially increasing the runoff volume generated from a particular precipitation event. The USFS (1999) reports that roads have increased the drainage network length by up to 70% in the upper basin, 47% in the study area (lower basin), and up to 60% in tributaries. The hydrologic response to road building and increased drainage length can be highly variable (King and Tenyson 1984). Increased drainage length may have no appreciable impact on the timing and magnitude of annual runoff, but may have an effect on short duration, high intensity storms.

In addition to increasing the effective length of the drainage network, valley bottom roads can also directly affect habitat and geomorphic processes. Road construction often results in channel straightening, floodplain disconnection, elimination of high flow channels, riparian clearing, and bank armoring. By reducing the channel's ability to dissipate energy through lateral movement and to attenuate floods through overbank flooding, road construction concentrates stream energy within the active channel resulting in channel incision, altered sediment transport, impaired aquatic habitat, and disturbance to geomorphic processes.

Highway 97 is the most prevalent anthropogenic feature currently affecting the lower mainstem and Tronson Creek. The present-day road alignment was constructed in 1956, although significant manipulations occurred in association with previous road construction. A total of 19,317 feet of stream channel was reconstructed as part of highway construction. The length of mainstem Peshastin Creek has been reduced by 0.8 miles and 34% of the floodplain has been disconnected (USFS 1999). Some of the greatest impacts have been to the wider, low elevation portions of Peshastin Creek within the study area (river mile 0 – 9.3). This area has experienced a reduction in channel length exceeding 0.3 miles and abandonment of greater than 42% of the floodplain. There are floodplain constrictions associated with bridges at river miles 1.4 and 5.0 (there are also several private bridges that cross the channel throughout the study area). Highway 97 abuts the channel directly for about 1.6 miles, or 18% of the total channel length in the study area. Between river miles 1.4 and 5.0, the roadway is directly adjacent to the channel for over 30% of the total channel length, and much of this segment has been hardened with rip-rap (Figure 2). Similar conditions exist where the roadway directly abuts the channel between RM 8.4 and 9.2.

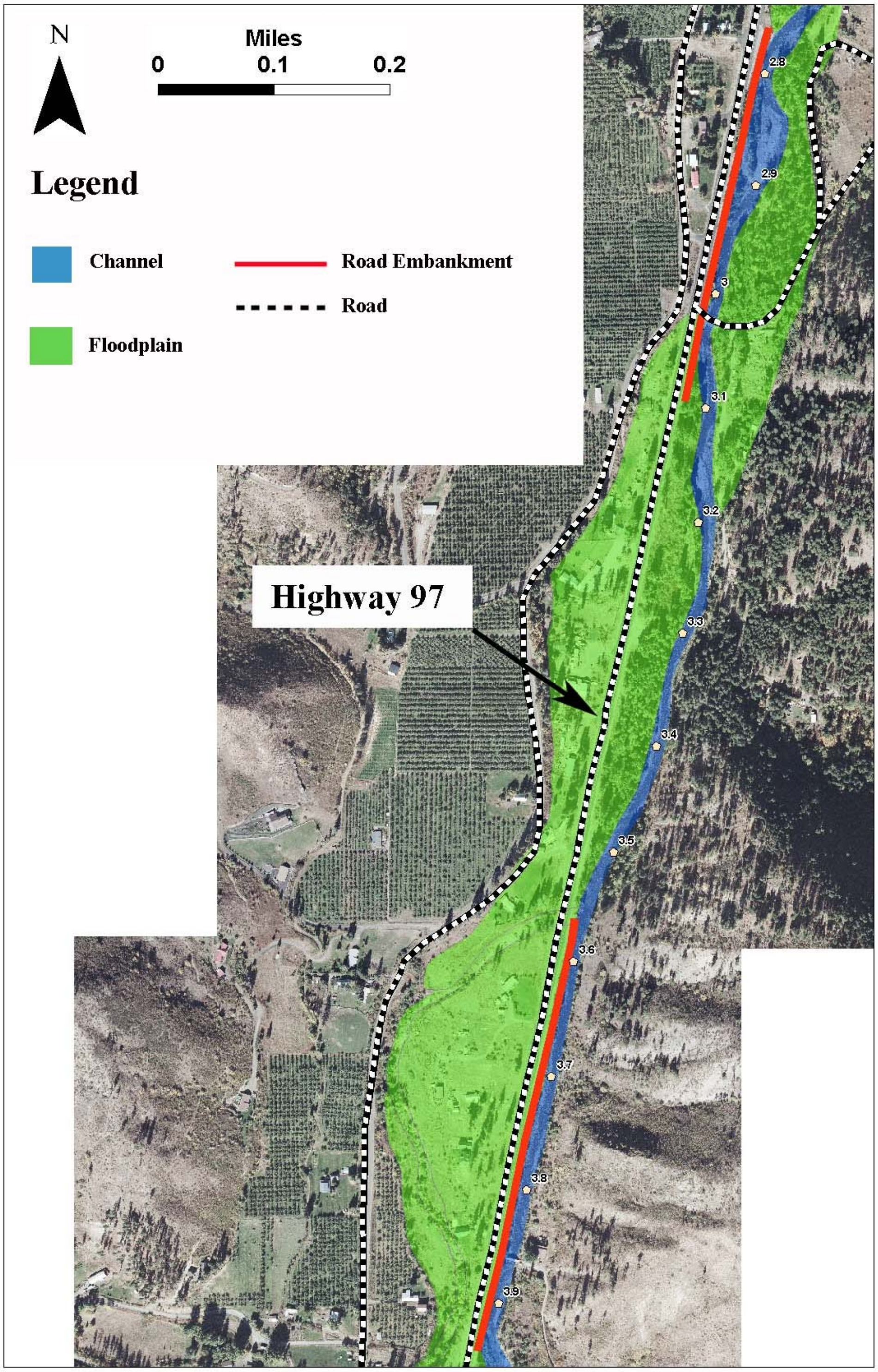


Figure 2. Aerial photo depicting channelization and floodplain disconnection due to Highway 97 between RM 2 and 3.

2.3 Geomorphology and Geology

2.3.1 Bedrock Lithology and Structure

Rocks in the Peshastin Creek Basin are consistent with the geology of the North Cascades geologic province where they are located, a region whose overall bedrock composition is primarily crystalline and metamorphic rock types but also sedimentary rocks (Lasmanis 1991). Two sedimentary formations of continental origin, the Swauk and Chumstick Formations, are the primary bedrock types in the Peshastin Creek Basin. Within the study area, the Chumstick Formation is the primary bedrock unit along the main channel as well as in tributaries and adjacent hillsides (WDGER 2005). This formation is composed mainly of sandstones and conglomerates that have been subsequently folded and faulted (USFS 1999). The resulting structural pattern creates hogback ridges (14% of the Basin area) that are subject to high surface erosion rates (Figure 3). Other rock types include intrusive mafic diabase rocks (gabbro) in the Camas drainage, older mafic intrusives in the Ingalls Tectonic Complex of the Ingalls Creek drainage, and the Mt. Stuart Batholith at the headwaters of Ingalls Creek which is composed of quartz diorite (granite) (WDGER 2005). The harder rock types in the Basin are less erodible, and often result in steeper stream gradients, larger and more durable channel substrate, and narrower valleys.

Figure 3. Low elevation aerial photograph of a large Chumstick Formation outcrop on a northwest facing slope of a hogback ridge near river mile 5.9. Sandstone outcrops such as this can contribute fine sediment to the channel over time.

From the mouth of Peshastin Creek to river mile 5.8, channel orientation coincides with the trace of a north/northeast trending fault (WDGER 2005). This suggests that the fault system is a control on channel orientation in this area. Further morphologic control appears to be exerted by faults that trend north/northwest between river miles 6.8 and 7.1. In this area, a west to east dog-leg occurs in the river coincident with the trace of mapped faults. The fault type and relative motion is not known.

2.3.2 Glacial History

The most recent large-scale glaciation in the region of the study area ended about 10,000 years ago. Deposits from that glacial period, and two others, correlate to glaciations extending back to 110,000 years ago. These glacial periods coincide with the Leavenworth, Chumstick, and Peshastin glaciations that have been mapped in the Icicle Creek drainage (Table 3, Porter 1969). The mapped till deposits extend from the mouth of Ingalls creek down to river mile 6.3, with till deposits potentially extending down to the mouth of Mill Creek at river mile 5.0. Downstream of Mill Creek to the mouth of Peshastin Creek, glacial deposits are primarily composed of outwash material suggesting a pro-glacial depositional environment, and a maximum extent of glacial ice somewhere upstream of river mile 5.0 (Figure 4). The depth of outwash material in the alluvial fan at the mouth of Peshastin Creek is up to 100 ft thick over an area of about 425 acres (MWG 2006). There are some indications that a glacial outburst flood on the Columbia River created backwater effects extending up the Wenatchee River, and that Peshastin Creek flowed into a lake at certain times (Porter 1969).

Table 3. Correlation of glacial deposits on Peshastin Creek to deposits found in the nearby Icicle Creek drainage, and the relative ages of these respective glacial periods (adapted from Porter 1969).

Glaciation periods that correlate with till deposits in the Icicle Creek Drainage	Tentative correlation to North American glacial stages	Correlation to till deposits on Peshastin Creek
Leavenworth	Late Wisconsin (20,000 years b.p.)	Advance to downstream of Ingalls Creek (Peshastin Creek river mile 9.2)
Chumstick	Early Wisconsin (70,000 years b.p.)	Advance to near Camas Creek (Peshastin Creek river mile 6.3)
Peshastin	Pre-Wisconsin (older than 70,000 years b.p.)	Advance to Mill Creek (Peshastin Creek river mile 5.0)

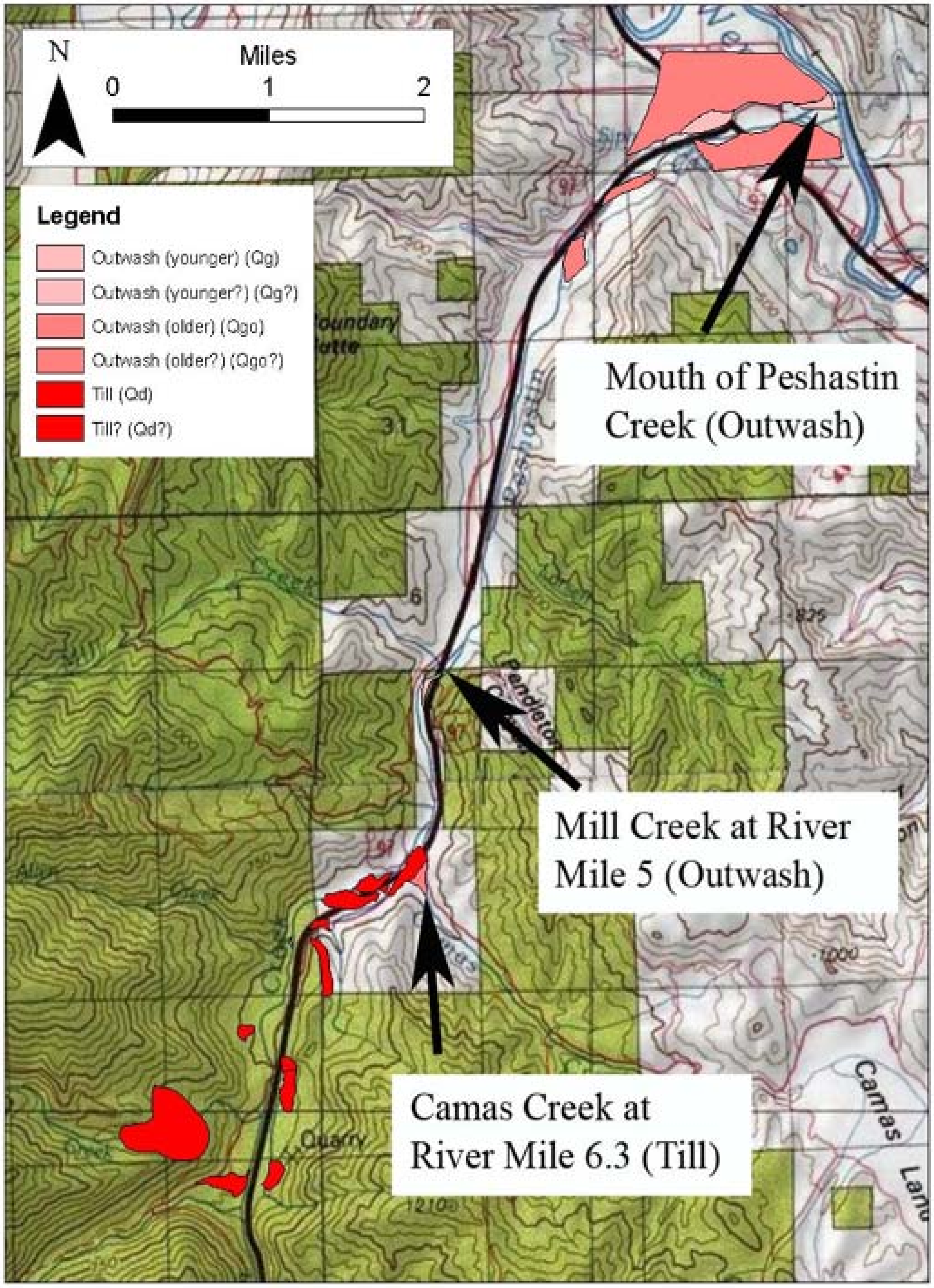


Figure 4. Topographic map depicting the locations of mapped glacial deposits in the study area.

2.3.3 Basin Geography

Peshastin Creek is a 5th order stream draining 135 square miles of the eastern slope of the

Cascade Mountains in central Washington State. The watershed area is triangularly shaped with a palmate drainage pattern drawing input from several tributaries with the primary being Ingalls Creek at river mile 9.2, which contributes approximately 65% of the annual flow. Peshastin Creek flows mainly north/northeast before joining the southeast flowing Wenatchee River. The total relief in the basin is 8,440 feet. Maximum elevation is 9,415 ft at the summit of Mt. Stuart and minimum elevation is 975 ft at the confluence with the Wenatchee River.

2.3.4 Valley Morphology

Current valley morphology owes primarily to the interplay between glacial erosion, bedrock lithology, and faulting. The valley bottom is relatively wide from the mouth of Ingalls Creek at river mile 9.2 to river mile 7.4 (Figure 5). At river mile 7.4, a bedrock promontory restricts the valley width and the river flows through a relatively narrow canyon down to river mile 6.3. Surficial geologic mapping suggests that glacial ice advanced down to at least river mile 6.3, which is the farthest downstream mapped glacial till unit. Between river mile 6.3 and river mile 5, the valley width remains narrow due to bedrock hillslopes that border the valley on both sides. Downstream of river mile 5, valley width increases again where the river alignment follows a fault trace (Figure 6). Glacial outwash has filled the valley bottom in this area. Modern colluvium and alluvial fan material generated from hillslopes and tributary drainages overlay outwash deposits here (Piety 2009). At river mile 1.4, valley width increases greatly as Peshastin Creek enters the Wenatchee River valley. Peshastin Creek has formed a broad alluvial fan within the Wenatchee River valley, with the current position of Peshastin Creek within the southeastern portion of the fan.

Figure 5. Low elevation aerial photo looking northeast in the downstream direction. The valley between river mile 8.4 and 7.4 is in the foreground. Valley width decreases immediately downstream, near the center of the photo. (August 2009)

Figure 6. Low elevation aerial photograph looking upstream toward the southwest. In the foreground, Peshastin Creek flows into the Wenatchee River Valley. In the background is Peshastin Valley. Valley width decreases greatly near river mile 5.0. (August 2009)

2.3.5 Sediment Sources

Sediment sources are provided by bed and bank material, tributary inputs, and hillslope inputs. Hillslope and tributary inputs are derived chiefly from sedimentary rocks within the Swauk or Chumstick Formations. The Chumstick Formation is the dominant formation, and has the potential for large mass wasting events caused by down slope trending bed plane failures within shale units (USFS 1999). The Chumstick Formation would be expected to provide fine-grain sediment out of sandstone and shale units, and some gravels out of conglomerates (Piety 2009). Much of the Ingalls Creek basin is granodiorite or quartz diorite, which provide larger and more durable channel substrate. At the stream valley scale within and upstream of the study area, sediment sources include bedrock (sedimentary), tributary deposits, and glacial deposits, providing a wide-range of material to the channel. Two significant sediment sources are the Larsen Creek drainage (junction near river mile 4.0) which saw a large fire and subsequent flooding in 1994, and the Ruby Creek slide (near river mile 10.4) which provided substantial fine sediment to the channel during the 1996 flood (Andonegui 2001) (Figure 7).

Human activity has the capacity to alter the contribution of sediment to the channel. Anthropogenic activities that have affected sediment contribution to the channel include logging, mining, agriculture, residential development, and road construction. The watershed has a naturally high surface erosion rate (NWPCC 2004) and therefore may be particularly susceptible to increased erosion through anthropogenic activities. Streambank condition (i.e. stability) has been rated poor for the watershed (USFS 1998) and the USFS rated fine sediment as a problem in Peshastin Creek (USFS 1993). Fine sediment sources have been attributed to high road densities, suction dredging and mining, and road sanding along mainstem Peshastin Creek and major tributaries (Andonegui 2001). Pebble counts conducted during the stream habitat survey (2009), and pebble counts conducted by the USBR in 2006 (USBR unpublished data), showed that fine sediment rarely exceeded 20% of the bed material composition. These data suggest that the proportion of fines may have decreased over time since previous studies (e.g. USFS 1993), although sample sizes in previous studies were low.

Figure 7. Low elevation aerial photo looking toward the northwest approximately 2.2 river miles upstream of the study area. The obvious slope instability on the left side of the photo is the Ruby Creek Slide.

2.3.6 Channel Morphology

Channel morphology is controlled by several factors including bank and bed material size, channel slope, riparian vegetation, and tributary inputs. In the lower 8.4 miles, mean channel bed slopes are 1 – 2% but locally (50 -100 ft scale) can be as high as 5% or 10% with maximum slopes of 25% and 30%. These locally steep sections occur in both confined and unconfined reaches. Channel types in lower Peshastin include plane-bed, pool-riffle, and step-pool, with plane-bed as the dominant type. Long, uniform, plane-bed riffles sometimes exceed 1,000 feet in length. In some cases, these sections are related to roadway encroachment where the channel has been straightened and the channel type altered. Between RM 8.4 and 9.3, there is no habitat or physical survey data available. However, the alignment of Highway 97 has straightened the channel dramatically, thus increased slope and decreased habitat complexity can be expected.

Within the study area, Peshastin Creek is dominated by coarse bank and bed material (Figure 8). Channel bed substrate is largely cobble and small boulder with smaller quantities of bedrock, gravels, and sand. The bed material is primarily derived from incised glacial deposits, hillslope sources, or tributary alluvial fan inputs. Based on pebble counts taken as part of the stream habitat assessment, median grain sizes range from 43 mm to 166 mm, with an average of 109 mm (See Habitat Assessment, Section 2.7). The percent of sediment smaller than 2 mm was usually less than 10% of a given sample. Sediment smaller than 2 mm exceeded 10% of the bed material at 30% of sample locations. Pebble count data is not available between RM 8.4 and 9.3, but ocular estimates place the majority of the material in the cobble/boulder size range.

Field observations and pebble counts suggest that many channel segments have developed a surface lag of coarse material on the bed, and therefore pebble counts spanning the active channel may not accurately represent the commonly-transported bedload. Surface lag develops due to winnowing of fine sediment between major transport events and is larger than material that would be found in transport during a moderate flood (i.e. on the order of a 1- to 5-year recurrence interval event). As part of previous studies, the USBR conducted pebble counts on bar deposits throughout the study reach (USBR 2006, unpublished data). The average median grain size for these measurements was 49 mm, compared to 109 mm for pebble counts taken at cross-sections spanning the active channel during the stream habitat survey (2009). The size of these bar sediments may be more indicative of the size of bedload material that is routinely transported during more frequent flood events.

Figure 8. Illustration of typical coarse bed and bank material along the study reach. River mile 4.5.

Large pulses of material delivered from hillslopes and tributaries often affect the shape of the longitudinal profile, with flatter slopes upstream of the material and steeper sections just downstream. This is evident at the slope break near river mile 7.5 (Figure 9), which appears to be a response to the Allen Creek alluvial fan. The remainder of the study area does not show any substantial expressions of these response modes, suggesting adjustment towards equilibrium since past sediment events. In general, the longitudinal profile is fairly uniform over the length of the study area. The average gradient between river mile 0 and 8.4 is 0.017. There is no channel survey data upstream of RM 8.4.

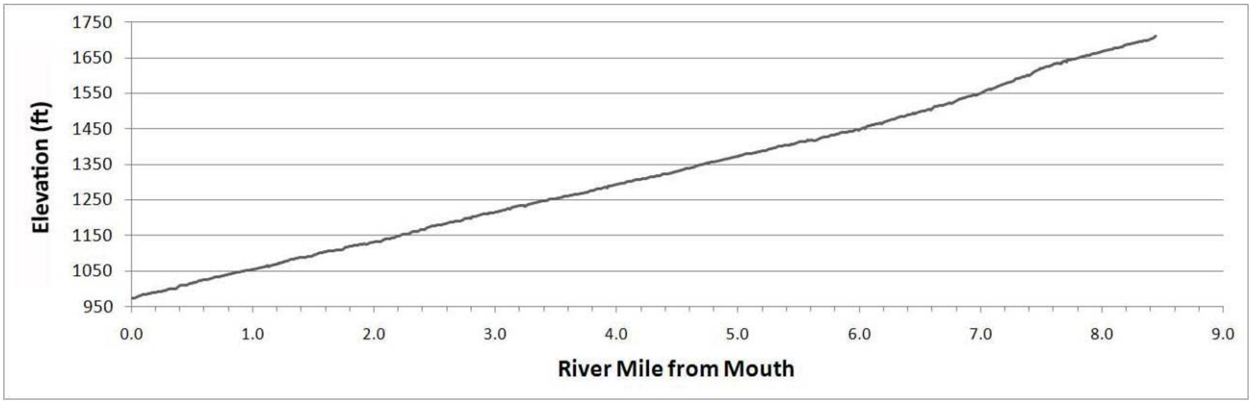


Figure 9. Longitudinal profile of Peshastin Creek within the study area. The profile shows the regularity of the profile without significant breaks in gradient (data collected by Pacific Geomatic Services 2007).

Anthropogenic channel straightening, riparian clearing, and floodplain disconnection have affected natural channel equilibrium processes. Stream segments once characterized by greater sinuosity and pool-riffle sequences have given way to straightened plane-bed segments with uniform bed topography (Figure 10) (USFS 1999). Higher gradient segments with natural confinement have been less impacted by roadway construction. These segments are influenced by large boulders and bedrock outcrops and exhibit step-pool morphology (Figure 11).

The Stream Habitat Assessment (Section 2.7) contains additional detail on channel morphology at the reach scale (river miles 0 – 8.4).

Figure 10. Upstream view near river mile 1.6. Long, plane-bed sections such as this are typical in the lower 8.4 miles of Peshastin Creek.

Figure 11. Step-pool channel with boulder and bedrock control near river mile 7.4.

2.3.7 Reach-Delineation

For assessment purposes, Peshastin Creek within the study area (river mile 0 to 9.3) has been divided into geomorphically distinct reaches based on valley morphology and geomorphic controls. Reach delineation was performed by the USBR in 2009 (Piety 2009) and included six reaches between river miles 0 and 9.3. The study area for this assessment extends up to river mile 9.3, which encompasses the USBR reaches 1 through 6. Reach 5b and 6 are lumped into a single reach for the purposes of this assessment. The location of the reaches is included in Figure 12.

2.3.8 Reach-Scale Geomorphology

Planform and stream channel geomorphic characteristics vary among the reaches within the study area. General comparisons among reaches are presented in Figure 12 and Figure 13. More in-depth discussions on reach-scale geomorphology are given in the Reach Assessment section of this report.

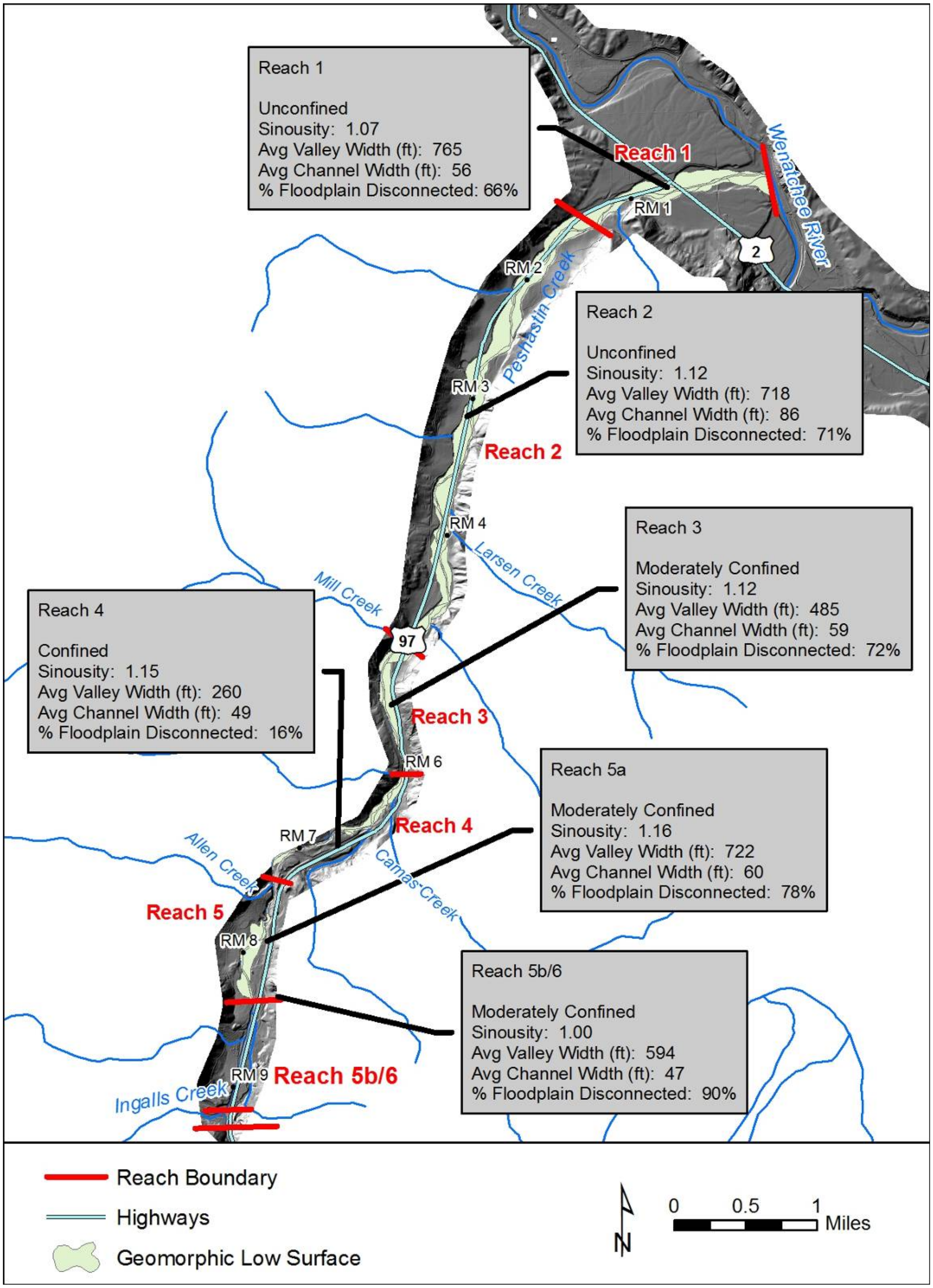


Figure 12. Map of reaches with planform geomorphology characteristics for each reach.

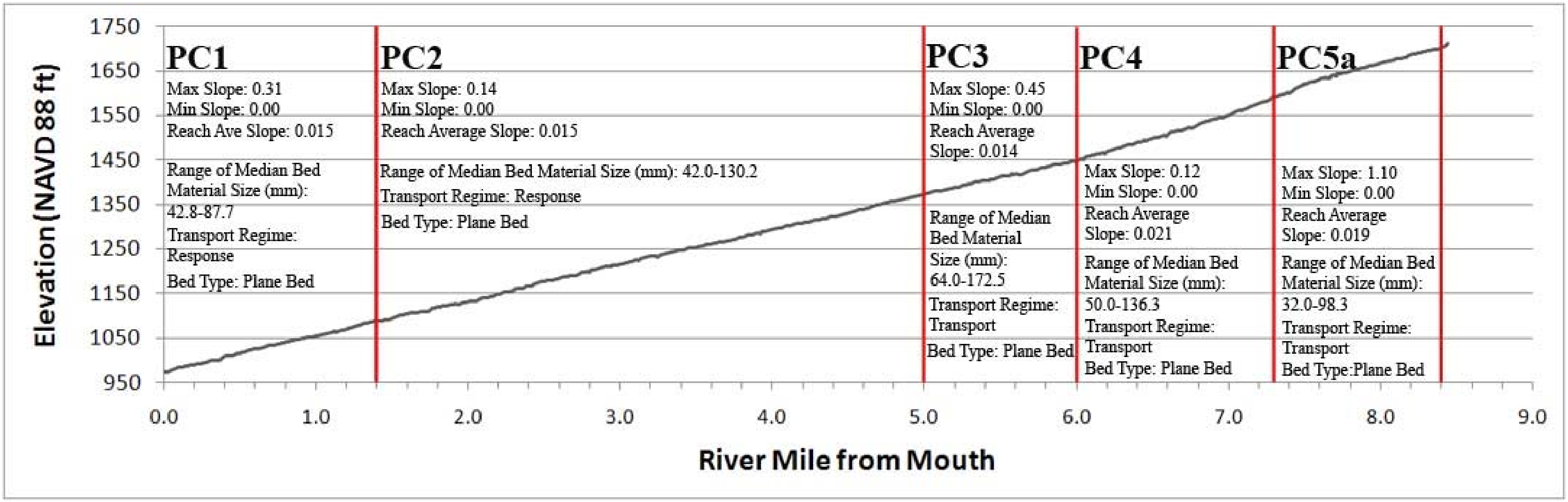


Figure 13. Longitudinal profile of the study area with reach breaks and stream bed characteristics for reaches 1 through 5a. Streambed survey data, substrate data and habitat data were not available for reach 5b/6.

2.4 Hydrology

This section describes basin hydrography, climate, flow regime, and flow augmentation within the Peshastin Creek Basin. Information is provided at the basin-scale in order to provide context for the reach-scale assessments within the lower Peshastin Creek study area (RM 0 and 9.3).

2.4.1 Hydrologic Setting

Peshastin Creek is a 5th order tributary of the Wenatchee River, which is a tributary of the Upper Columbia River (Figure 14). Peshastin Creek is a relatively small tributary to the Wenatchee River, contributing about 4% of the summer flow (NPCC 2004). The headwaters of Peshastin Creek and its primary tributaries are located in high elevation areas on the east slope of the Cascade Mountains. Mean annual precipitation is 35 inches near Blewett Pass, just east of the headwaters of Peshastin Creek; but it ranges from 15 to 80 inches throughout the watershed (NRCS SNOTEL 2009, USFS 1999). Over 53% of the total annual precipitation occurs during the months of November, December, and January (Figure 15). Average monthly temperatures are near freezing during these months, and snowfall is the main form of precipitation (Figure 16). Rising spring temperatures in April, May, and June give rise to snowmelt runoff and the annual high-flow season.

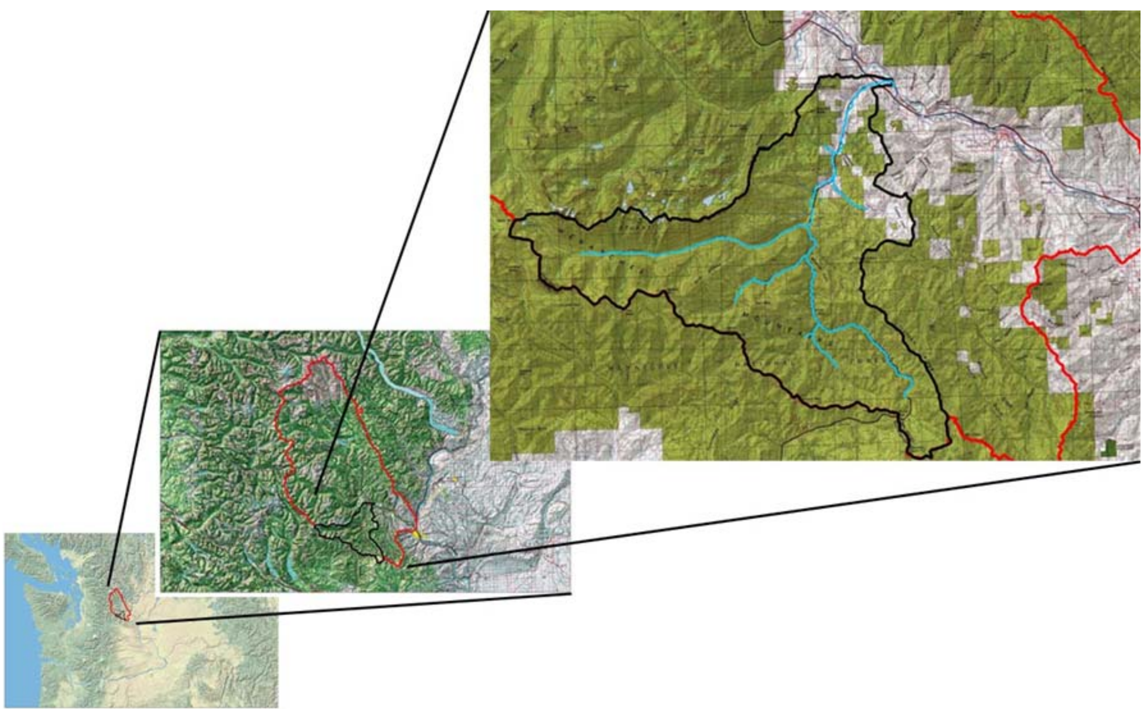


Figure 14. Hydrographic location. The Wenatchee River Watershed is outlined in Red. The Peshastin Creek Watershed is outlined in black.

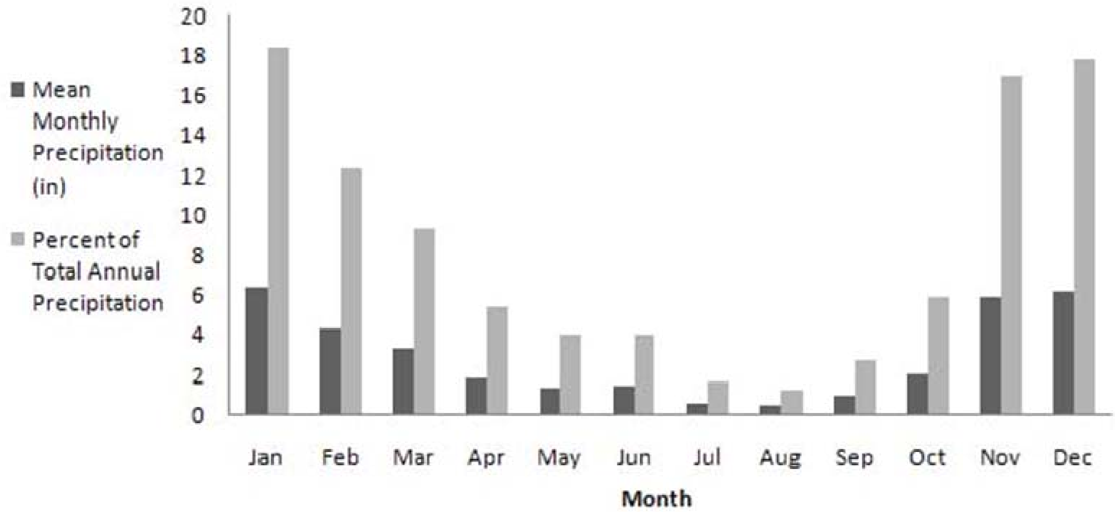


Figure 15. Mean annual precipitation patterns derived from NRCS SNOTEL data at Blewett Pass, near the headwaters of Peshastin Creek.

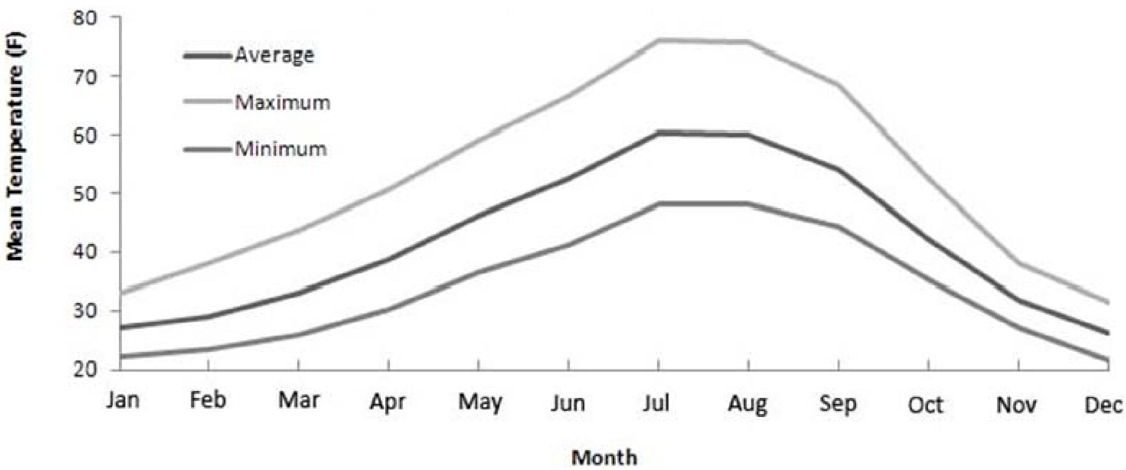


Figure 16. Mean annual temperature patterns derived from NRCS SNOTEL data at Blewett Pass, near the headwaters of Peshastin Creek.

2.4.2 Primary Tributaries

There are three primary tributaries in addition to the headwaters of Peshastin Creek: Tronsen Creek, Negro Creek, and Ingalls Creek (Figure 17). Ingalls Creek is the primary tributary, contributing about 65% of Peshastin Creek's annual flow. Ingalls is the largest tributary watershed (about 28% of the basin area) and includes the highest elevations. About 95% of the Ingalls Creek Watershed is designated wilderness and it has received much less anthropogenic impact than the rest of the basin over the last 150 years. Thus, natural runoff patterns and relatively unaltered delivery of wood, sediment, and nutrients are expected from the Ingalls Creek Basin (USFS 1999).

Negro Creek provides at least 30% of the flow for Peshastin Creek. Flow from Negro Creek lowers summer temperatures in Peshastin Creek downstream of the confluence. The Negro Creek watershed has been heavily mined, which has altered hillslopes, stream channels, and vegetation, resulting in altered runoff patterns and degraded water quality.

Tronsen Creek is the lesser of the tributaries in terms of flow contribution. Highway 97 construction has had a deleterious effect on Tronsen Creek by straightening over one mile of channel. Habitat conditions in Tronsen Creek are poor (USFS 1999).

Several smaller tributaries (some perennial and some seasonal) flow into Peshastin Creek throughout the Basin. Within the study area these include Allen Creek, Camas Creek, Larsen Creek, and Mill Creek. Most of these drainages have been altered through logging, mining, or agriculture. In addition, 1994 saw widespread fires in these drainages, resulting in an overall reduction in riparian and upland forest cover and increased erosion rates (USFS 1999).

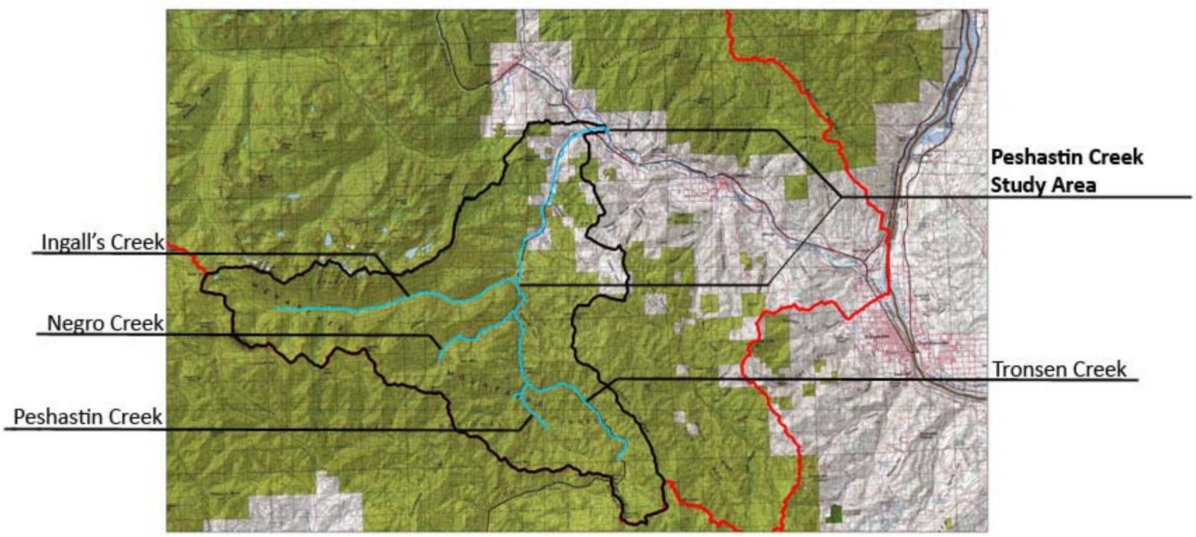


Figure 17. Major Peshastin Creek tributaries. The study area is located between river mile 0 and 9.3.

2.4.3 Streamflow

Streamflow data is limited in the Peshastin Basin. The Washington State Department of Ecology (WADOE) has operated a continuous stream gage on Peshastin Creek near river mile 1.4 since 2003. Some of the data obtained from this gage is considered preliminary, and the short period of record is not conducive to robust flood frequency calculations. It is useful, however, for representing the general variation in seasonal flow patterns (Figure 18). The hydrograph indicates a typical spring snowmelt pattern, with the highest flows occurring in May and June and the lowest flows occurring Aug to October. Winter flows tend to be moderate. Occasional fall, winter, and spring peaks occur due to rain or rain-on-snow events. Summer low flows are occasionally increased briefly by high-intensity thunderstorms.

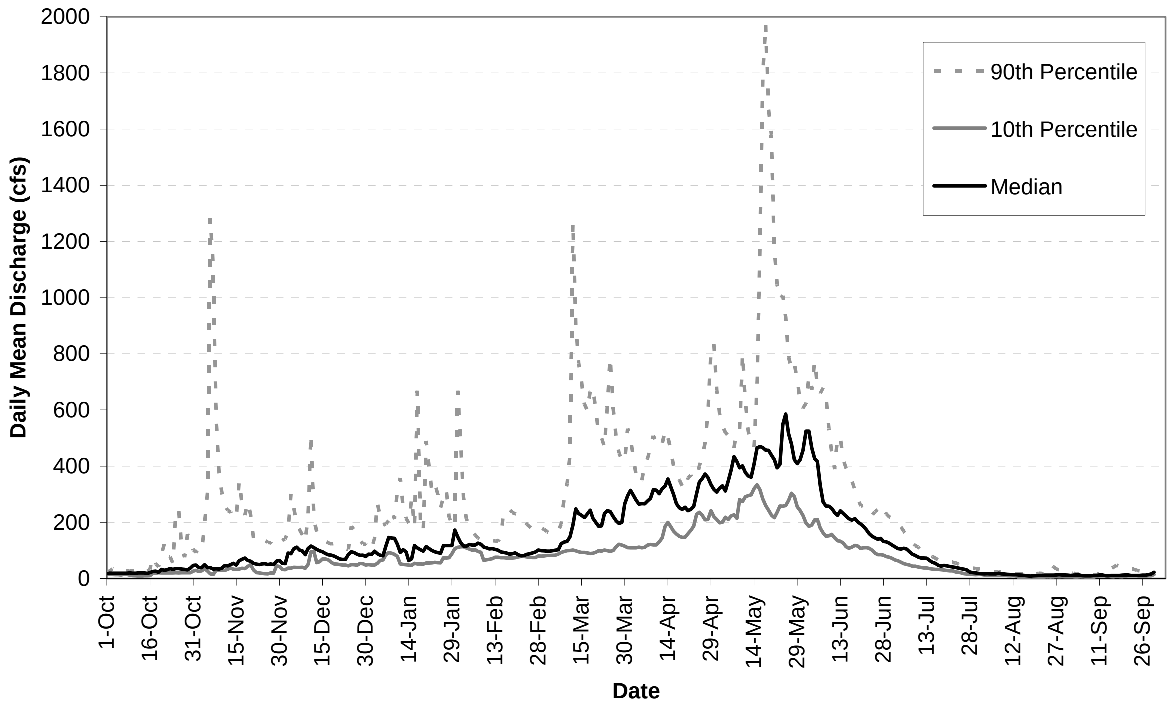


Figure 18. Daily median, 10th percentile, and 90th percentile streamflows for water years 2003 – 2008 (WADOE gage "Peshastin Ck @ Green Bridge Rd", ID#45F070).

2.4.4 Flooding

Direct measurements of large floods are mostly unavailable for Peshastin Creek; however, data from the Wenatchee River at the Peshastin Gage gives a good indication of the relative magnitude and years of large floods that occurred in the area (Figure 19). These floods would be expected to correlate with big floods on Peshastin Creek. Although annual peak events typically occur in the spring as a result of snowmelt runoff, some of the largest and most damaging floods have occurred in the fall and winter as a result of rain or rain-on-snow events. Large floods (25 year recurrence and greater) in the Wenatchee Basin occurred in 1948 (>50-year event), 1990 (≥100 year event), 1995 (≥100 year event), and 2006 (>25 year event). The flood of November 1995 is the largest flood on record for the Wenatchee River, and is considered a 100-year event (FEMA 2004). In addition, floods in 1972 and 1957 were reported as "extremely damaging" by FEMA. The largest recent flood on the Wenatchee River was a 25-year event that occurred on November 6 and 7, 2006. Although the WADOE Peshastin Creek gage was operating during this period, the data is considered an "unreliable estimate" and is excluded from the published record (WADOE 2010).

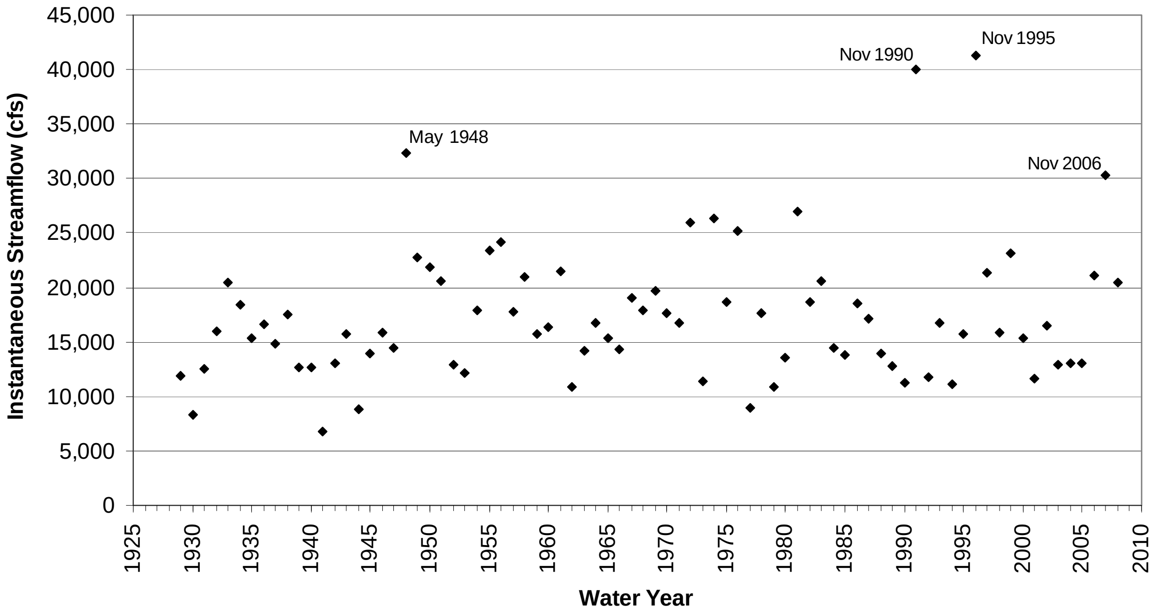


Figure 19. Annual peak flows for the period of record at USGS Gage #12459000 (Wenatchee at Peshastin Creek).

A flood frequency analysis was completed for subwatersheds within the Wenatchee River Basin by the USBR as part of the Nason Creek Tributary Assessment (USBR 2008). This data is presented in Table 4 for multiple locations along the Peshastin mainstem and major tributary basins. These data were obtained by conducting a regional gage analysis (USBR 2008). The values for the mouth of Peshastin Creek are higher than estimates made by FEMA (2008) that used USGS regional regression equations and gage data from Icicle Creek (Table 5).

Table 4. Estimated flood discharges for selected recurrence intervals at several locations on mainstem Peshastin Creek and major tributaries. Data obtained from GIS data layer provided by the USBR (2008).

	River	Flood Recurrence Interval (ft^3/sec)					
Location	**Mile**	**Q2**	**Q5**	**Q10**	**Q25**	**Q50**	**Q100**
Mainstem Peshastin Creek							
Peshastin at Mouth	0	1,212	1,856	2,369	3,121	3,765	4,485
Peshastin above Mill Creek	5	1,007	1,543	1,969	2,595	3,130	3,728
Peshastin above Camas Creek	6.1	895	1,371	1,750	2,306	2,781	3,312
Peshastin above Ingalls Creek	9.2	412	631	806	1,062	1,280	1,525
Peshastin above Negro Creek	11	252	387	493	650	784	934
Peshastin above Magnet Creek		93	142	181	239	288	343
Peshastin above Shaser Creek		39	60	76	101	122	145
Tributary Basins							
Mill Creek		17	26	33	44	53	63
Camas Creek		34	52	67	88	106	126
Ingalls Creek		221	339	433	570	688	820
Negro Creek		50	77	98	129	156	186
Shaser Creek		34	51	66	87	104	124
Transen Creek		73	112	143	188	227	270

Table 5. Estimated flood discharges for selected recurrence intervals for the mouth of Peshastin Creek calculated using USGS regional regression equations and gage data from Icicle Creek. Adapted from FEMA (2008).

Location	River Mile	Flood Recurrence Interval (ft^3/sec) Q10	Q50	Q100	Q500
Peshastin at mouth	0	1,980	3,210	3,790	5,130

2.4.5 Flow Augmentation

Irrigation demands for local agriculture drive the need for flow alteration to Peshastin Creek (Anchor Environmental and EES Consulting 2007). There are two primary irrigation diversions on the mainstem of Peshastin Creek within the study area (Figure 20). Located near river mile 2.5, the primary agricultural diversion in the basin supplies the Peshastin Canal operated by the Peshastin Irrigation District (Figure 21). The Peshastin Canal has a maximum capacity of 40 cfs, which far surpasses the maximum capacity of any other diversion in the basin. The next largest diversion is located at river mile 4.9 and supplies the Tandy Ditch at a maximum rate 4.6 cfs (Figure 22). The Tandy Ditch is also operated by the Peshastin Irrigation District. A few small diversions are located on Mill Creek and other unnamed tributaries to Peshastin Creek (Andonegui 2001).

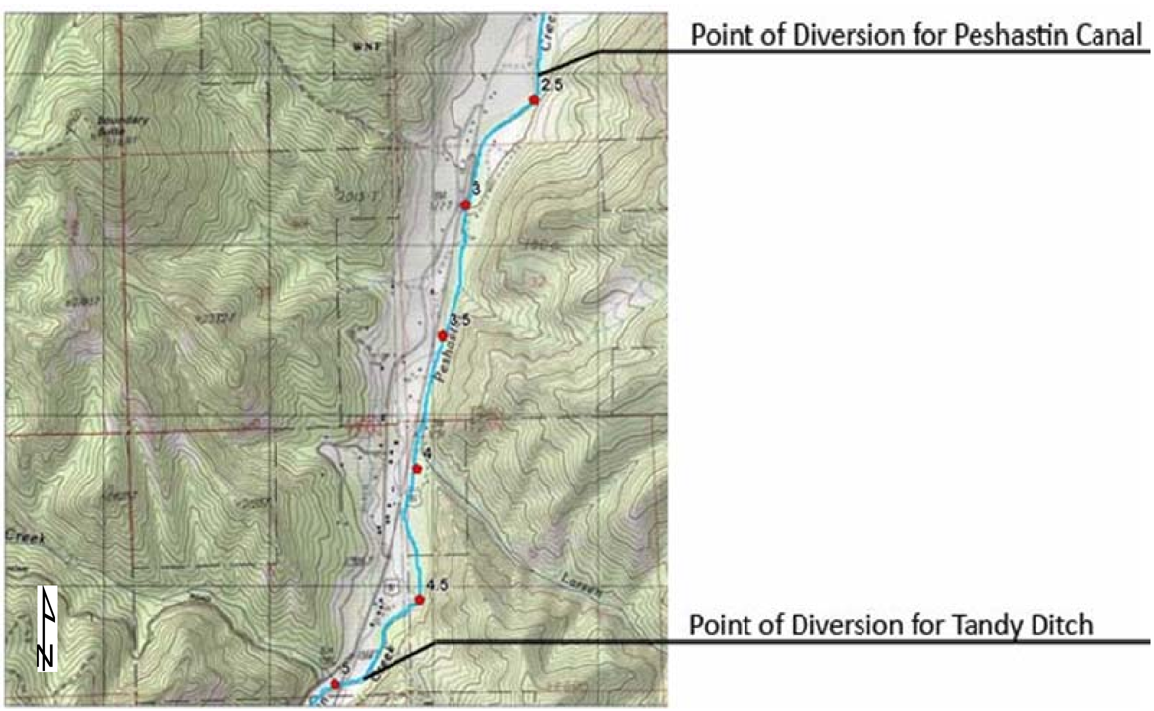


Figure 20. Locations of major diversions on Peshastin Creek. Flow is towards top of figure. Red dots are river mile locations.

Figure 21. View looking upstream toward the southwest at the Peshastin Canal diversion near river mile 2.5.

Figure 22. View looking to the north at the Tandy Ditch diversion near river mile 4.9.

The rate of diversion and the total volume of water diverted annually depend on several factors including natural rainfall, available water in Peshastin Creek, and timing of harvest for local agricultural products. The irrigation season typically runs from April through mid-September with a cut-off date of September 15th. Peak diversions typically occur during June and July. Flow diversions are not large enough to significantly alter the shape of the hydrograph or the magnitude of peak flows (Figure 23). However, as flows decrease later in the summer and irrigation withdrawal rates are maintained, diversion begins to have a proportionally greater impact on instream flows (Figure 24). Portions of the channel downstream of the main diversion at river 2.5 may become de-watered during drought years (Andonaegui 2001). These critically low baseflows create depth and temperature barriers for fish passage. In addition, the diversion canal intercepts flow from several small tributaries that enter lower Peshastin Creek from the east; in some cases eliminating their connection with Peshastin Creek (Andonaegui 2001).

In addition to flow withdrawals, flow addition to Peshastin Creek is also possible via the Icicle creek drainage. Three cross-basin diversions exist, with the potential to deliver over 30 cfs to Peshastin Creek or the Peshastin Canal.

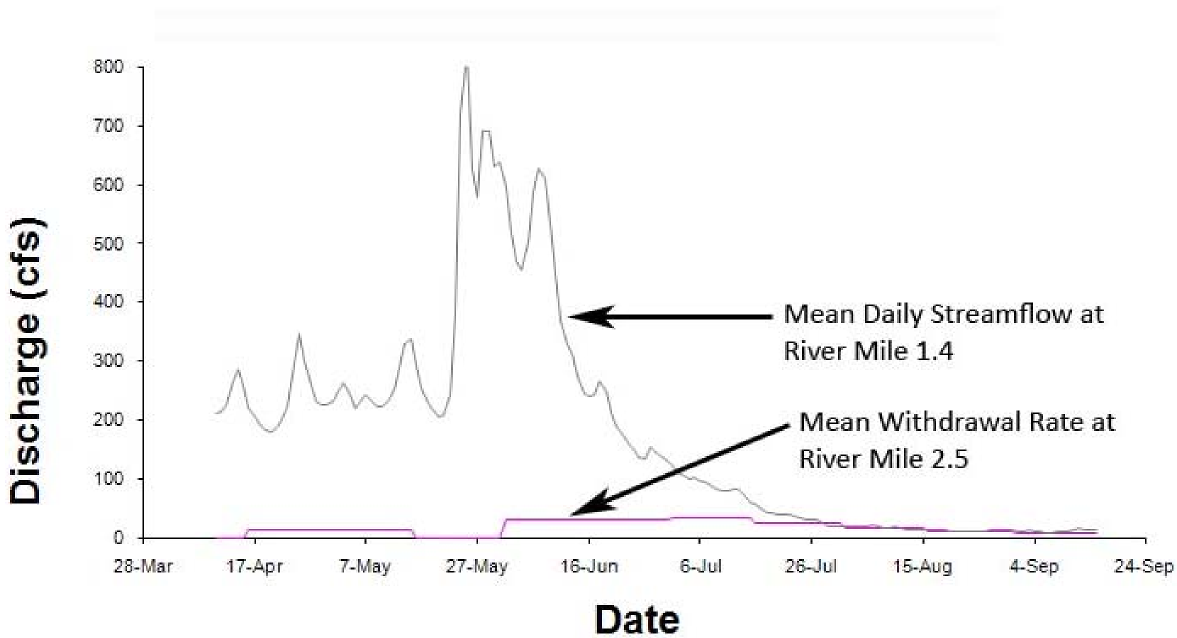


Figure 23. Plot of mean daily streamflow and mean withdrawal rate for Peshastin Creek for part of the year in 2003. High flows are proportionally less affected by withdrawal than low flows.

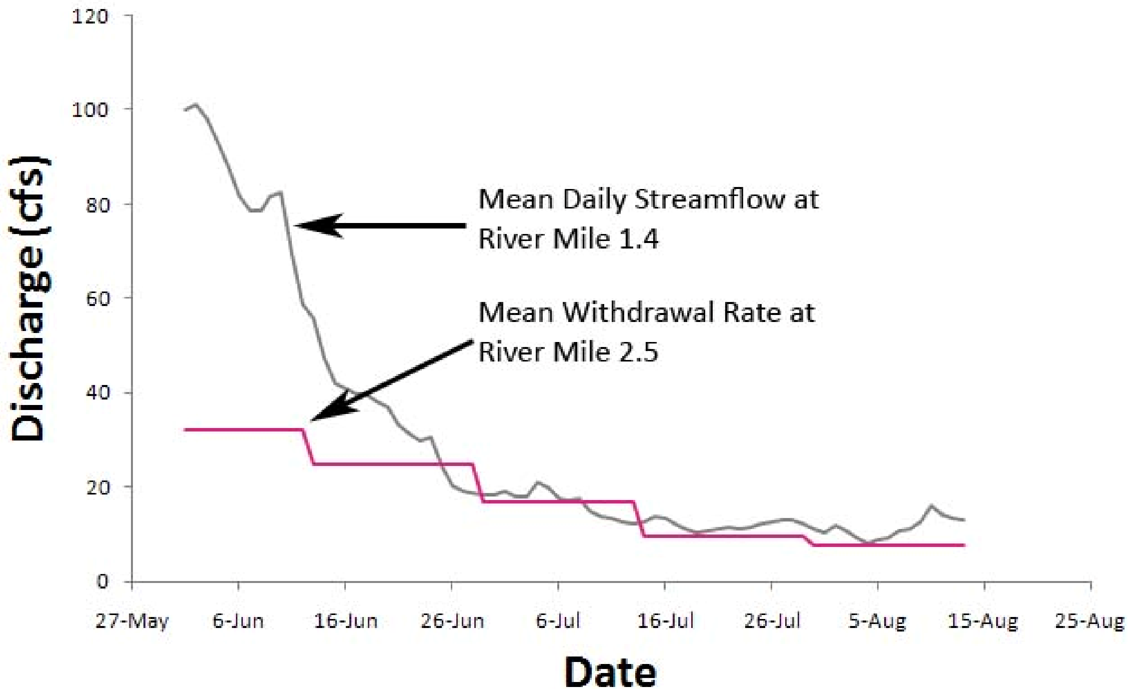


Figure 24. Plot of mean daily streamflow and mean bi-weekly withdrawal rate for Peshastin Creek for the late summer irrigation season in 2003.

2.5 Hydraulics and Sediment Mobility Assessment

2.5.1 Flood Inundation Assessment

A flood inundation assessment was performed to support the Peshastin Creek Reach Assessment, including project identification and future project evaluation and design. Inundation analysis and mapping was conducted in order to represent how flow is distributed across the Peshastin Creek floodplain at a high frequency, moderate flood event (2-year flood) and a low frequency, large flood event (100-year flood).

Methods

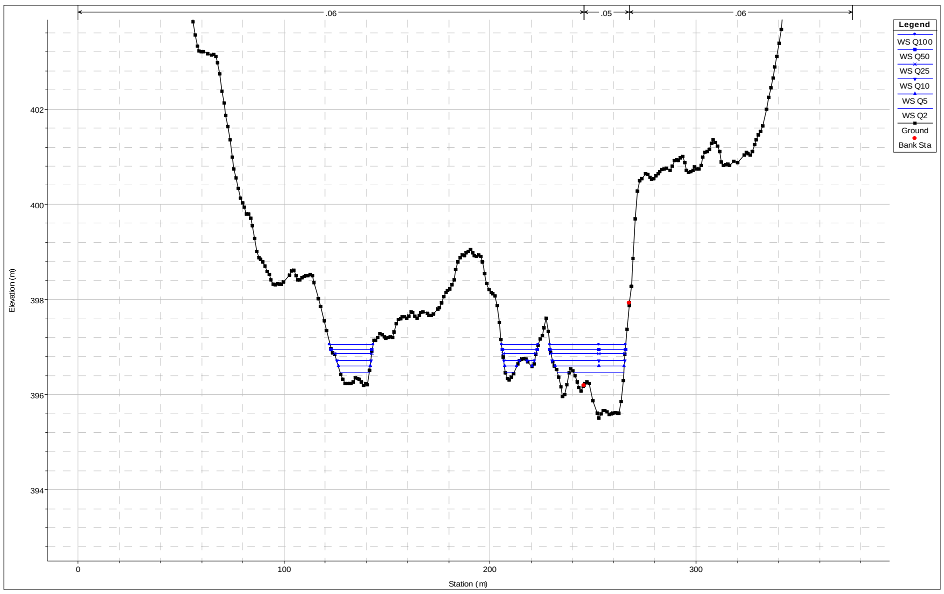
Floodplain inundation was modeled using the HEC-GeoRAS tool for ArcGIS and the 2006 LiDAR (Light Detection and Ranging) data set for topography. HEC-GeoRAS allows the user to build a georeferenced hydraulic model in GIS, perform the 1-dimensional modeling in HEC-RAS, and visualize results in GIS. The process of creating a hydraulic model using HEC GeoRAS includes building the key features and boundaries of the model system, including stream centerline, bank stations, overbank flowpaths, and cross sections. These features are overlaid on a digital elevation model (in this case, LiDAR) from which elevations are extracted for all components of the geometric data set. Cross sections were spaced every 150 ft. Once the geometric data was developed, the model was exported from ArcGIS and brought into HEC-RAS 4.0. Steady-flow data was input based on flood frequency data at several river stations (see Table 6). For the purposes of this effort, we used a Manning's n value of 0.05 for the channel and 0.06 for overbank areas based on the average channel geometry and roughness characteristics (USGS 2010).

Table 6. Flood frequency data used in the hydraulic model developed for the inundation mapping effort. Original data from USBR (2008). See the Hydrology Section (Section 2.4) for more information.

Location	River Mile	Flood Recurrence Interval (ft^3/sec)					
		Q2	Q5	Q10	Q25	Q50	Q100
Mainstem Peshastin Creek							
Peshastin at Mouth	0	1,212	1,856	2,369	3,121	3,765	4,485
Peshastin above Mill Creek	5	1,007	1,543	1,969	2,595	3,130	3,728
Peshastin above Camas Creek	6.1	895	1,371	1,750	2,306	2,781	3,312
Peshastin above Ingalls Creek	9.2	412	631	806	1,062	1,280	1,525
Peshastin above Negro Creek	11	252	387	493	650	784	934

Several model iterations and edits of geometric data were performed in order to provide the best representation of actual site conditions. Because HEC-RAS is not a suitable tool for modeling subsurface flow, "levees" were inserted to restrict river flow to surface and overbank pathways. For example, construction of Highway 97 created numerous abandoned channel sections that are no longer connected to the mainstem. The "levee" function was used to prevent flow from entering these areas in the model (see Figure 25). Furthermore, ineffective flow areas were created for locations where backwaters form at high flow. Defining an ineffective flow area is appropriate for locations that do not convey water downstream.

A)



B)

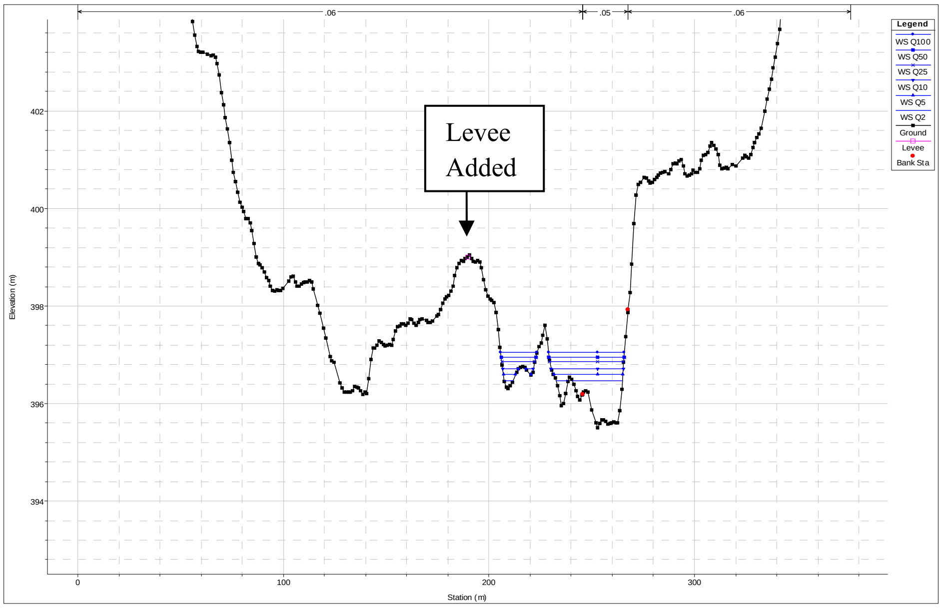


Figure 25. Sample HEC-RAS cross-section for Peshastin Creek displaying the 2, 5, 10, 25, 50 and 100-year flood elevations. In the top figure (A), HEC-RAS allocates some of the flow to the river left depression (cut-off channel) despite a lack of surface connection with the mainstem. As seen in the bottom figure (B), the "levee" function was used in the model to prevent flow from entering these areas.

Results

Inundation mapping results are presented in the 12 maps located at the end of this section. There are limitations of using LiDAR data in this application. The LiDAR data available for Peshastin Creek is capable of producing accurate elevation data in terrestrial environments but cannot produce ground elevations below water (i.e. bathymetry). Despite this limitation, the inundation analysis is assumed to be relatively accurate for larger flood flows (i.e. 2-year return interval and above), where the topography errors would have less effect (proportionally) on the results.

2.5.2 Stream Energy and Bed Mobility Analysis

Stream energy and the potential for bed sediment mobility were evaluated for the study area (river mile 0 to 8.4) using an excess shear stress analysis and a stream power analysis. These analyses suggest some general patterns in stream energy and bed mobility potential in lower Peshastin Creek. These analyses help to develop our understanding of the physical characteristics and processes operating throughout the study area. The information will be useful for evaluating reach-scale sediment transport and response conditions and will help inform the project evaluation process.

Excess shear stress analysis

The excess shear stress analysis was performed for the 2-year return interval flow. Excess shear stress is defined as the ratio of shear stress exerted by flow (τ) to the critical shear stress needed to mobilize bed sediments (τ_{crit}):

$$\frac{\tau}{\tau_{crit}}$$

If the shear stress applied to the channel exceeds the critical shear stress for a given particle size, then that particle is assumed to be mobile. Mobility of the D_{84} particle size was assumed to represent the threshold at which the bed is mobilized for Peshastin Creek, which is mostly comprised of step-pool and cobble/boulder planebed reaches. In these types of systems, the larger, grade controlling particles that make up the bed tend to govern bed mobility and channel form (i.e. only once these particles become mobile does significant bed re-shaping occur) (Grant et al. 1990, Chin 1998).

In boulder-bed channels, larger particles may be entrained at lower flow thresholds because of their protrusion above smaller neighboring particles, which increases their exposure to flow and reduces their pivoting angles (Komar and Li 1986). In order to take into account the potential effect of particle exposure, critical shear stress was calculated using a method that modifies the Shield's parameter according to the size of the difference between the D_{50} and the particle size of interest (D_{84} for this study, Komar 1987). The equation for τ_{crit} is as follows:

$$\tau_{crit} = 102.6\tau^{*}_{D50} D_i^{0.3} D_{50}^{0.7}$$

Where τ_{crit} is the critical shear stress (lb/ft^2) at which the D_i particle size is mobile, τ^{*}_{D50} is the Shield's parameter for the D_{50}, and D_i is the particle size of interest (in ft), and D_{50} is the median particle size (in ft). Shield's parameters for the D_{50} were taken from Julien (1995).

The excess shear stress analysis was performed using the D_{84} from Inter-Fluve and USFS pebble counts at 28 locations (Figure 26). The output from the HEC-RAS model was used for the total shear stress applied to the bed (τ). In order to limit the impact of variability of shear stress between cross-sections, shear stress applied to the channel was taken as the average of two or more cross sections surrounding the pebble count location. In most cases, this included the cross section from the hydraulic model that was closest to the pebble count location, one upstream and one downstream cross section.

The results of the excess shear stress analysis are summarized in Figure 27 by reach and river mile. Results should be interpreted with caution given model resolution and low frequency of pebble count data. In general, the largest excess shear values occur in the downstream portion of the study area (Reaches 1 and 2), whereas the smallest values occur in the upstream portion (Reaches 4 and 5). This may be attributable to decreasing grain size in the downstream direction, resulting in lower thresholds for sediment transport.

Stream power analysis

To supplement the excess shear stress analysis, stream power was analyzed to identify high energy reaches in Peshastin Creek. Stream power (Ω) is a measure of the potential energy exerted per unit length of channel (Knighton 1998). Stream power is controlled by the quantity of flow and the steepness of the channel:

$$\Omega = \gamma Q s$$

where γ is the specific weight of water, Q is discharge, and s is slope.

Stream power calculations were output from the HEC-RAS model and plotted against river mile with excess shear stress for the 2-year flood discharge.

Stream power ranges from 0.2 to 34.1 lb ft^{-1} s^{-1} for the 9.3 miles of Peshastin Creek analyzed. Mean stream power by reach ranges from 10.3 to 15.0 lb ft^{-1} s^{-1}. The distribution of stream power is generally consistent with the results of the excess shear analysis; i.e. lower energy reaches in the upstream portion of the study area.

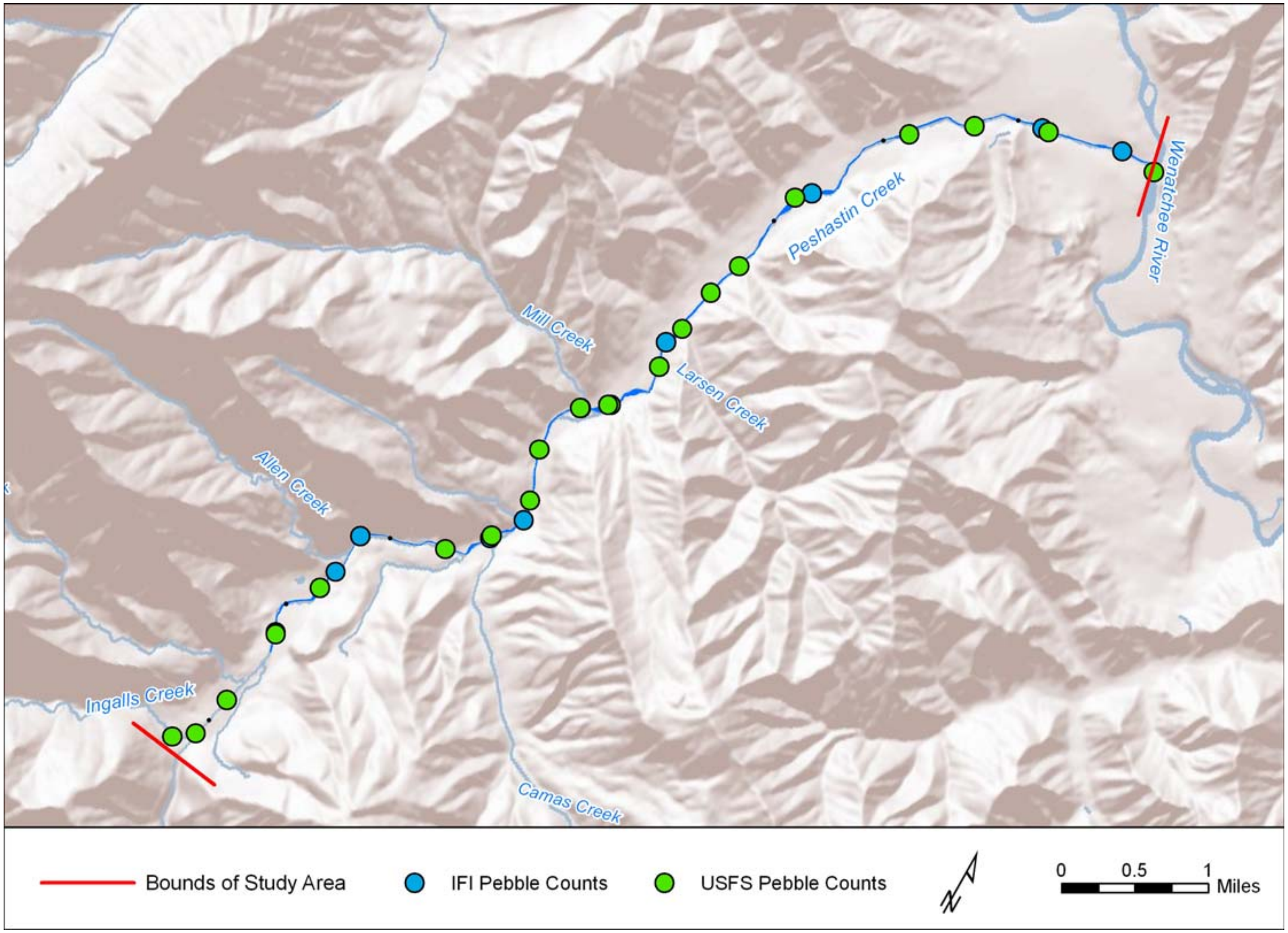


Figure 26. Overview map of Peshastin Creek showing locations where pebble counts were collected by Inter-Fluve and USFS.

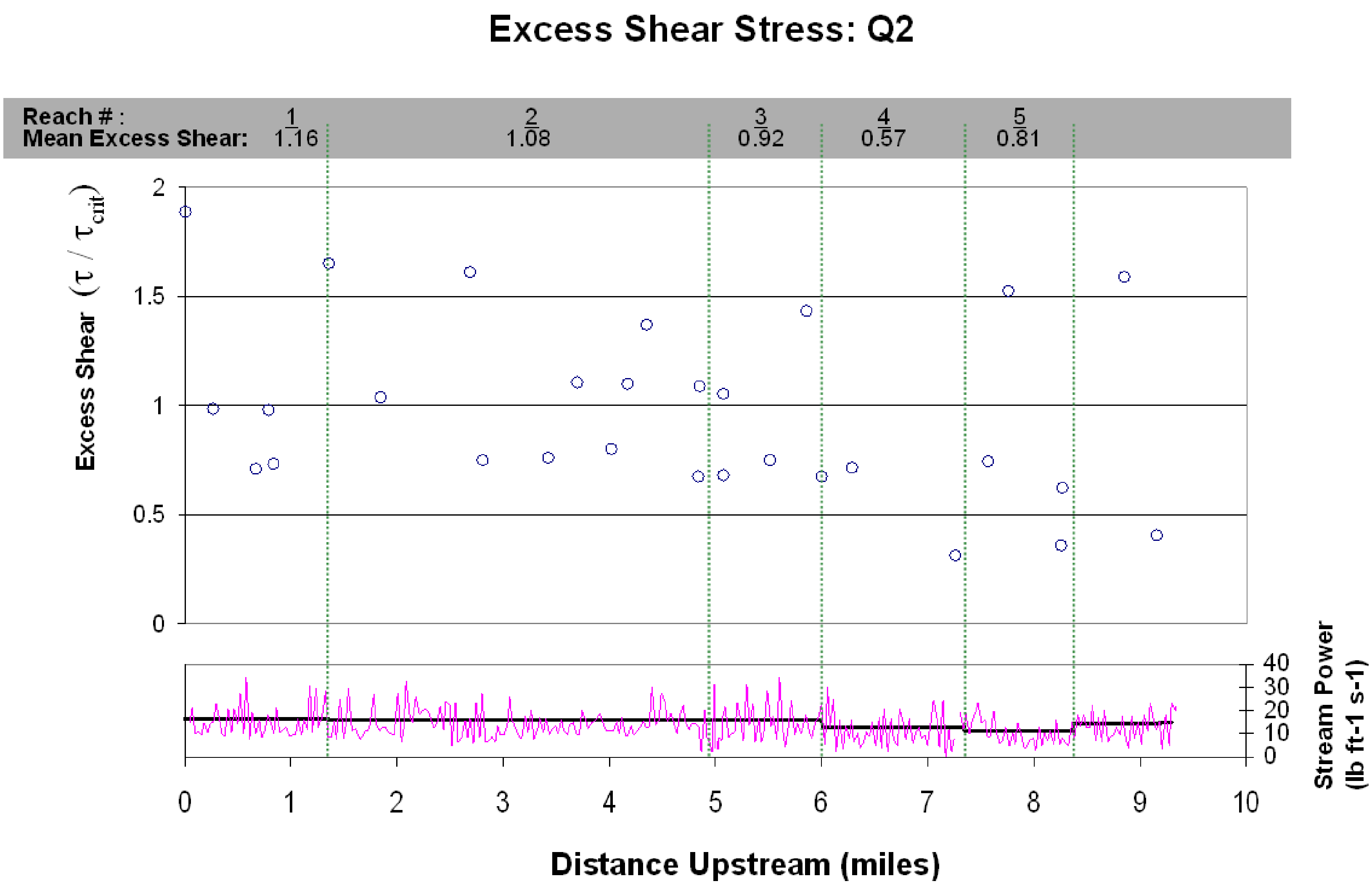
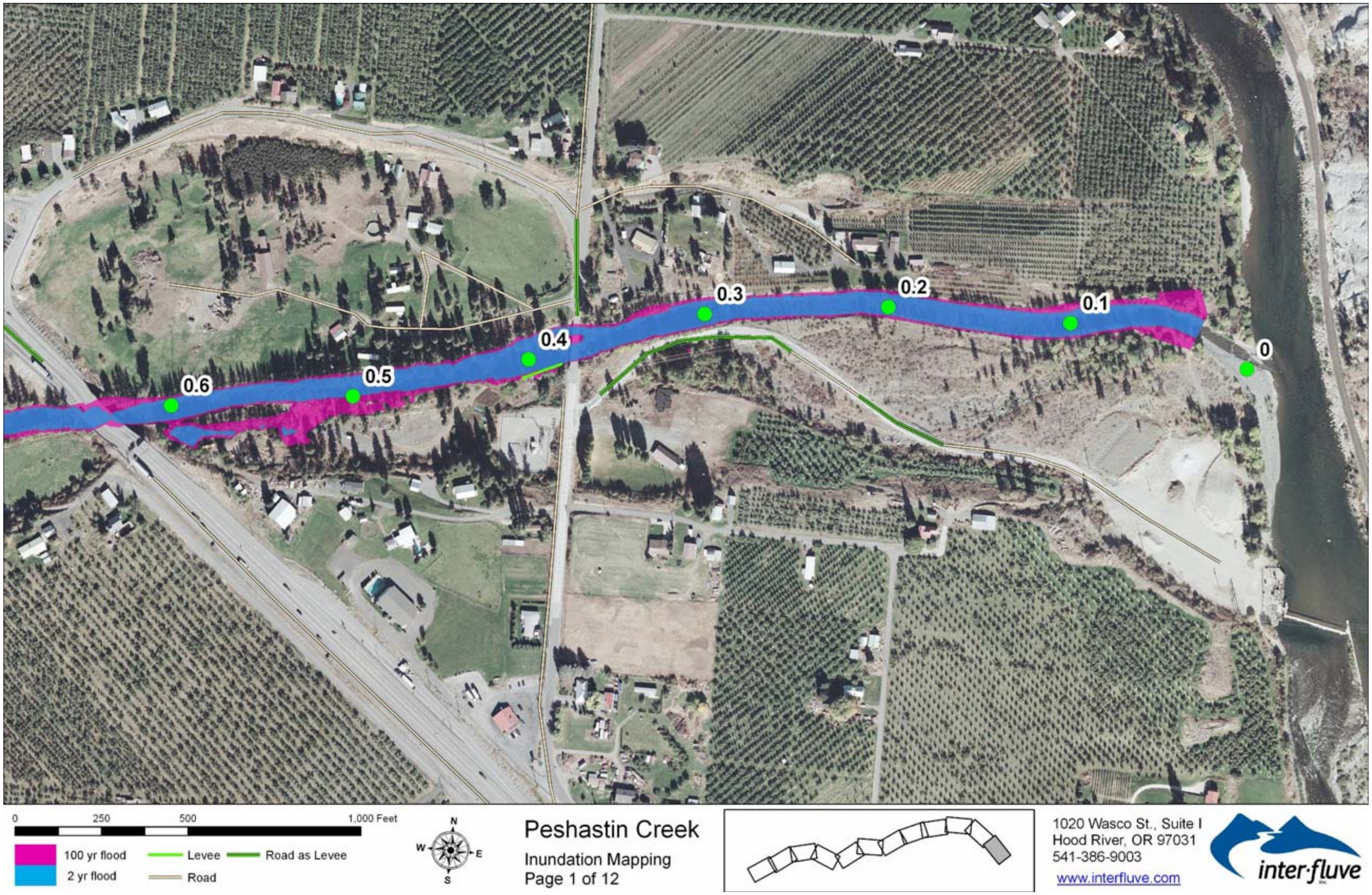


Figure 27. Results of excess shear stress analysis (top graph) and stream power calculations (bottom graph) by reach and river mile.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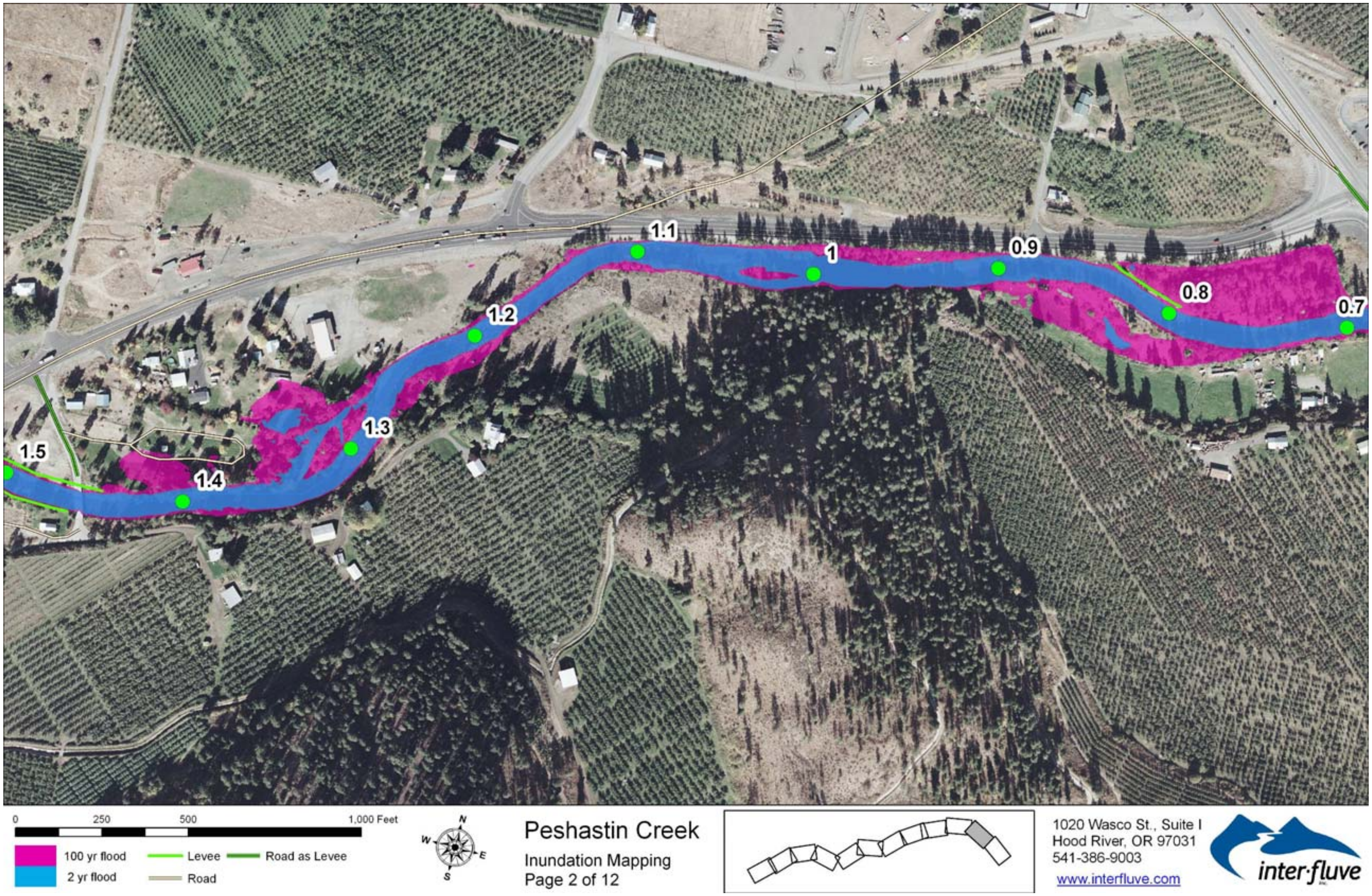
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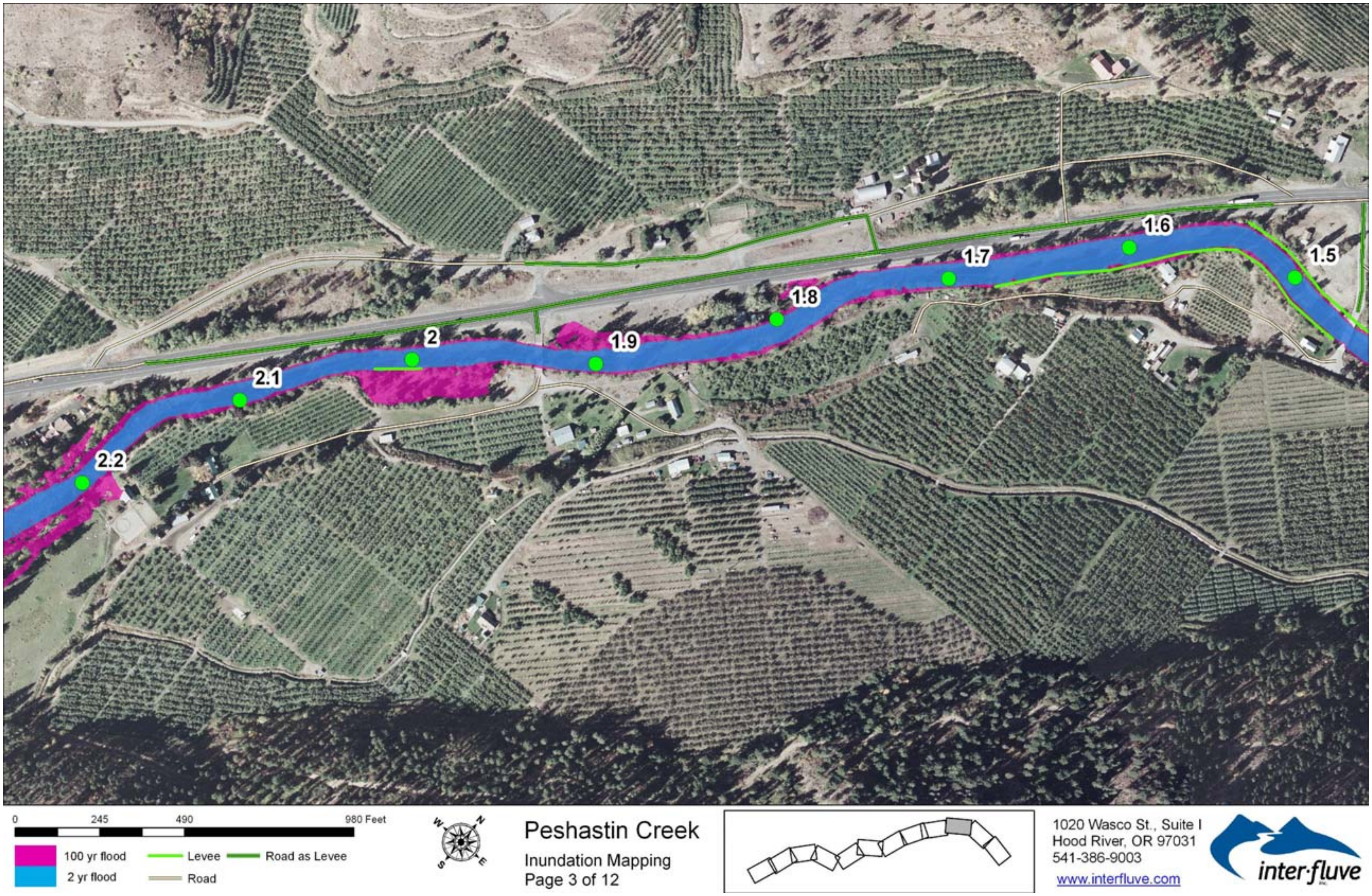
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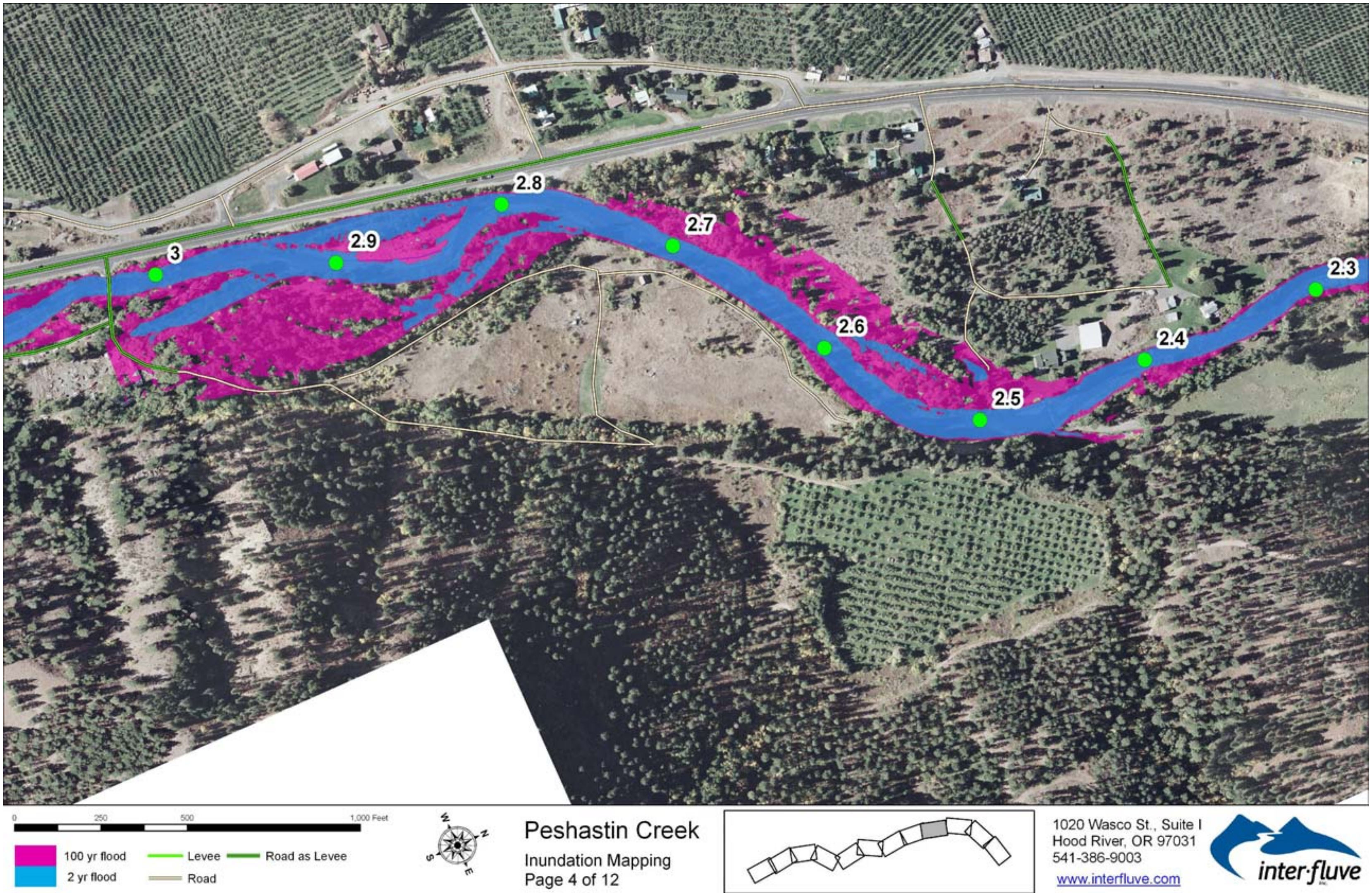
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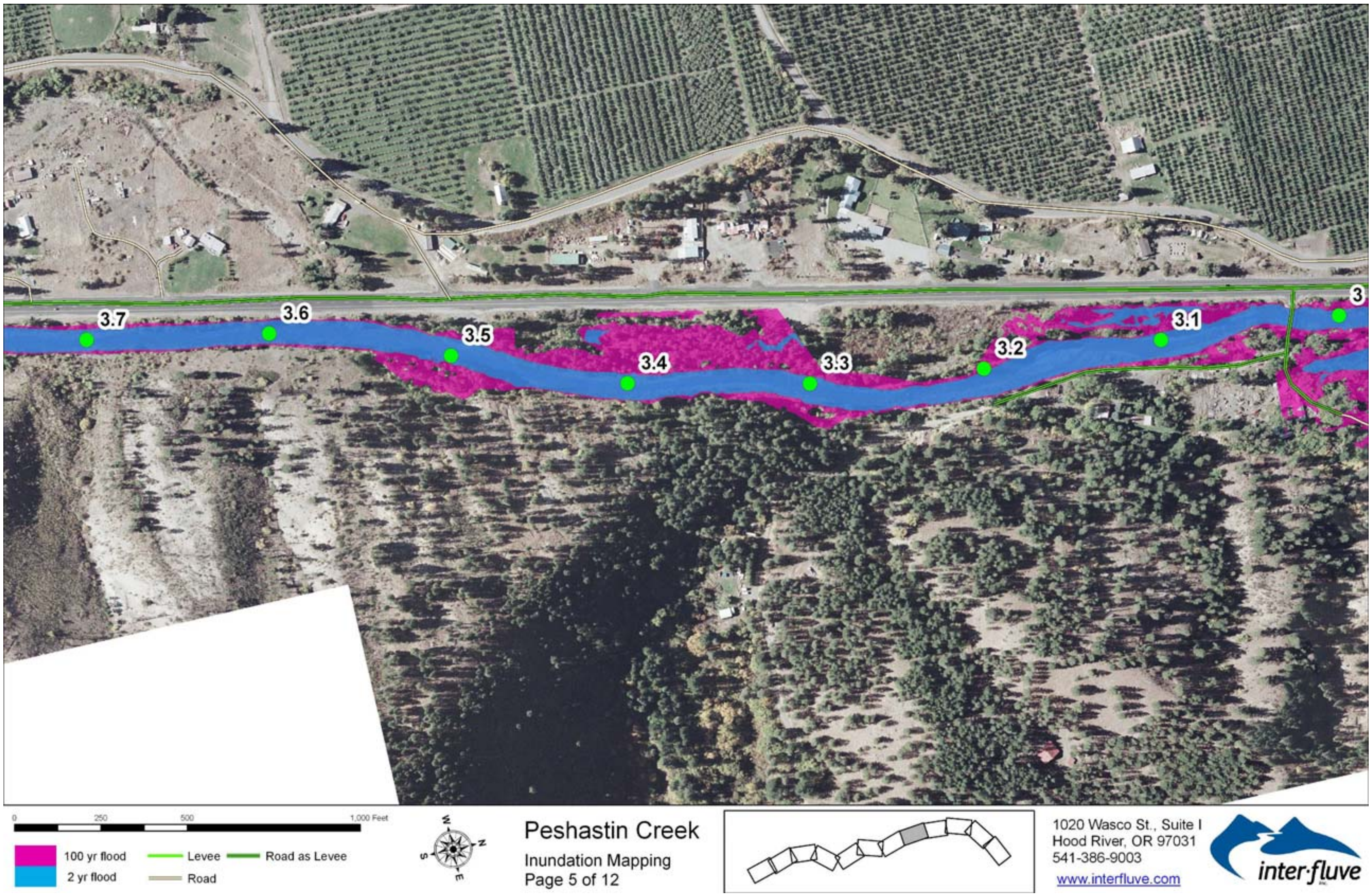
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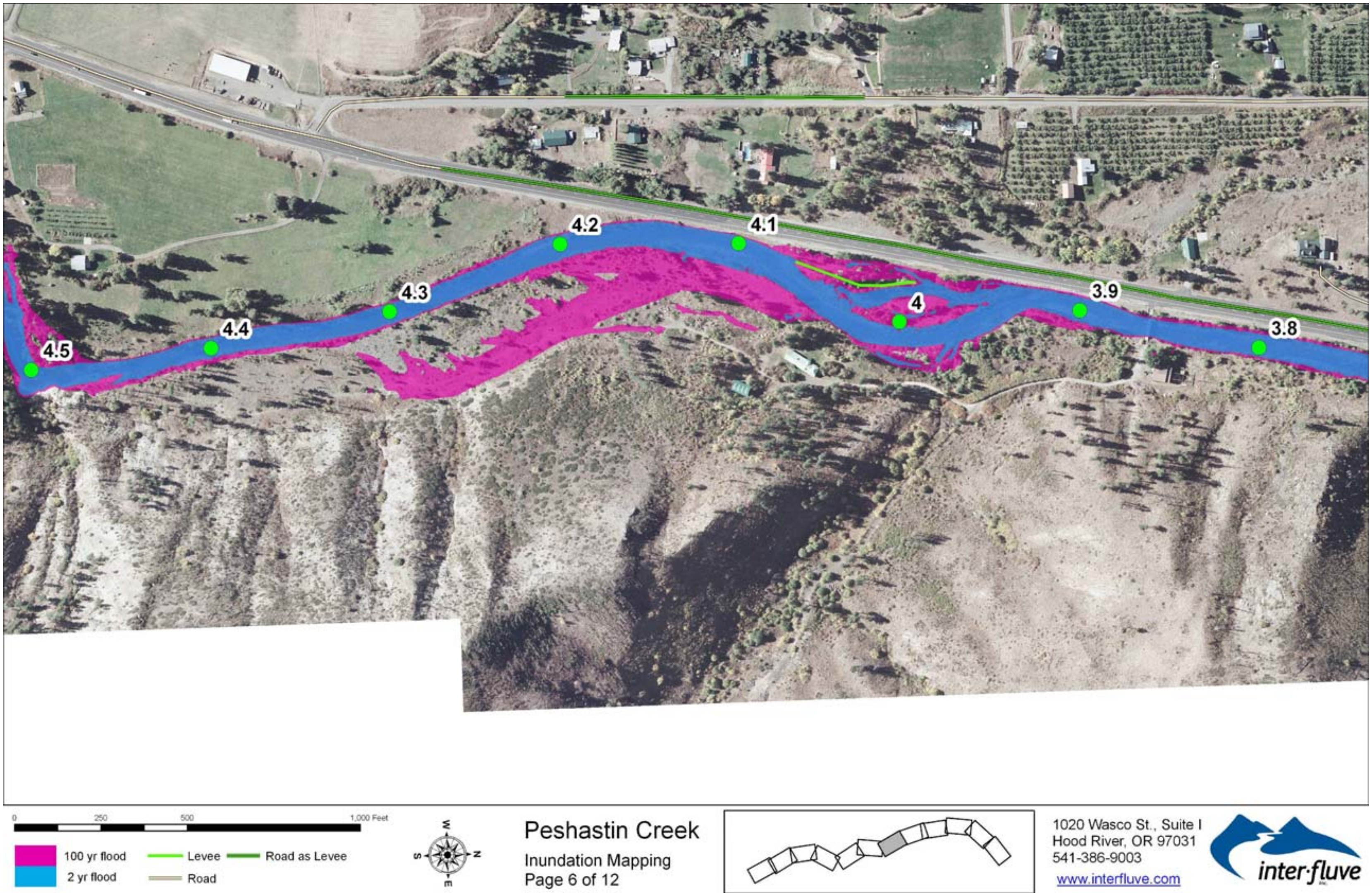
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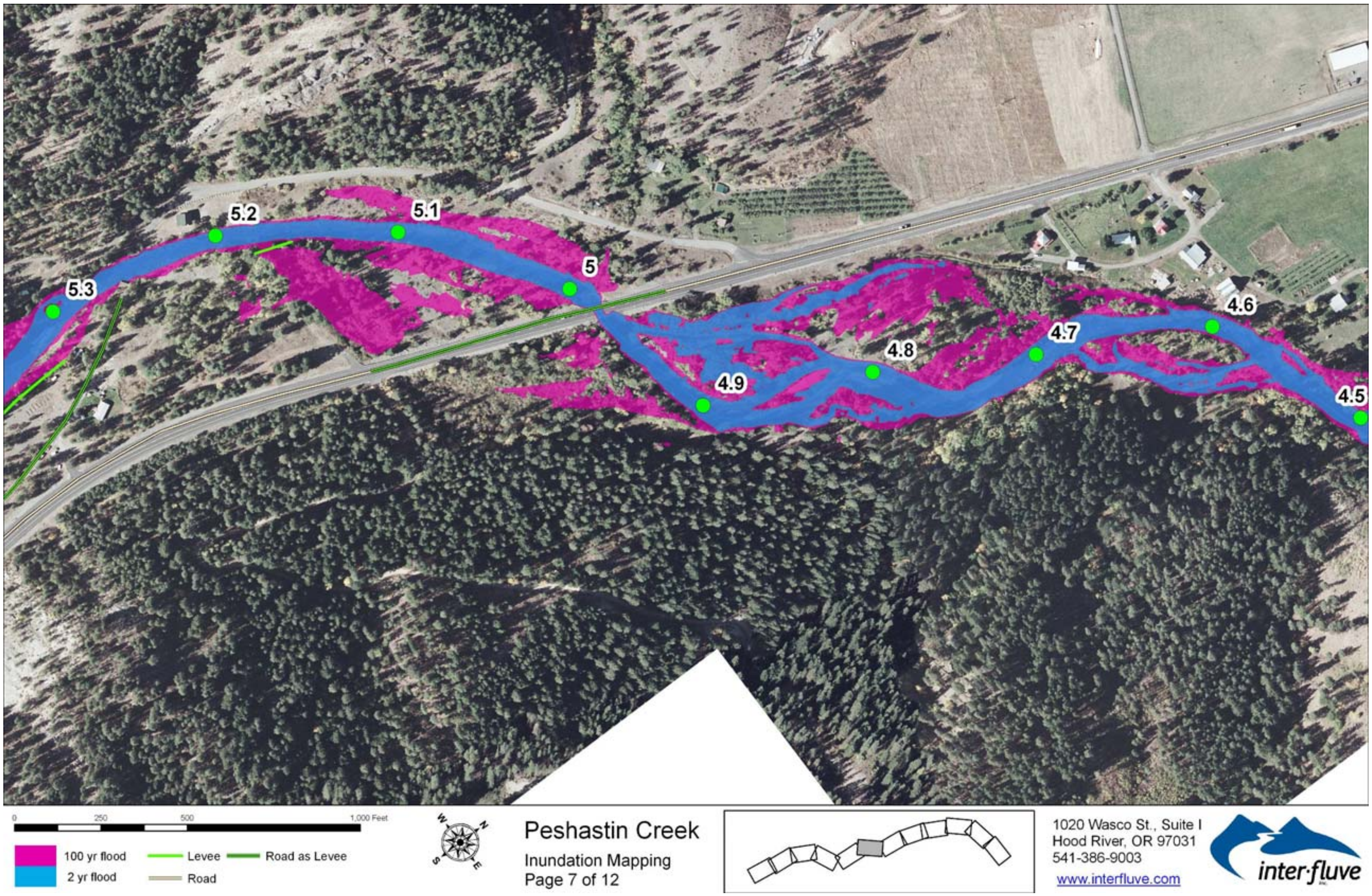
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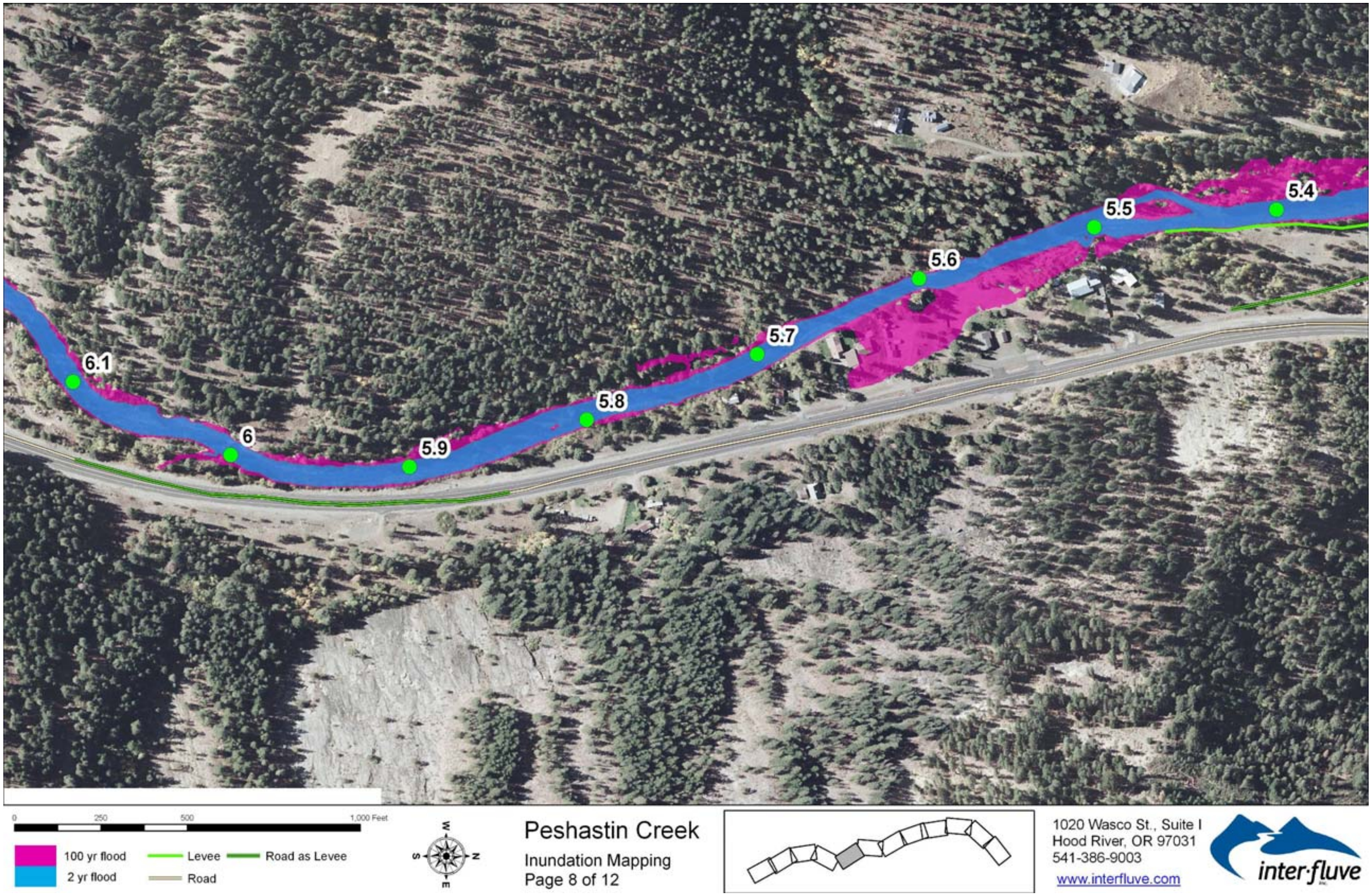
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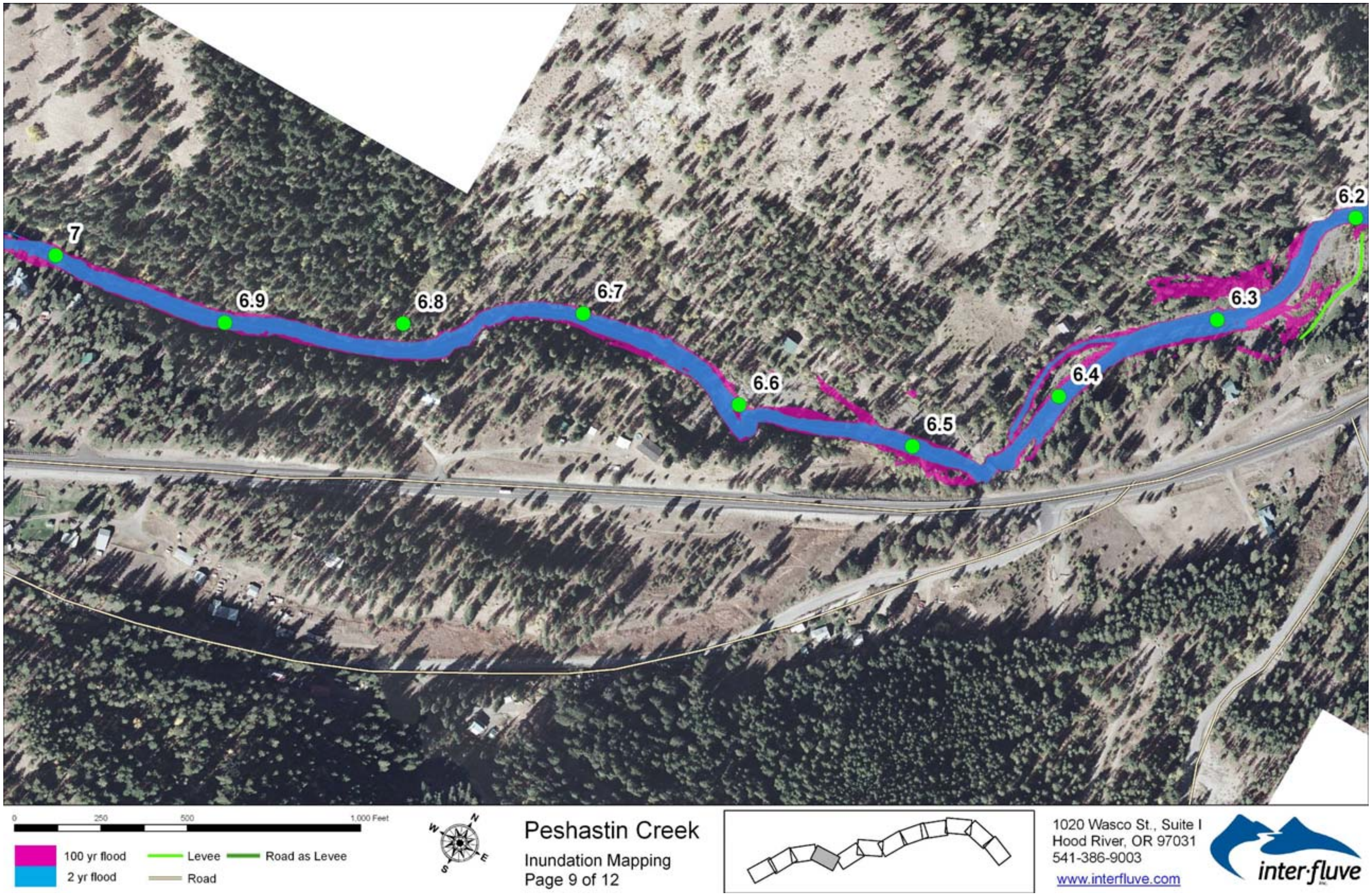
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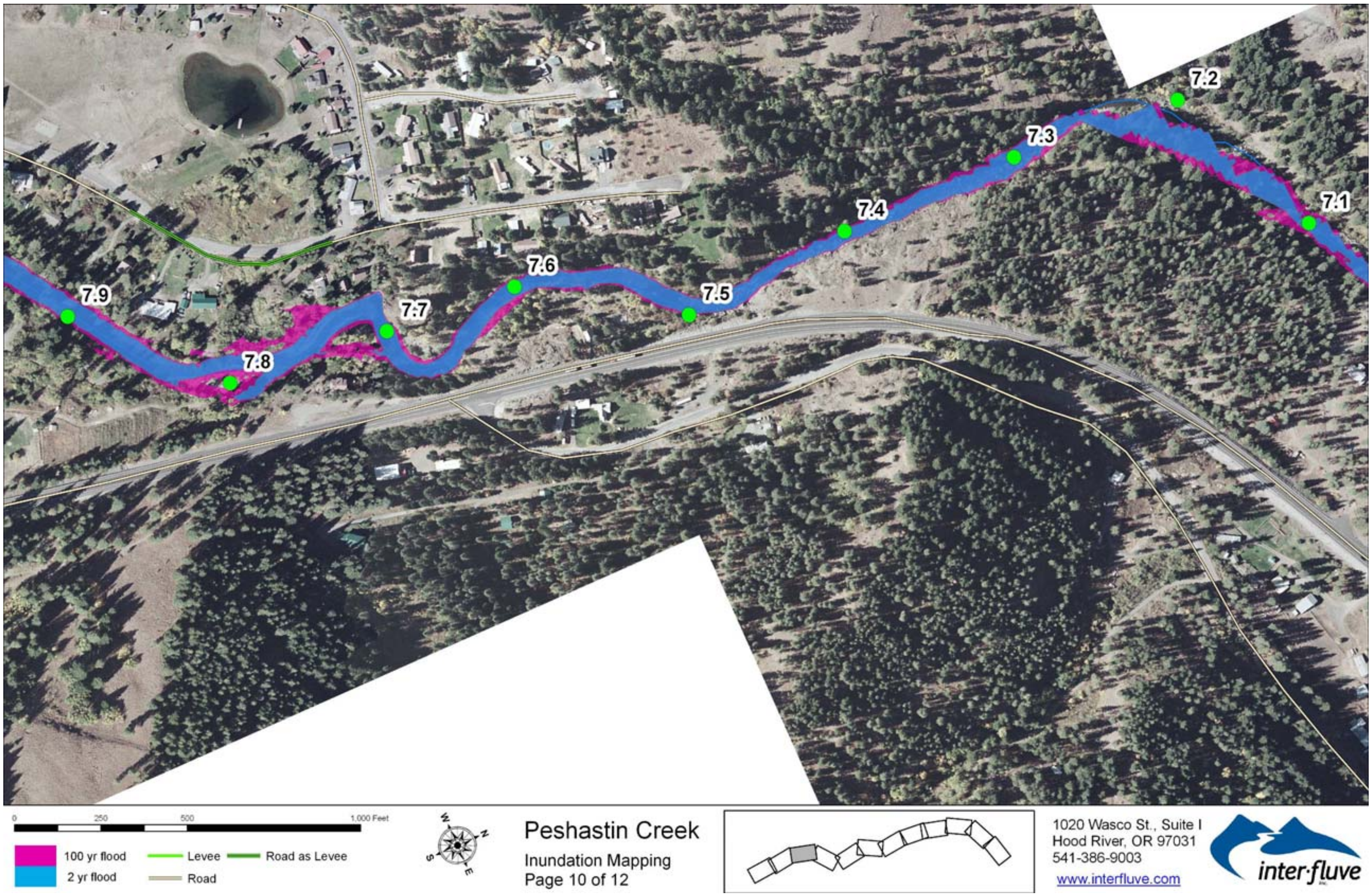
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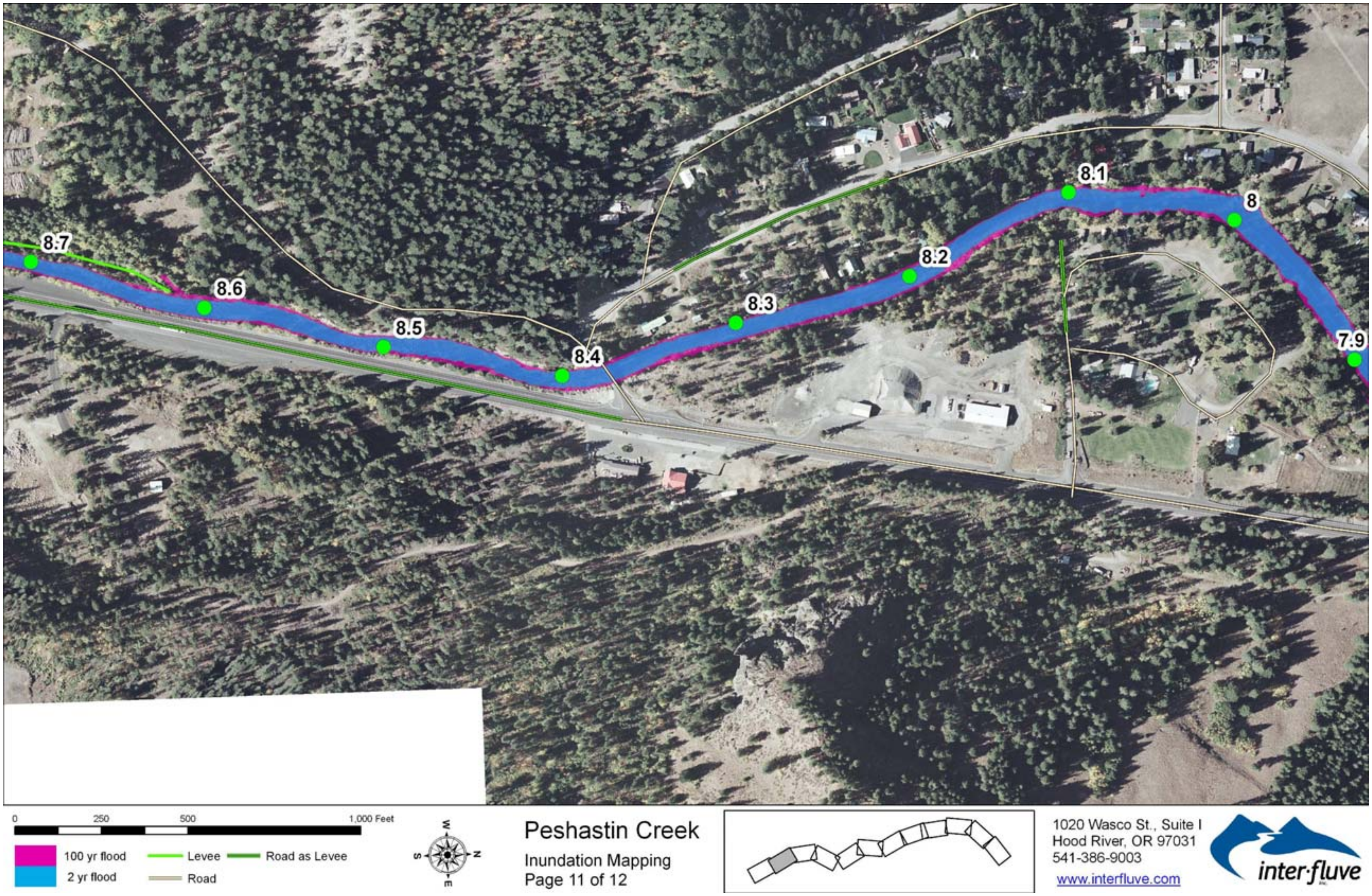
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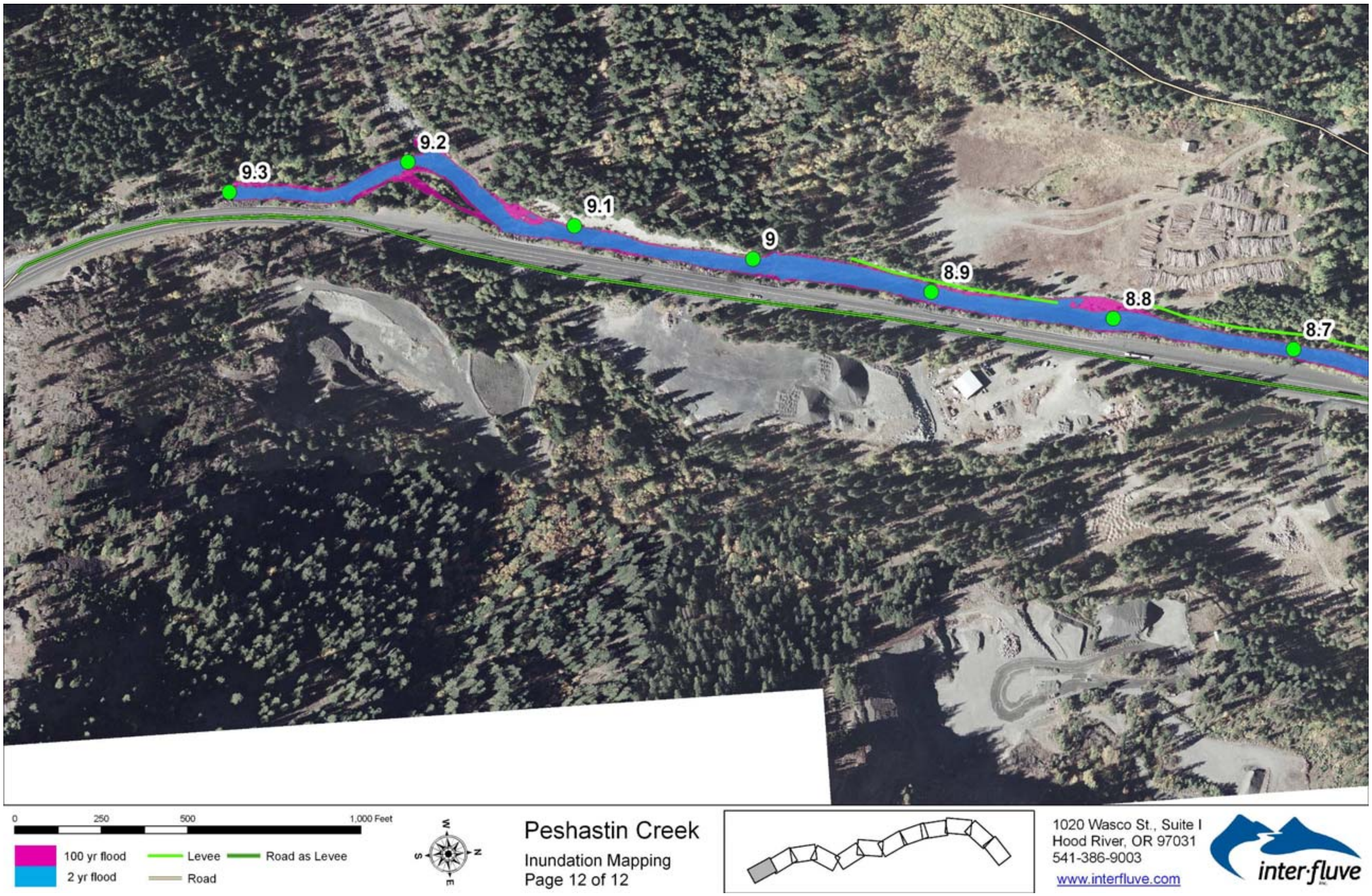
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2.6 Biological Overview

2.6.1 Introduction

The Biological Overview provides a summary of fish use, life-history patterns, and primary habitat limiting factors within the Peshastin Creek Basin. Information for this summary was obtained from agency reports and data, the WRIA watershed plan (WRIA 45 Planning Unit 2006), the Upper Columbia Salmon Recovery Plan (UCSRB 2007), the Wenatchee Subbasin Plan (NPCC 2004), and the WRIA 45 and 40 Limiting Factors Analysis (Andonaegui 2001).

2.6.2 Background

The Peshastin Creek Basin is utilized by a number of resident and anadromous fish species. These include spring Chinook salmon, coho salmon, steelhead trout, rainbow trout, bull trout, westslope cutthroat trout, brook trout, sculpin, sucker, speckled dace, long nose dace, and crappie (NPPC 2004 and Andonaegui 2001). Historically, the Peshastin Creek Basin supported numerous steelhead, spring Chinook, coho, and bull trout that were distributed throughout the basin. Within-basin and out-of-basin impacts since European settlement have reduced the abundance of these populations (Andonaegui 2001). By the 1930s, anadromous runs were decimated due to the Columbia River hydrosytem, overfishing, irrigation diversions, and habitat degradation related to mining, grazing, and logging (Andonaegui 2001).

The Peshastin Creek Basin is considered a "Category 2" watershed in the Upper Columbia region according to the Upper Columbia Regional Technical Team (UCRTT 2008). The categories include the following:

Category 1: (Protection/Restoration)

Category 2: (Restoration/Protection)

Category 3: (Restoration)

Category 4: (Major restoration or minor fish use)

Category 2 watersheds are described as follows (UCRTT 2008):

> *'These watersheds support important aquatic resources, and are strongholds for one or more listed fish species. Compared to Category 1 watersheds, Category 2 watersheds have a higher level of fragmentation resulting from habitat disturbance or loss. These watersheds have a substantial number of subwatersheds where native populations have been lost or are at risk for a variety of reasons. Connectivity among subwatersheds may still exist or could be restored within the watershed so that it is possible to maintain or rehabilitate life history patterns and dispersal. Restoring and protecting ecosystem functions and connectivity within these watersheds are priorities."*

Lower Peshastin Creek, which encompasses the study area from river mile 0 to 9.3, is considered one of the "significant" subwatersheds in the Peshastin Basin (UCRTT 2008). Lower Peshastin Creek is utilized primarily for juvenile rearing and as a migration corridor for steelhead and bull trout spawning in the upper reaches of the catchment, with limited migration, rearing, and spawning by Spring Chinook. Spawning use of these reaches is naturally limited by steep gradients and coarse sediments. Spawning and rearing habitat has also been impacted by anthropogenic impacts including road building, mining, land clearing, and development.

2.6.3 Species Overviews

Species overviews are provided below for spring Chinook, steelhead, coho, and bull trout.

Spring Chinook

Spring Chinook salmon were historically distributed throughout the basin where natural access was available (Andonaegui 2001). The current natural population is considered very depressed or non-existent (Cooper and Mallas 2004). Within lower Peshastin Creek, occasional spawning, rearing and migration use does occur. Spawning typically occurs from river mile 5.2 (Mill Cr) to 9.3 (Ingalls Cr). Rearing typically occurs from river mile 0 to 14.8 (Magnet Cr) (Andonaegui 2001). Run timing and fish distribution are displayed in Figure 28 and Figure 29, respectively.

Spawning ground surveys from 1958 to 1989 found an average of five redds per year. Surveys from 1990 to 1995 found ten Chinook redds total (Ringel 1997). Surveys by the Chelan County Public Utility District and the Washington Department of Fish & Wildlife found no spring Chinook redds from 1997-2000 (Mosey & Murphy 2000). The US Forest Service conducted snorkel and electrofishing surveys near the mouth and at an upriver site in 2004 (USFS 2004). Spring Chinook were found at both sites (USFS 2004).

Spring Chinook have been reintroduced to the watershed in recent years using out-of-basin non-ESA listed stock. Beginning in 2001 and continuing annually through 2004 a portion of the adult hatchery spring Chinook that returned to Leavenworth NFH were outplanted to Peshastin Creek in a joint effort by the United States Fish & Wildlife Service and the Yakama Indian Nation (Cooper and Mallas 2004). Smolt monitoring was conducted in 2004 using a screw trap at river mile 6.3, near the Camas Creek confluence. The trap was fished March 18 to November 21, 2004 and included 208 days of complete sampling. Spring Chinook comprised 48.2% of the catch (4,319 individuals); most of the remainder were steelhead/rainbow trout. It was estimated there were 66,395 sub-yearling (age-0) Chinook. Only one yearling (age-1) spring Chinook was captured in the 2004 season (Cooper and Mallas 2004).

Despite these re-introduction efforts, there is very little evidence of natural origin spring Chinook spawning. Most of the recent spawning activity has been from placement of unlisted hatchery fish from the Leavenworth NFH. According to the Upper Columbia Salmon and Steelhead Recovery Plan (UCSRB 2007), the Wenatchee spring Chinook population is currently considered not viable and to be at a high risk of extinction.

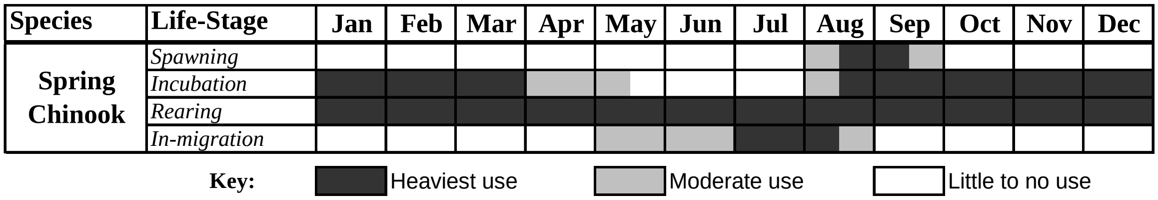

Figure 28. Spring Chinook life-stage timing. Data is from Anchor Environmental and EES Consulting (2007).

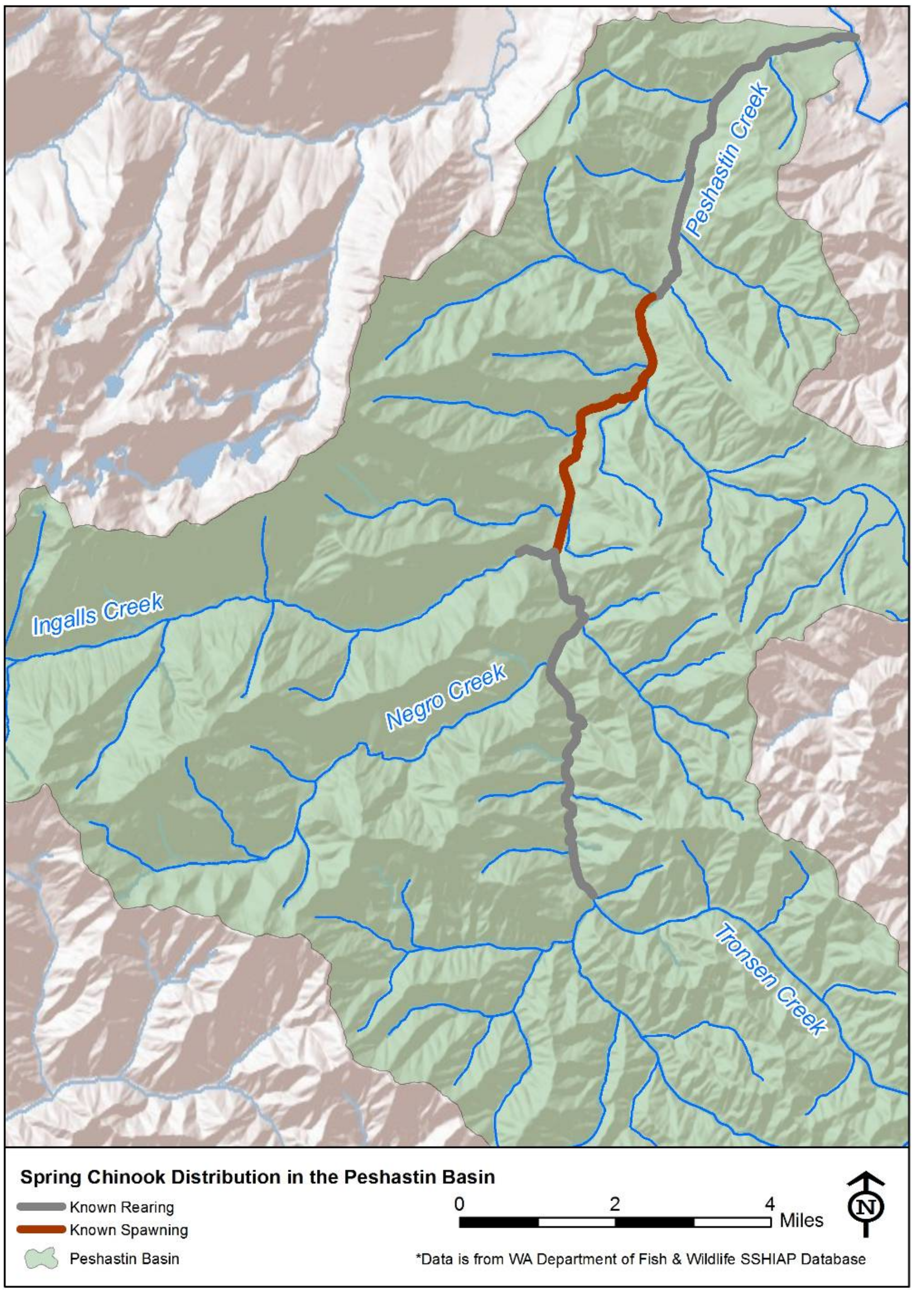

Figure 29. Spring Chinook distribution and use in the Peshastin Basin.

Steelhead

Steelhead were historically distributed throughout the basin where natural access was available. Current abundance and distribution have been reduced compared to historical conditions (Andonaegui 2001). Steelhead have been planted in the basin by WDFW since 1981 and as recently as 1990 (Andonaegui 2001). Rainbow trout have also been extensively stocked in the basin (Ringel 1997).

Steelhead use mainstem Peshastin Creek for spawning, rearing, and as a migration corridor to access upper basin spawning grounds. Run timing and fish distribution are displayed in Figure 30 and Figure 31, respectively.

Steelhead/rainbow trout were found in Peshastin Creek during surveys in 1994-1995 (Ringel 1997). In 2004, WDFW counted 23 steelhead redds between the mouth and Camas Creek (WDFW 2005). The US Forest Service conducted snorkel and electrofishing surveys near the mouth and at an upriver site in 2004 (USFS 2004). Steelhead were found at both sites and were found to be more abundant at night.

The USFS conducted spawning surveys for steelhead in 2007 and 2008, including redd surveys, snorkel surveys, and electrofishing (USFS 2007 and 2008). No steelhead adults were found but rainbow trout were found. In 2008, one dead hatchery steelhead was found near river mile 5 but no redds were found. Redds were not surveyed in 2007. Chinook, sculpin, rainbow trout, and whitefish were observed during surveys in low flow periods (USFS 2007 and 2008).

Steelhead/rainbow trout comprised 48.0% of the catch (4,302 individuals) during smolt monitoring at river mile 6.3 in 2004. The expanded estimate was 16,082 steelhead/rainbow trout. Age-0, age-1, and age-2 were estimated to represent 52% (8,419), 42% (6,770), and 6% (893) of the population estimate, respectively (Cooper and Mallas 2004).

According to the Upper Columbia Salmon and Steelhead Recovery Plan (UCSRB 2007), the Wenatchee steelhead population is not currently viable and has a moderate to high risk of extinction.

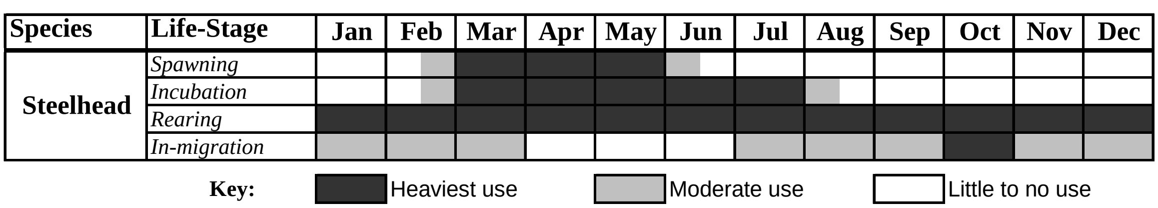

Figure 30. Steelhead life-stage timing. Data is from Anchor Environmental and EES Consulting (2007).

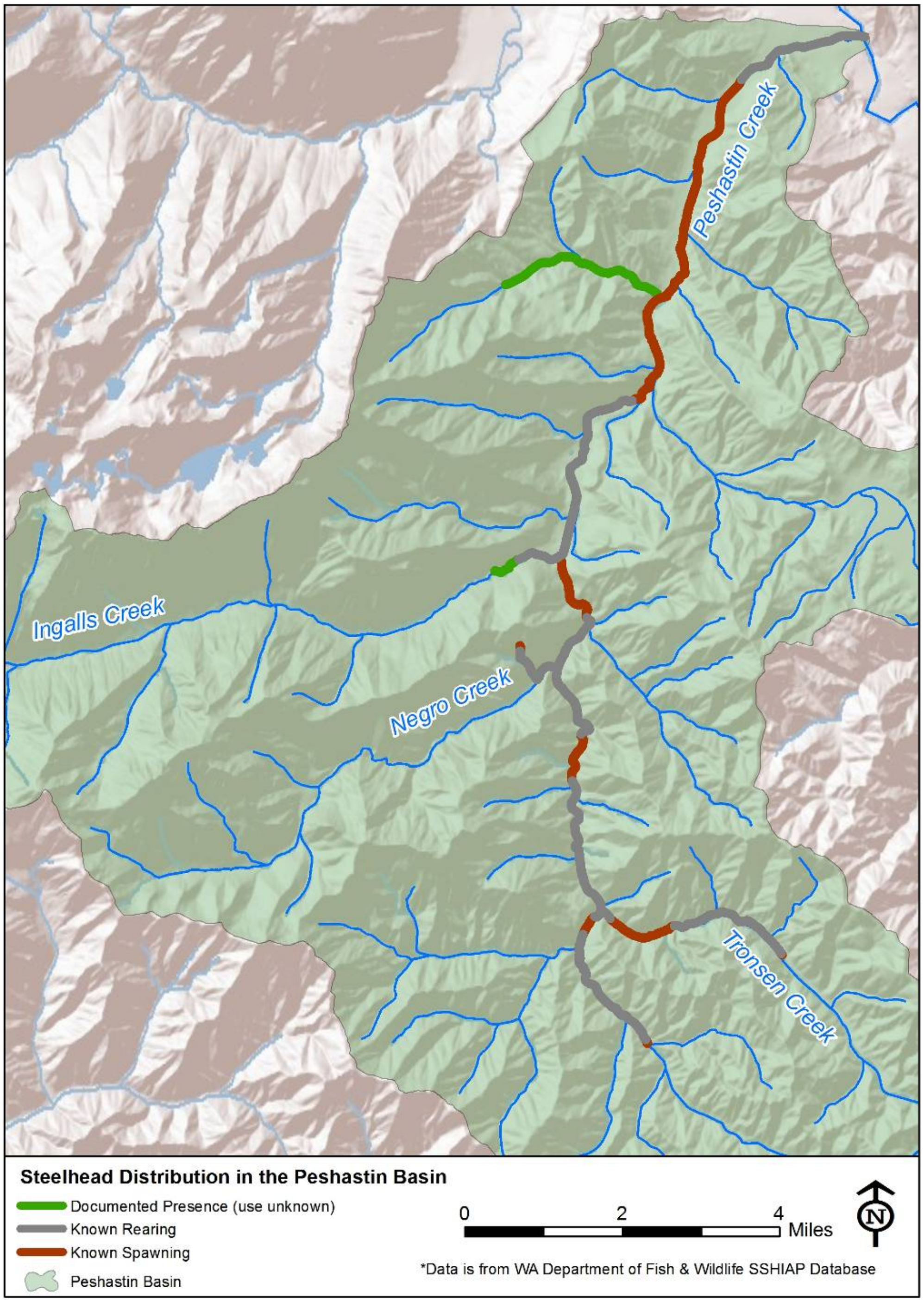

Figure 31. Steelhead distribution and use in the Peshastin Basin.

Coho

Indigenous coho were historically present in the Peshastin Basin but they have been extirpated from the upper Columbia region since the early 1900s (Andonaegui 2001). Upper and mid-

Columbia coho are not included on the Endangered Species List because natural populations have been extirpated from this region.

The Yakama Nation (YN) conducts a coho re-introduction program in the mid-Columbia region that is guided by the following long-term vision (Kamphaus et al. 2009):

> *"to re-establish naturally reproducing coho salmon populations in mid-Columbia river basins at biologically sustainable levels which will provide opportunities for harvest for tribal and non-tribal fishers."*

In the Wenatchee Basin, broodstock is collected at Dryden Dam or Tumwater Dam from September to mid November. Eggs are incubated either locally or off-site. Pre-smolts are acclimated at sites at Icicle Creek, Beaver Creek, and Nason Creek. Fish are released from April to June (in most cases, volitional release is used). In 2007, 989,508 smolts were released and approximately 5,000 adult fish returned, resulting in a smolt-to-adult return (SAR) of about 0.5%. Estimates of SAR for naturally produced coho were 1.64%. (Kamphaus et al. 2009)

The Yakama Nation conducts spawning ground surveys on the Wenatchee River, on tributaries where fish are released (Nason, Icicle, and Beaver creeks), and on other tributaries where they have been observed in previous years (incl. Chiwawa, Chiwaukum, Mission, and Peshastin Creeks). Spawning surveys have been conducted on Peshastin Creek in the following locations: (1) mouth to river mile 3.5 (termed reach "P1"), (2) river mile 3.5 to 8.0 ("P2"), and (3) river mile 8.0 to 13.3 ("P3'). Over the course of nine surveys conducted in 2007 (October 15 – January 2), 88 coho redds were identified. Redds located in Peshastin Creek represented 5.3% of the coho redds recorded in the Wenatchee River Basin (Kamphaus et al. 2009).

Bull trout

Bull trout were historically distributed throughout the Peshastin Basin. Peshastin Creek was once host to a notable run of bull trout in the late summer, with spawning extending up into Ingalls Creek (Andonaegui 2001). Currently, there is believed to be a small population of bull trout in Ingalls Creek, and only limited use of mainstem Peshastin Creek. For mainstem Peshastin, the Limiting Factors Analysis (Andonaegui 2001) listed bull trout presence as "known" from river mile 0 to 1.42 and "potential/historic" from the mouth to the headwaters. Run timing and fish distribution are displayed in Figure 32 and Figure 33, respectively.

Past surveys by various entities have found low numbers of bull trout in the Peshastin Creek Basin. Bull Trout were found in Ingalls Creek during surveys in 1994-1995, but none were found in Peshastin Creek surveys from river mile 10.5 to 16.6. Surveys in 1997 between the mouth and Ingalls Creek found a total of 3 bull trout, but only within the first 1.42 miles. No bull trout redds were found by the USFS during surveys of Ingalls Creek in 2000 (Andonaegui 2001). Smolt monitoring in 2004 at river mile 6.3 found a total of 112 bull trout. Juvenile bull trout were captured primarily in the spring and fall, with the majority captured from mid-September to November. All adult bull trout were captured in the fall, presumably as post-spawning fluvials emigrating to the Wenatchee River (Cooper and Mallas 2004).

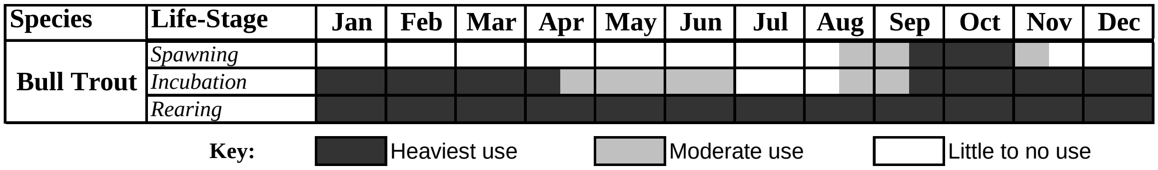

Figure 32. Bull trout life-stage timing. Data is from Anchor Environmental and EES Consulting (2007).

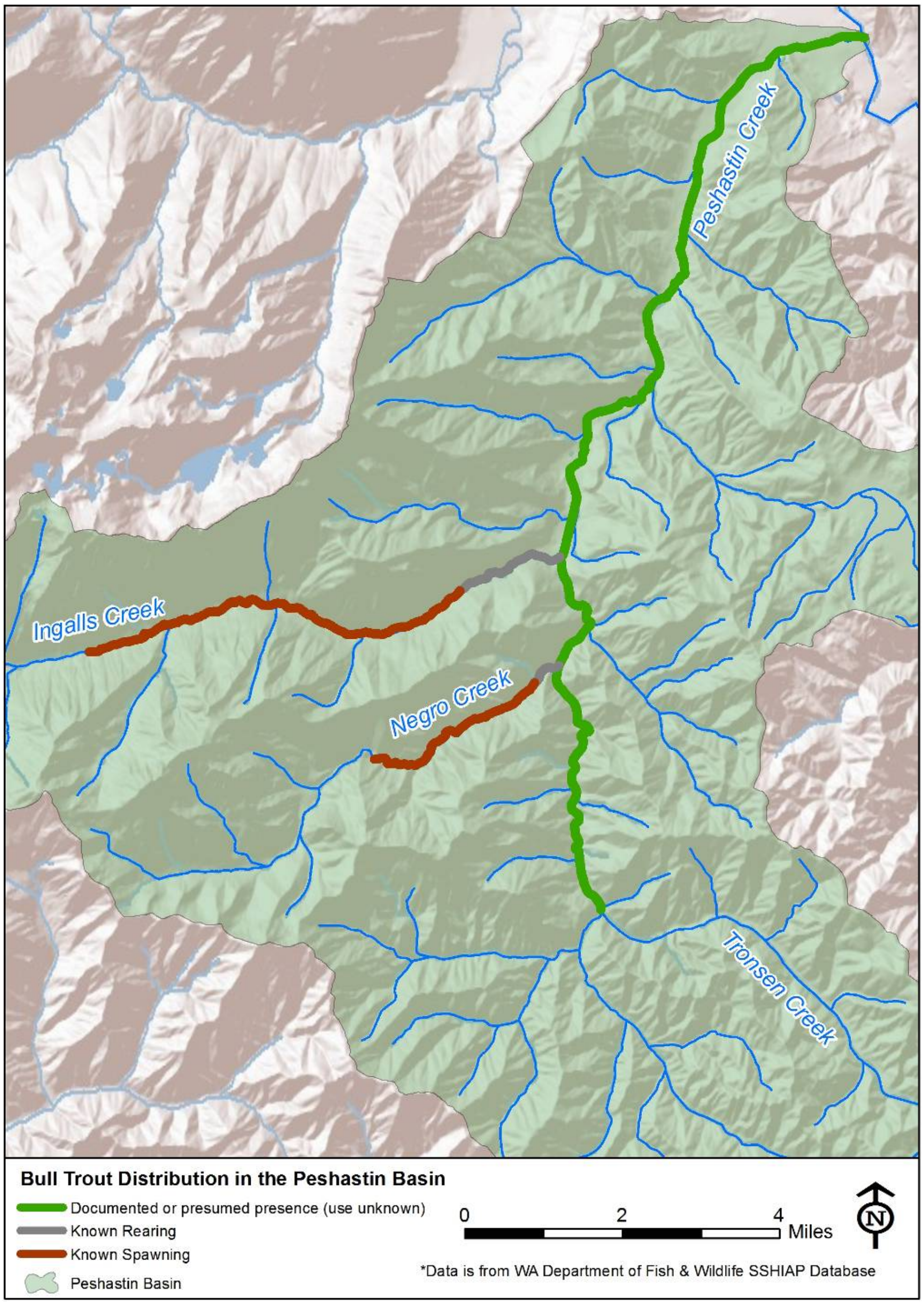

Figure 33. Bull Trout distribution and use in the Peshastin Basin.

2.6.4 Habitat Limiting Factors

A number of habitat limiting factors have been identified as causing impairment for salmonid populations in the Peshastin Creek Basin. The Upper Columbia Regional Technical Team describes the following factors (UCRTT 2008):

Channel migration, riparian habitat, floodplain function, stream sinuosity, and gravel recruitment are severely impacted by Highway 97.

Low instream flows in lower Peshastin Creek impede upstream migration, reduce rearing habitat, and likely contribute to elevated water temperature.

Loss of riparian habitat resulting from land development and state highway reduces quantity and quality of spawning and rearing habitat.

Comprehensive reviews of limiting factors are included in the WRIA 45 and 40 Limiting Factors Analysis (Andonaegui 2001) and the Northwest Power and Conservation Council's Wenatchee River Subbasin Plan (NPPC 2004). These reports summarize habitat impairments that have been identified through a variety of sources, including monitoring efforts, inferences from other sources, and professional judgment.

2.7 Stream Habitat Assessment

Summary Report for River Mile 0.0 – 8.4

2.7.1 Introduction

The objective of the Habitat Assessment is to characterize and document the quantity and quality of available salmonid habitat in lower Peshastin Creek (river mile 0 – 8.4 corresponding to USBR reaches 1-5a). This data is used to inform potential restoration/preservation actions and will provide a baseline for future habitat trends analysis and effectiveness monitoring. Identification of restoration/preservation actions includes areas upstream of the habitat assessment to RM 9.3 including USBR reaches 5b and 6. Information gathered in the habitat assessment will be used to inform decisions in reaches PC5b and 6. To our knowledge, this is the first comprehensive stream habitat survey that has been conducted on this portion of Peshastin Creek and it is intended to compliment existing habitat survey data that has been collected in other portions of the basin.

Spring Chinook salmon, steelhead trout, rainbow trout, bull trout, and west slope cutthroat trout are native salmonid species that utilize lower Peshastin Creek for at least a portion of their life history. The distribution of these species throughout the basin and the specific use of lower Peshastin Creek is covered in the Biological Overview section of this report (See Section 2.6).

In summary, lower Peshastin Creek is utilized primarily for juvenile rearing and as a migration corridor for steelhead and bull trout spawning in the upper reaches of the catchment, with limited spawning in the Peshastin Creek mainstem by Spring Chinook. Spawning use of these reaches is naturally limited by steep gradients and coarse sediments. Spawning and rearing habitat has been further limited by anthropogenic impacts including road building, mining, land clearing, and development. These activities have simplified and steepened the channel planform and have resulted in an armored streambed, an absence of high quality pools, and low quantities of large woody debris.

Results from this assessment indicate that the lower 8.4 miles of Peshastin Creek are at an “at risk” or “unacceptable risk” condition for several parameters important to spawning and rearing life stages of salmonids (see Section 2.9, REI Metrics). The results highlight habitat deficiencies by reach that will be useful for establishing objectives and performance targets to guide restoration and enhancement activities.

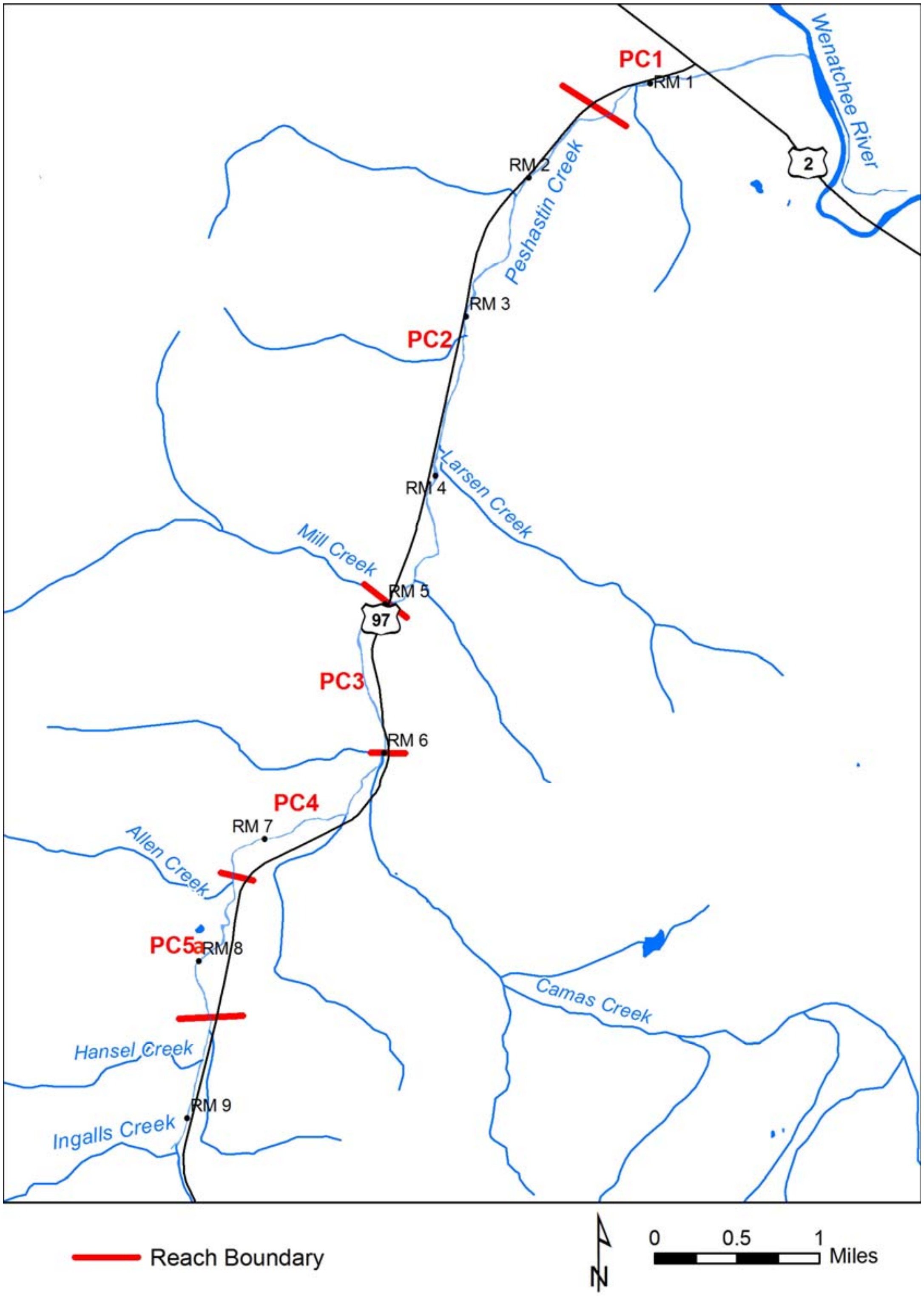

Figure 34. Map of the lower 8.4 miles of Peshastin Creek included in the habitat assessment. The reach assessment study area extends to RM 9.3.

2.7.2 Methods

A stream habitat survey was conducted along lower Peshastin Creek from RM 0 to approximately RM 8.4 from August 13 through August 18, 2009 (Figure 34). Streamflow during the survey ranged from 13.4 to 19.7 cubic feet per second (cfs) according to the WA Dept of Ecology gaging station located at the Green Bridge Road crossing near river mile 1.5.

Field methods for the habitat survey used the USFS Region 6 Level II Stream Survey Protocol Version 2.6 (USFS 2006). Geomorphic reaches had been previously delineated in the study area by the US Bureau of Reclamation (See Section 2.3). These same reaches were used for the stream habitat assessment in order to achieve consistency with other assessment components.

A modification was made to the USFS survey protocol with respect to the n^{th} unit measurement frequency. The protocol indicates that n^{th} unit measurements should occur at no less than a 10% sampling frequency with a minimum of 10 n^{th} unit samples of each unit type per reach. Due to long habitat units relative to reach length, this would have required the measurement of more n^{th} units than was possible given time constraints. As a compromise, the minimum n^{th} unit sampling frequency was increased to 20% with no minimum number of n^{th} units per reach. Sampling frequency achieved 30% or more in most of the reaches.

In accordance with the USFS survey protocol, we compared the ocular (visual) estimates of wetted width performed for every unit with the measured values at n^{th} units in order to determine if correction of the ocular estimates was necessary. The average difference between the actual and ocular values was 4.9 feet and the distribution of the residuals (actual measurement – ocular estimate) was normally distributed. As a result, ocular estimates were not corrected and are considered generally accurate to within +/- 5 feet.

Because “runs” were virtually absent from Peshastin Creek due to the lack of a “homogenous streambed” (from USFS definition, USFS 2006), the survey used the basic USFS protocol that utilizes fast water (i.e. riffle) and slow water (i.e. pool) unit types. Stream temperature was not recorded as part of this stream survey. Visual (ocular) estimates of bed sediment composition (considered a “forest option” in the USFS protocol) were recorded for every n^{th} unit. The lengths of unstable banks were visually estimated for every unit.

2.7.3 Summary of Results

This section summarizes the results across all five reaches. Detailed reach summaries with reach-specific results are included in Appendix A.

Channel Morphology

Lower Peshastin Creek reaches exhibit plane-bed, pool-riffle, and step-pool morphology. Plane-bed morphology is the dominant channel type and many of the long riffle units measured in the survey are actually long plane-bed channel segments with very uniform bed features. Step-pool morphology dominates the upstream reaches and pool-riffle sequences are interspersed throughout the entire study area. Channel bed substrate is largely cobble and small boulder with smaller quantities of bedrock, gravels, and sand. Mean channel bed slopes are 1 – 2% but locally

(50 -100 ft scale) can be as high as 5% or 10% with maximum slopes of 25% and 30% (Figure 35). These locally steep sections occur in both confined and unconfined valley reaches.

Channel widths do not vary substantially between stream reaches and do not increase in the downstream direction as might be expected. This may be attributed to a large degree of artificial channel confinement in the downstream portion of the study area. Similarly, bankfull widths do not vary substantially among reaches (Figure 36); mean bankfull width is 72 ft (st. dev. 14.4). Bankfull depths, however, are more variable, both among and within individual reaches (Figure 37). Bankfull depths range from 3 to 6 feet with the largest bankfull depths occurring, on average, in Reaches 1 and 3. Bankfull depths decrease in the upstream direction in Reaches 3, 4, and 5.

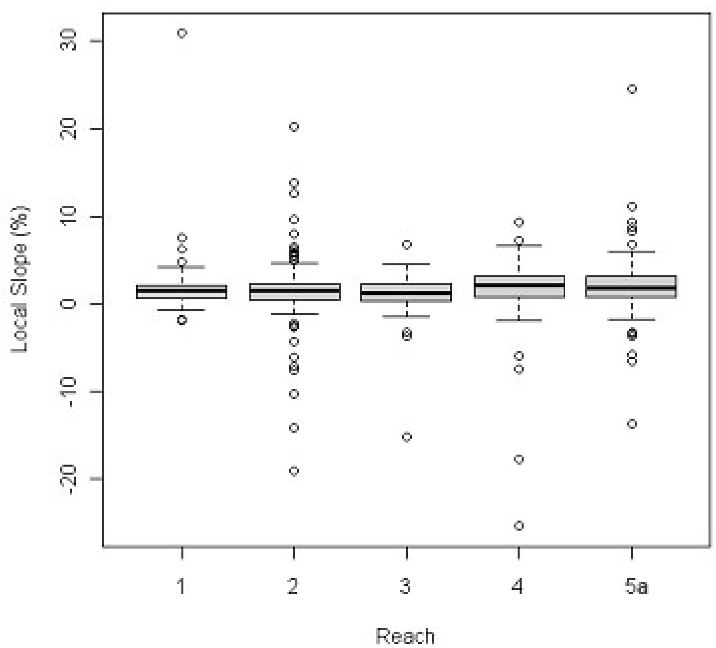

Figure 35. Boxplot of local channel bed slope for each of the five reaches in Peshastin Creek.

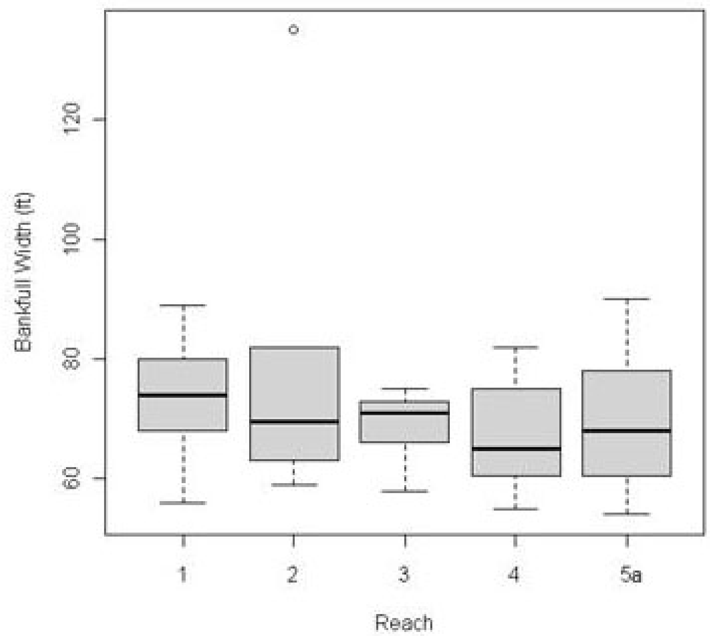

Figure 36. Boxplot of bankfull widths for each reach in feet.

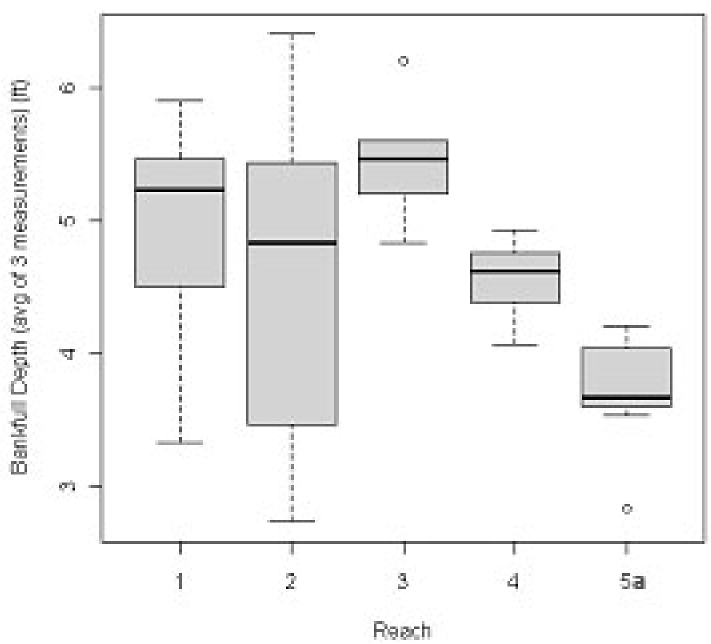

Figure 37. Boxplots of bankfull depths in feet. Each value is an average of three individual measurements taken at each nth riffle unit in each reach.

Habitat Unit Composition

Riffles are the predominant habitat unit type and make up 77% of the total habitat area. Pools comprise approximately 21% of the total habitat area and the remaining 2% is side channel habitat (Figure 38).

Pool frequency ranges from 8 to 19 pools/mile per reach, with a mean pool spacing of 320 ft, or a pool approximately every 4 bankfull widths. Reaches 4 and 5a have the greatest number of pools/mile (17.9 and 19.3, respectively) and the shortest pool spacing (188 ft and 195 ft, respectively). These reaches also have the greatest number of deep pools (residual depth exceeds 3 ft in several pools). The majority of the pools throughout the study site are relatively shallow, with residual depths of 1-2 ft in one-half to two-thirds of the pools. According to the REI metrics (Section 2.9), pool frequency and quality are considered "at risk" for reaches 2, 4, and 5a due to an adequate number of pools/mi but inadequate habitat cover. Pool frequency and quality in Reaches 1 and 3 is considered "unacceptable" due to a lack of pools >1 m deep with good fish cover.

Overhead cover in the riffles was generally poor throughout all reaches. Mean summer low flow wetted widths are 36 ft (st. dev. 9.6 ft) and riffles are 4 ft wider than pools on average. Mean riffle depths are 0.77 ft (st. dev. 0.2 ft) with mean maximum depths of 1.8 ft (st. dev. 0.4 ft) (Figure 39). Minimum depths of 0.8 feet and 0.6 feet have been reported as necessary to maintain Chinook and large trout passage, respectively (Thompson 1972). Shallow riffle depths may limit passage for spring Chinook and steelhead at summer low flow periods; however, many adults will migrate through this area during higher spring or fall flows.

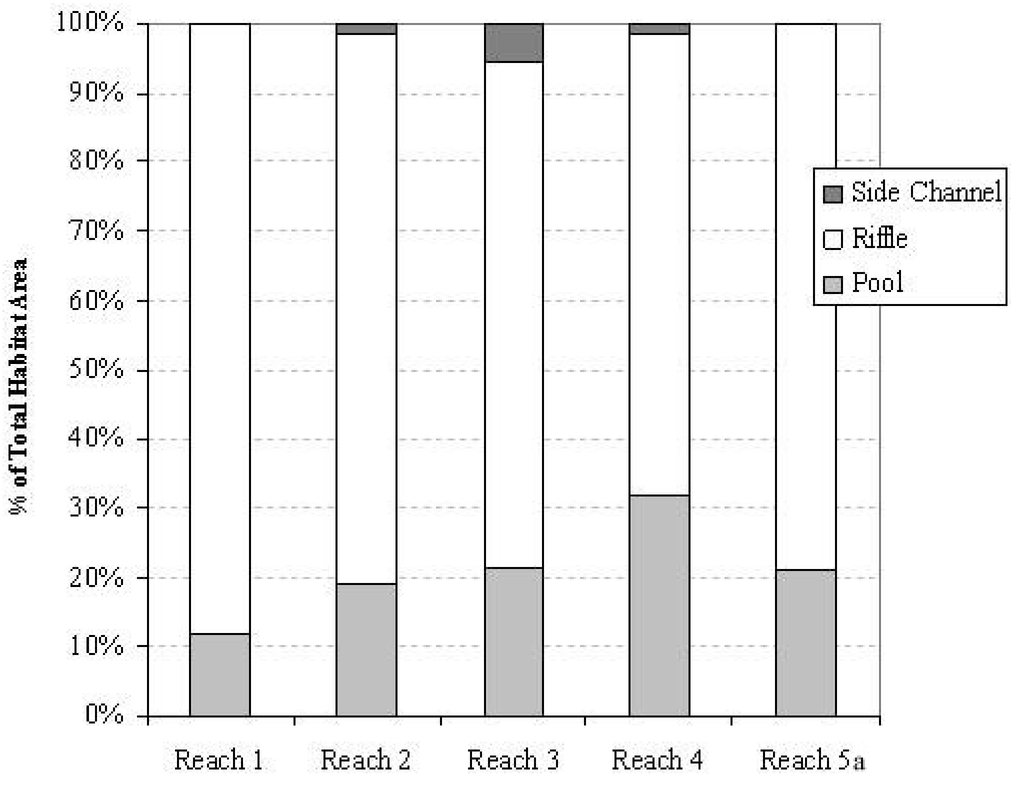

Figure 38. Habitat unit composition by reach.

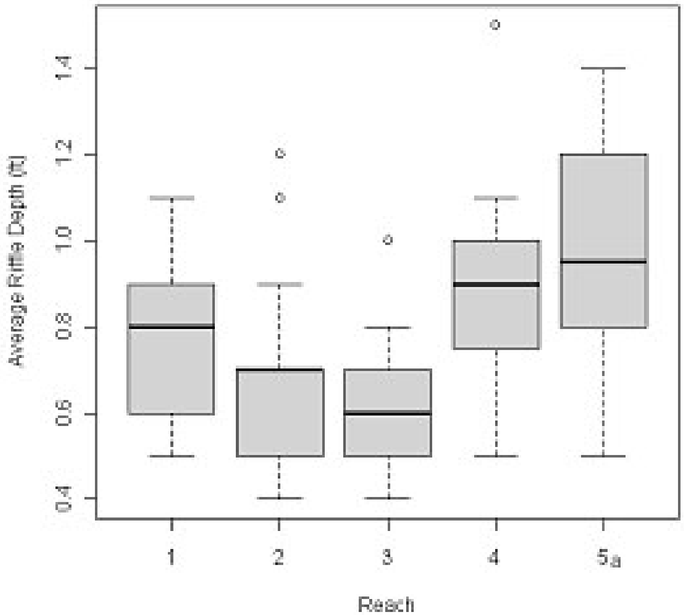

Figure 39. Average riffle depths in feet for each reach.

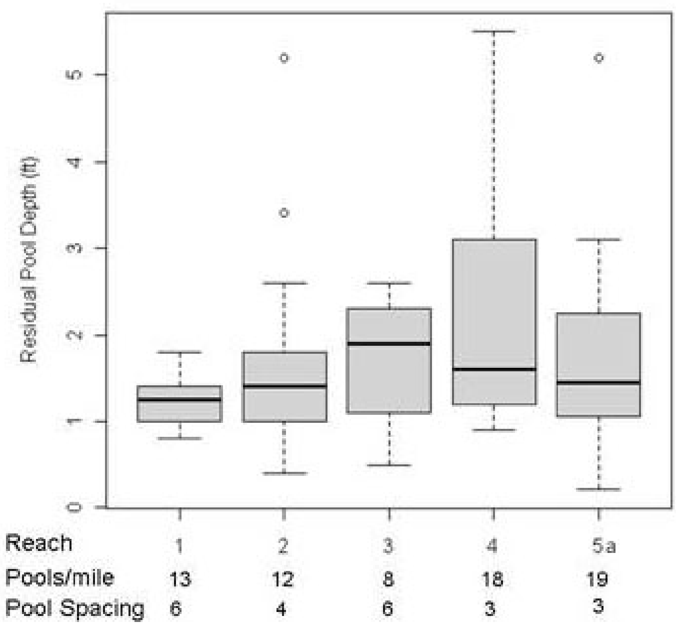

Figure 40. Boxplot of residual pool depth in feet for each reach.

Off-Channel Habitat

Off-channel habitat accounts for approximately 3% of the surveyed length along the lower 8.4 miles of Peshastin Creek. There were no active low-flow side channels in Reaches 1 or 5a. Lack of side channels is partially related to natural confinement but is also the result of artificial confinement and hydromodifications. Many portions of the study area have experienced road building, levee construction, and channel/floodplain filling that have reduced the abundance and connectivity of side channels and off-channel habitat. According to the REI metrics (Section 2.9), availability of off-channel habitat is at the “unacceptable risk” level for reaches 1 and 2; “at risk” for reaches 3 and 5a; and “adequate” for reach 4 due to natural limitations of off-channel habitat.

Large Woody Debris

Large wood quantities in lower Peshastin Creek are extremely low. The number of pieces ranges from approximately 10 to 43 pieces/mile (Figure 41 and Table 7) and “small” LWD makes up the majority of pieces (68% for the entire study site and approximately 90% for Reaches 1 and 4) (Figure 41). Median wood loading on “undisturbed” streams of comparable size and type in the region is 274 pieces/mile and the 25th percentile is 80 pieces/mile (Fox and Bolton 2007). The average wood frequency of 35 pieces/mile on lower Peshastin Creek (all reaches combined) is well below these thresholds. According to the REI metrics (see Section 2.9), wood quantities are at the “unacceptable risk” levels in all reaches except reach 4, which is at an “at risk” condition.

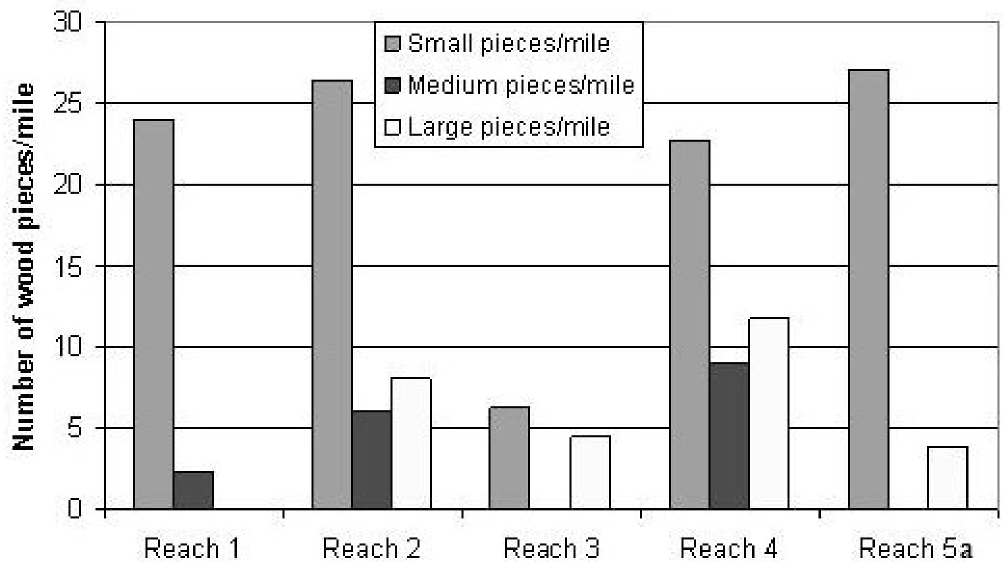

Figure 41. Bar graph of small (6 in. by 20 ft.), medium (12 in. by 35 ft.), and large (20 in. by 35 ft.) wood pieces/mile for each reach.

Substrate and Fine Sediment

Bed composition in lower Peshastin Creek is based on ocular estimates at the nth unit sampling locations and two pebble counts in each reach. The ocular estimates and pebble counts correlate well, with only minor discrepancies mostly within the sand and boulder size classes (Figure 42 and Figure 43). In general, bed substrate is dominated by cobbles, followed by gravels and boulders. Sand and bedrock generally comprise less than 10% of the bed. As expected, riffles tend to be coarser, with more cobbles and less gravels than pools (Figure 44 and Figure 45). The quantity of fine sediment (<2mm) does not appear to be an issue in these reaches. According to the REI evaluation (Section 2.9), streambed substrate is in an “at risk” condition for all reaches except reach 2, which received an “adequate” designation.

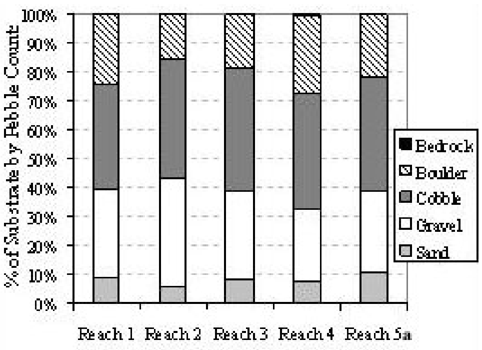

Figure 42 Percent coverage of substrate by clast size based on pebble counts for the study reach.

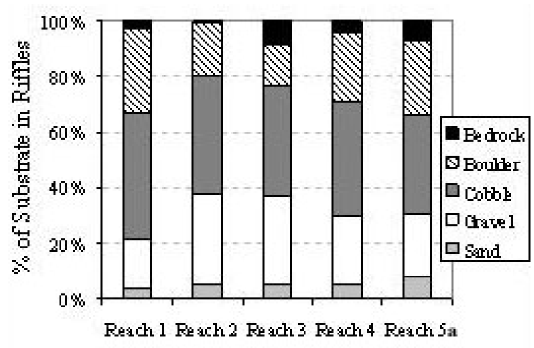

Figure 43. Percent coverage of substrate by clast size based on ocular estimates for study reach.

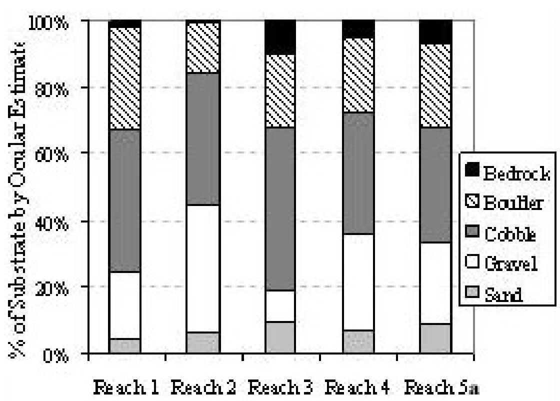

Figure 44. Percent coverage of substrate in riffles based on ocular estimates for each study.

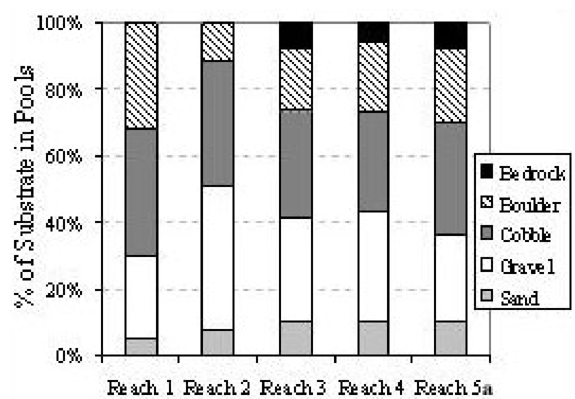

Figure 45. Percent coverage of substrate in pools based on ocular estimates for each reach.

Instability and Disturbance

In general, streambanks have high lateral stability and bank erosion above the bankfull margin is uncommon. Only approximately 4% of the entire stream length within the study area was identified as actively eroding and no bank instability was identified in Reaches 1 or 4. Bank erosion occurs most in riffle units, with very little erosion in pools. Reaches 2 and 5a have the most active erosion. Historical channel straightening (e.g. for Highway 97), artificial confinement, and bank armoring have increased horizontal stability, likely at the expense of vertical stability, which has resulted in channel incision. Active streambank erosion and lateral migration of Peshastin Creek may be an important process that is necessary to reduce incision, speed channel evolution, recruit streambed material, and increase active channel dynamics and habitat diversity.

Fish Passage Barriers

Findings from a 2007 Needs and Alternatives Study conducted for Peshastin Creek indicate that summer low flows may present fish passage issues for in-migrating spring Chinook (Anchor

Environmental and EES Consulting 2007). The in-migrating period for spring Chinook extends into July and September. Low flow passage issues are mainly a concern in late July, when low stream flows are combined with irrigation withdrawals to present potential passage limitations.

The irrigation diversion dam at RM 2.5 has recently (2005) undergone modification to provide fish passage. This structure now has a fish passage channel on the river left side of the dam (see Figure 46). No other in-channel structural barriers were identified during the 2009 habitat survey.

Based on riffle thalweg depths measured during the habitat survey, the findings from the Needs and Alternatives Study (Anchor Environmental and EES Consulting 2007), and the irrigation diversion structure at river mile 2.5, reaches 1 and 2 are ranked "at risk" for fish passage and reaches 3, 4, and 5a are ranked as "adequate" (see REI Metrics, Section 2.9).

Figure 46. Fish passage channel at diversion dam at river mile 2.5. (August 2009)

Riparian Corridor

The riparian corridor along the study segment is frequently confined to a narrow corridor that is bounded by agricultural land, residential development, or Highway 97 (Figure 49). The inner zone is dominated by shrub/seedling with some representation of sapling/pole and small tree classes (Figure 47). The outer zone is a combination of grass/forbes and small and large tree classes (Figure 48).

The inner zone overstory is predominantly cottonwood. The inner zone understory is characterized by willow, cottonwood, and dogwood. The outer zone overstory is predominantly ponderosa pine, cottonwood, and Douglas fir. The outer zone understory was mostly grass with some representation by madrone, cottonwood, and alder.

In general, there is a lack of large trees in the riparian zone. Large riparian trees were initially cleared in the late 1800s as part of timber harvest and mining activities. Since the early-to-mid 1900s, riparian trees have been cleared for road building, residential development, and agriculture. The narrow riparian inner zone continues to have a robust shrub component, but in many areas, the outer zone is either non-existent or is confined to a very narrow buffer that lacks large trees that are necessary to provide stream shade, bank stabilization, and a source of LWD recruitment.

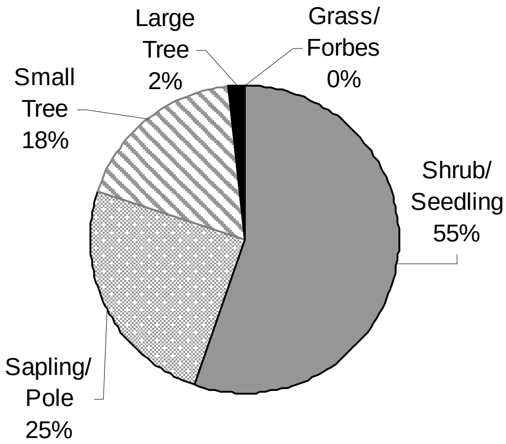

Figure 47. Vegetation class by percentage in the riparian inner zone along the lower 8.4 miles of Peshastin Creek.

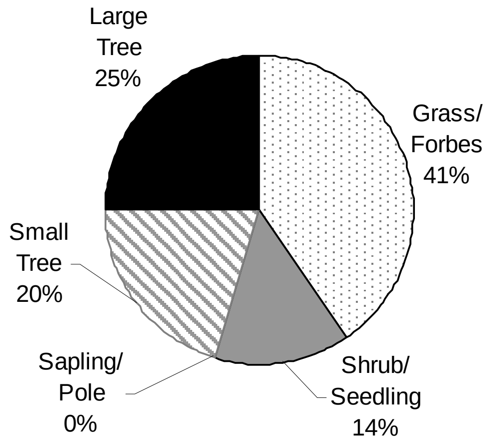

Figure 48. Vegetation class by percentage in the riparian outer zone along the lower 8.4 miles of Peshastin Creek.

Figure 49. Narrow riparian corridor influenced by the Highway 97, agriculture, and residential development near river mile 1.7. (August 2009)

Table 7. Data summary report for Peshastin Creek.

		Total	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5a
Reach Mileage Boundaries			0-1.4	1.4-5.0	5.0-6.0	6.0-7.3	7.3-8.4
Channel Morphology			Plane-bed	Plane-bed	Plane-bed/ Step-Pool	Plane-bed/ Step-Pool	Plane-bed/ Step-Pool
Slope (ft/ft)							
Average		0.015	0.018	0.014	0.011	0.014	0.020
Maximum		0.309	0.309	0.202	0.068	0.093	0.245
Wetted Width (ft)							
Total							
	Mean	35.6	34.6	37.5	39.1	36.0	30.8
	Median	35.0	34.5	37.0	38.0	35.0	29.5
	StDev	9.9	11.5	11.1	7.2	6.1	8.2
Pool							
	Mean	33.3	29.7	35.7	36.3	34.9	29.2
	Median	32.0	30.5	33.0	36.0	34.0	28.5
	StDev	8.4	7.0	13.0	5.1	5.5	5.4
Riffle							
	Mean	37.7	38.1	39.1	41.9	37.2	32.4
	Median	38.0	37.0	40.0	41.0	39.5	30.8
	StDev	9.6	13.0	8.8	8.2	6.6	8.9
Depth (ft)							
Maximum Riffle Thalweg Depth							
	Mean	1.8	1.7	1.7	1.8	1.9	2.0
	Median	1.8	1.8	1.6	1.8	2.0	1.9
	StDev	0.4	0.3	0.4	0.3	0.2	0.3
Average Riffle Thalweg Depth							
	Mean	0.8	0.8	0.7	0.7	0.9	0.9
	Median	0.7	0.8	0.7	0.6	1.0	1.0
	StDev	0.2	0.2	0.2	0.2	0.2	0.3
Bankfull							
Width (ft)							
	Mean	72.0	73.5	76.7	68.6	67.3	72.0
	Median	71.0	74.0	69.5	71.0	65.0	72.0
	StDev	14.4	11.1	22.1	6.8	9.2	12.7
Depth (ft) Averaged over 3 depth measurements							
	Mean	4.6	4.9	4.6	5.5	4.6	3.7
	Median	4.8	5.2	4.8	5.5	4.6	3.8
	StDev	0.9	0.9	1.2	0.5	0.3	0.5
Maximum Depth (ft)							
	Mean	6.6	5.5	5.4	6.4	5.4	11.3
	Median	5.7	5.7	5.8	6.3	5.4	5.4
	StDev	5.9	0.7	1.3	0.6	0.6	14.1
Width:Depth Ratio							
	Mean	16.2	15.1	17.6	12.6	14.9	19.8
	Median	14.6	14.3	16.0	13.4	14.1	18.6
	StDev	4.9	2.7	6.4	1.7	3.0	5.8
Floodprone Width (ft)		4.4	5.7	4.4	4.7	4.0	3.5
	Mean	315	416	334	323	267	253
	Median	300	500	300	350	260	198
	StDev	134	115	141	129	88	167
Channel Confinement (floodprone width / bankfull width)							
	Mean	4.6	5.7	4.4	4.6	4.0	4.1

Table 7 continued. Data summary report for Peshastin Creek.

	Total	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5a
Reach Mileage Boundaries (BOR)		0-1.4	1.4-5.0	5.0-6.0	6.0-7.3	7.3-8.4
Habitat Area %						
Pool	20.8	11.8	19.1	21.4	31.8	21.1
Riffle	77.4	88.2	79.4	73.0	66.5	78.9
Side Channel	1.8	0.0	1.4	5.6	1.6	0.0
Pools						
Pools per mile	13.4	12.8	11.9	8.1	17.9	19.3
Pool Maximum Depth (ft)						
Mean	-	2.2	2.5	2.6	3.3	3.0
Median	-	2.1	2.3	2.5	2.9	2.6
StDev	-	0.4	0.8	0.7	1.3	1.1
Pool Residual Depth (ft)						
Mean	-	1.2	1.5	1.6	2.2	1.8
Median	-	1.3	1.4	1.9	1.6	1.5
StDev	-	0.3	0.8	0.8	1.4	1.2
Resid depth/mile						
Pools< 1 ft	-	3	2.1	1.8	2.1	3.9
Pools 1-2 ft	-	10	7.0	3.6	10.3	10.6
Pools 2-3 ft	-	0	2.3	2.7	0.7	1.0
Pools > 3 ft	-	0	0.5	0.0	4.8	3.9
Riffle:Pool Ratio	1.1	1.4	1.1	1.2	1.0	1.0
Mean Pool Spacing	318	473	293	442	188	195
Mean Pool Spacing/Mean Bankfull Width	4	6	4	6	3	3
Large Wood						
Number of Pieces						
Small (6 in x 20 ft)	201	31	102	7	33	28
Medium (12 in x 35 ft)	39	3	23	0	13	0
Large (20 in by 35 ft)	57	0	31	5	17	4
Total	240	34	125	7	46	28
Number of Pieces/Mile						
Small (6 in x 20 ft)	23	28	26	6	23	27
Medium (12 in x 35 ft)	5	3	6	0	9	0
Large (20 in by 35 ft)	7	0	8	5	12	4
Total	35	31	40	11	43	31
Bank Erosion (ft/mile)						
Total/Mile	214	0	315	167	0	410
Left Bank/Mile	47	0	52	0	0	188
Right Bank/Mile	167	0	263	167	0	222
Pool						
Total/Mile	56	0	96	0	0	101
Left Bank/Mile	23	0	31	0	0	72
Right Bank/Mile	33	0	65	0	0	29
Riffle						
Total/Mile	158	0	219	167	0	309
Left Bank/Mile	24	0	21	0	0	116
Right Bank/Mile	135	0	198	167	0	193
Percent Erosion (both banks)	4.0	0.0	6.0	3.2	0.0	7.8

Table 7 continued. Data summary report for Peshastin Creek.

	Total	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5a
Reach Mileage Boundaries (BOR)		0-1.4	1.4-5.0	5.0-6.0	6.0-7.3	7.3-8.4
Substrate						
Ocular Estimate						
Total						
% Sand	7	4	7	7	7	9
% Gravel	30	20	38	7	29	24
% Cobble	38	43	40	37	36	35
% Boulder	21	31	16	17	23	25
% Bedrock	4	2	0	8	5	7
Pool						
% Sand	9	5	8	10	10	10
% Gravel	34	25	44	31	33	26
% Cobble	35	38	38	33	30	34
% Boulder	19	32	12	19	21	23
% Bedrock	4	0	0	8	6	8
Riffle						
% Sand	6	4	6	5	5	8
% Gravel	27	18	33	32	25	23
% Cobble	41	45	42	40	41	36
% Boulder	23	30	20	15	25	27
% Bedrock	4	3	1	8	4	7
Pebble Count						
% Sand	8	9	6	8	8	11
% Gravel	29	31	38	30	25	27
% Cobble	40	36	41	43	40	40
% Boulder	21	25	15	18	27	22
% Bedrock	0	0	0	0	0	0
Vegetation						
Class (Percent of sampled units)						
InnerZone						
Grass/ Forbes	0	0	0	0	0	0
Shrub/ Seedling	55	5	20	6	17	8
Sapling/ Pole	25	0	5	6	5	9
Small Tree	18	11	6	0	0	2
Large Tree	2	0	0	2	0	0
OuterZone						
Grass/ Forbes	40	9	12	6	6	6
Shrub/ Seedling	14	2	8	2	2	2
Sapling/ Pole	0	0	0	0	0	0
Small Tree	20	3	11	2	0	5
Large Tree	25	0	0	5	14	6

2.8 Water Quality and Quantity Overview

2.8.1 Stream Temperature

Stream temperature is the most significant water quality concern in the Peshastin Creek Basin. Peshastin Creek is considered "impaired" with respect to temperature by the State of Washington. Segments of Peshastin Creek were originally placed on the state's 303(d) list of polluted waters in 1996 due to exceedances of state temperature standards (WDOE 2008). Additional segments of Peshastin Creek, and a segment of Tronson Creek, were added to the list in 2004. In 2004, these streams were considered Category 5 streams, meaning they were impaired streams without a Water Quality Improvement Plan, also known as a TMDL (Total Maximum Daily Load). In 2005, the TMDL was completed for the Wenatchee River Basin, including Peshastin Creek and tributaries. Because a TMDL has now been completed for the basin, Peshastin Creek segments are now considered Category 4A, which means they are still impaired but are covered under an active TMDL.

The State's reporting on water quality in the basin is found in the 2008 WDOE 305(b) listing, which is a comprehensive water quality report for the state that includes the information formally found separately in the 303(d) list (WDOE 2008). The 2008 305(b) listing for Peshastin Creek includes several stream sections in the basin listed for temperature, and one section listed as impaired for instream flow (Table 8).

Table 8. Peshastin Creek 305(b) listing for 2008 (WDOE 2008).

Waterbody	River Mile	Parameter	Category	EPA ID
Peshastin Creek	0.4-1.3	Instream Flow	4c (not addressed by TMDL)	5792
Peshastin Creek	0.4-1.3	Temperature	4a (active TMDL)	8428
Peshastin Creek	10.1-11.3	Temperature	4a (active TMDL)	39381
Peshastin Creek	11.3-13.0	Temperature	4a (active TMDL)	42884
Peshastin Creek	14.0-15.2	Temperature	4a (active TMDL)	42885
Peshastin Creek	2.8-3.9	Temperature	4a (active TMDL)	8427
Peshastin Creek	6.1-7.1	Temperature	4a (active TMDL)	42881
Peshastin Creek	9.0-10.1	Temperature	4a (active TMDL)	39344
Tronsen Creek	0.0-0.6	Temperature	4a (active TMDL)	39385

Data gathered by the USFS, Cascadia (Chelan County) Conservation District (CCCD), and the Yakima Nation contributed to the original 303(d) listing. All of these groups found multiple excursions above temperature thresholds in Peshastin Creek between 1992 and 1995. The most comprehensive water temperature record in the basin is provided by the USFS, which has performed summer season monitoring at several sites on Peshastin Creek since 1993. This monitoring has been conducted in order to measure compliance with the Wenatchee National Forest Land Management Plan, which includes the following temperature thresholds: (1) a daily maximum temperature of 61°F, and (2) a 7-day average maximum temperature of 58°F (USFS

2008). Upstream of the confluence of Negro Creek, Peshastin Creek stream temperature is extremely poor, often exceeding 70°F during the summer (Figure 50). Negro Creek provides a cold water input that improves stream temperature in Peshastin Creek, which fluctuates from the mid to low 60's between Negro Creek and Ingalls Creek (Figure 51). These temperatures still exceed USFS and Washington State water quality standards for temperature. Ingalls Creek provides another cold water input that moderates stream temperature downstream of the confluence, although high temperatures continue to occur in lower Peshastin Creek (Figure 52).

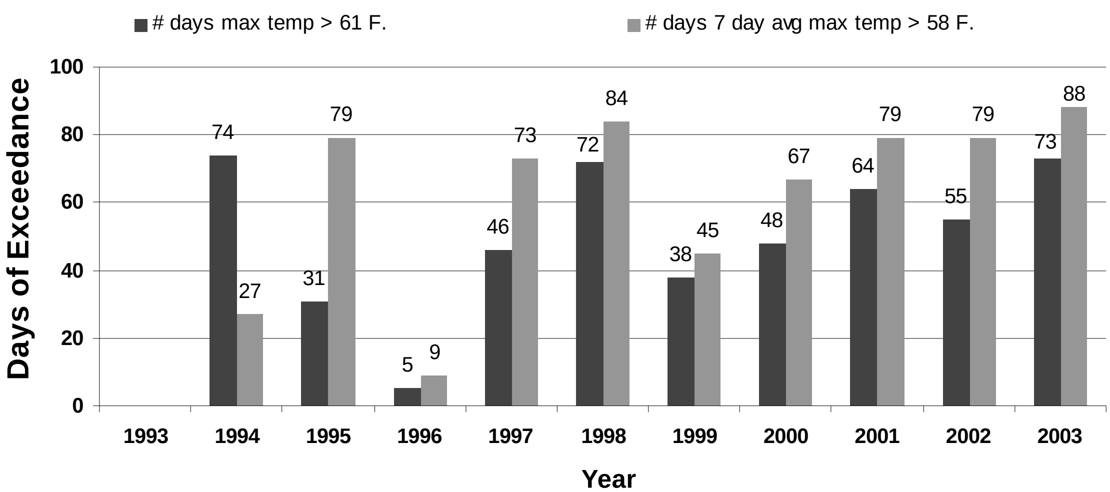

Figure 50. Temperature record for Peshastin Creek above Negro Creek from 1994-2003. Data is from USFS (2008).

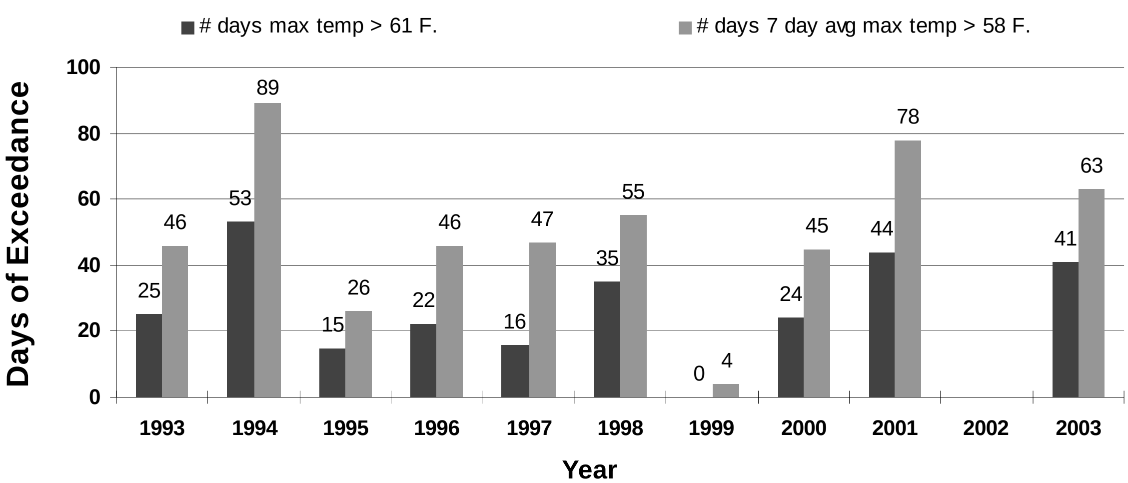

Figure 51. Temperature record for Peshastin Creek above Ingalls Creek from 1993 to 2003 with data missing for 2002. Data is from USFS (2008).

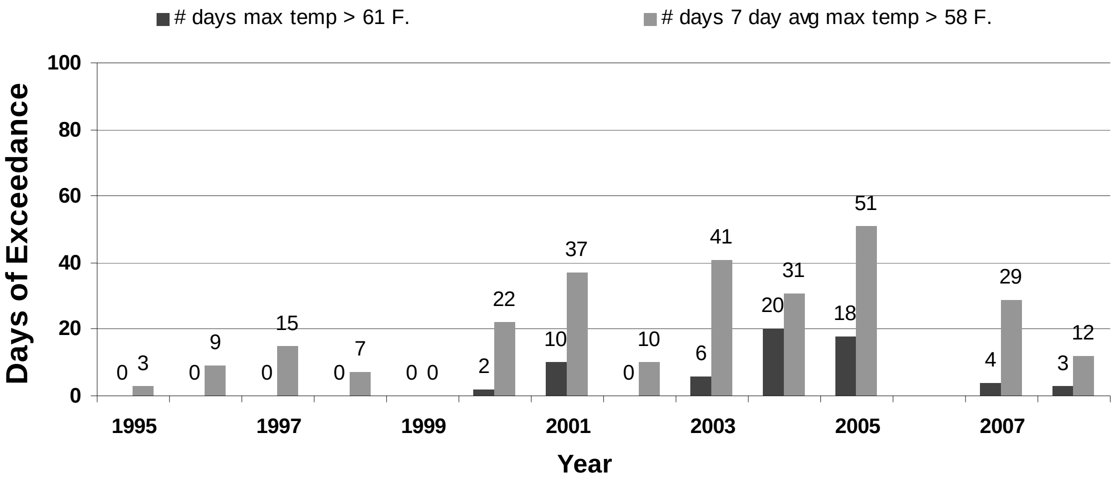

Figure 52. Temperature record for Peshastin Creek below Ingalls Creek for 1995-2008 with data missing for 2006. Data is from USFS (2008).

As part of the TMDL Study, the WDOE recorded Peshastin Creek temperatures that exceeded state water quality standards (including the old standards and the revised standards that became effective in 2003, see WAC 173-201A) for several periods and locations during sampling in 2002 and 2003. Year 2003 sampling resulted in the greatest frequency of violations of state water quality standards.

Thermal Infrared Radiation (TIR) imaging was also conducted as part of the TMDL Study in order to provide a spatial representation of surface temperature. Thermal imaging was conducted by helicopter for Peshastin Creek on August 11, 2003. The TIR data revealed areas of cold and warm water inputs; these data can be used to help identify problem areas as well as restoration opportunities. An example thermal image is provided in Figure 53.

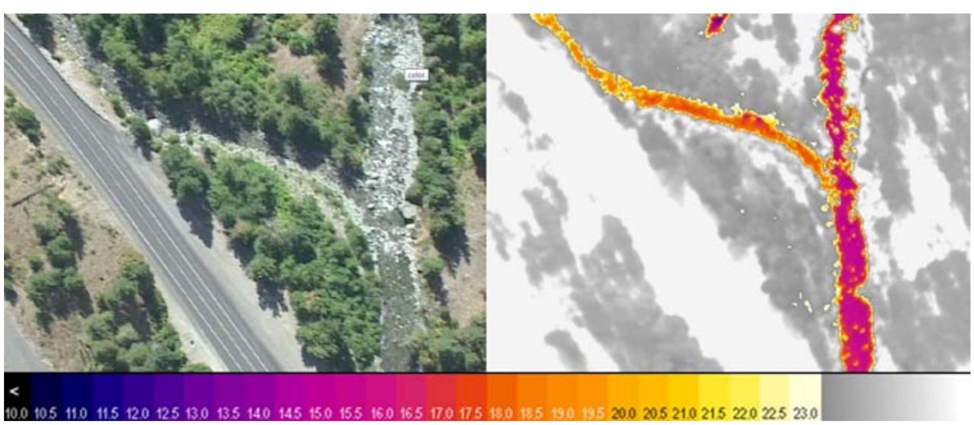

Figure 53. Thermal (TIR) image of Peshastin Creek at the Ingalls Creek confluence. The temperature scale at the bottom is in degrees Celsius. Streamflow is from top to bottom of images. Ingalls Creek enters at the top right and upper Peshastin is at left. Ingalls Creek is an important contributor of cool water to Peshastin Creek, and its impact carries downstream for a few miles.

As part of the TMDL, temperature modeling was used to evaluate the potential for management actions to lower stream temperatures. This analysis was not conducted specifically for Peshastin Creek; however, results for the Wenatchee River, Icicle Creek, and Nason Creek demonstrate that at the low-flow scenario, average maximum temperatures could be decreased by 2.7°C through increasing shade, reducing channel widths, and eliminating flow withdrawals (WDOE 2005). Similar results could be expected for Peshastin Creek. The vegetation assessment in the TMDL determined that Peshastin Creek within the study area (river mile 0 – 9.3) had effective shade deficits in the <5%, 5-20%, and 20-35% categories (Figure 54).

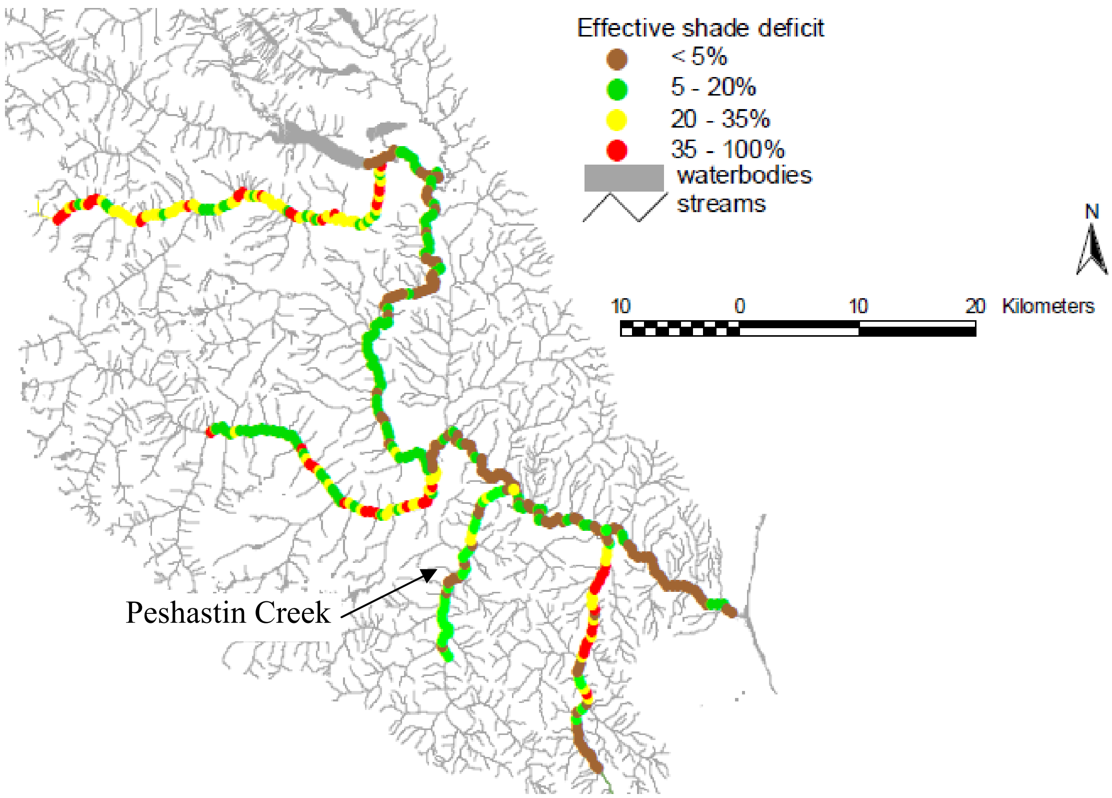

Figure 54. Effective shade deficit in the Wenatchee River basin. Reproduced from WDOE (2005).

The lack of historical temperature data in Peshastin Creek makes it difficult to determine the relative influence of land use activities on stream temperature. However, based on the temperature monitoring and assessment work that has been completed, a number of reasonable conclusions can be made with respect to management practices that may help to reduce temperatures. First, increasing stream shading through restoring the large tree component in riparian areas could help to reduce the effective shade deficit that was identified in the TMDL Study. Secondly, narrowing stream channels can reduce width-to-depth ratios to reduce stream heating. These practices are particularly applicable in areas where channels have been over-widened or where historical multi-thread segments, with multiple low width-to-depth channels, have been simplified and converted to single-thread channels. Lastly, reducing water withdrawals during warm summer months can reduce stream heating associated with low instream flows.

2.8.2 Fine Sediment

Elevated fine sediment is a potential concern in the basin, although results are mixed. The USFS sampled two locations for fine sediment on mainstem Peshastin Creek using the McNeil core sampling method. These samples yielded an average of 25.5% fine sediment for the two bulk surface/sub-surface samples (USFS 1993). These samples exceed the USFS standard of 20% for fine sediment (material <1mm diameter, or medium sand), which is based on salmonid spawning requirements (USFS 1993). USFS also performed surface pebble counts in the wetted channel and on active point bars at 20 locations along the mainstem of Peshastin Creek for the USBR in 2006 (USBR 2006, unpublished data). The highest percentage of material smaller than 2mm at any of these locations was 11.7%, which is within the USFS standards. The smaller percentage of fines in surface material is not surprising, given the natural development of coarse surface lag that commonly develops in gravel channels.

A total of 10 surface pebble counts were conducted as part of the 2009 Habitat Survey (see Section 2.7 of this report). The percent of sediment smaller than 2 mm was usually less than 10% of a given sample. Sediment smaller than 2 mm exceeded 10% of the bed material at 30% of sample locations. The highest fine sediment composition was 14%.

Several point sources of sediment, both natural and anthropogenic, have been identified in the basin. The Larsen Creek drainage contributed fine sediment to the channel during a 1996 flood event that followed severe forest fires in 1994 (Andonaegui 2001). The Ruby Creek Slide near river mile 10.5 has been recognized as a chronic source of fine sediment input to the channel. This is a naturally occurring feature; however, protection of Highway 97 near the slide has included bank hardening, which has probably exacerbated erosion along the toe of the slide (Andonaegui 2001). Winter road sanding on Highway 97 provides a source of fine-sediment to the channel. Sand is used to increase traction on Highway 97 when snow and ice is present on the roadway. This material eventually gets washed into the channel. Mining activities that include dredging in the channel are ongoing in some of the tributaries in the basin. These activities disturb channel substrate and can mobilize fine sediment. Streambank condition in the basin has been rated as “poor” by the USFS. Bank stability has been compromised by logging, mining, grazing, riparian deforestation, and road building (USFS 1999).

2.8.3 Other Water Quality Parameters

There is limited information on other water quality parameters in the Peshastin Creek Basin. According to a summary provided in the Wenatchee River Subbasin Plan (NPCC 2004), Peshastin Creek exceeded dissolved oxygen standards 9 times, exceeded turbidity standards 2 times, and exceeded fecal coliform standards one time (CCCD 1998 as cited in NPCC 2004). The dissolved oxygen sampling occurred throughout the watershed and fecal coliform sampling was conducted at the mouth. It was speculated that the fecal coliform exceedance may be related to the influence of private lands in the lower 8 miles.

2.8.4 Water Quantity

Water quantity in lower Peshastin Creek is affected by basin-scale impacts as well as flow diversion for irrigation. There are two irrigation diversions on lower Peshastin Creek. The

Tandy Ditch Company diverts flow at the Tandy Ditch at RM 4.9; up to 4.6 cfs can be diverted. The Peshastin Irrigation District can divert up to 40 cfs at the Peshastin Canal at RM 2.5, but typical diversions range from 11 cfs to 33 cfs during the irrigation season (based on 2002 and 2003 data from Peshastin Irrigation District) (Anchor Environmental and EES Consulting 2007). Irrigation diversions typically occur April through mid-September. Diversions at the Peshastin Canal are highest during June and July and taper off in August and September. Peshastin Canal can also receive water from the Icicle Canal, which originates on Icicle Creek. Water is delivered via a 16-inch pipeline from a bifurcation structure located on the hillside just north of Peshastin Creek. There are also 3 means of spilling water from the Icicle Canal into Peshastin Creek in this area (Anchor Environmental and EES Consulting 2007).

Washington State has established minimum instream flow requirements for Peshastin Creek in order to protect fish, wildlife, navigation, water quality, scenic, aesthetic, and other environmental values (WDOE 1983). Instream flow rules were initially established in 1983 (Chapter 173-545 WAC) based on recommendations of a 1982 instream flow report by the WA State Department of Ecology (WDOE 1983). These rules closed Peshastin Creek to new water withdrawals between June 15 and October 15 of each year. Instream flow rules were amended in 2008 based on recommendations that came out of the Wenatchee watershed management planning process (WRIA 45 Planning Unit 2006). These new rules went into effect January 12, 2008 (Chapter 173-545 WAC). Minimum instream flows were established for 4 time periods throughout the year. The period of closure to new withdrawals was also revised. The new closure period is from August 1 to October 15 in order to "allow allocation of water during spring runoff periods" and to "provide storage opportunities that would not otherwise be possible and provide incentive for mitigation" (WRIA 45 Planning Unit 2006).

Primary water needs during the summer are irrigation and instream flow for bull trout and Chinook upstream migration. As part of a water needs study, Anchor Environmental and EES Consulting (2007) used the Oregon Method (Thompson 1972) to estimate fish passage flows in lower Peshastin from the Peshastin Canal diversion structure downstream to the mouth. Four transects and 3 flow levels (31.4 – 35.6 cfs, 13.8 – 24.3 cfs, and 7.1 – 9.9 cfs) were used for the study. Results indicate that for bull trout, an average flow of 17.25 cfs is necessary for passage in the lower river. For Chinook, an average flow of 39.75 cfs is needed. Gage data suggests that flows are adequate for passage until mid July, when they begin to drop below the thresholds needed for passage. The study cautions the use of the OR Method, and notes that even without irrigation diversion, flows are often inadequate for Chinook passage according to this method. However, they also suggest that human-induced channel changes may have impaired passage conditions in the lower river, resulting in more flow that is now required for passage.

Based on their study, several recommendations are given for addressing water and fish passage needs (Anchor Environmental and EES Consulting 2007). These include:

- Complete the piping project on the Peshastin Canal from Brender Spill to the end of the canal to conserve water that would otherwise be diverted from Peshastin Creek

- Coordinate with the Bureau of Reclamation on their geomorphic study of lower Peshastin Creek to assess whether modifications to gravel bars could help fish passage
- Work with the Instream Flow Subcommittee of the Wenatchee Watershed Planning Unit to develop an instream flow strategy for Peshastin Creek
- Continue discussions with the U.S. Forest Service and property owners on the Campbell Creek reservoir
- Work with the Icicle Irrigation District to evaluate the feasibility of Icicle Canal modifications to deliver additional water in July and August
- Perform more detailed analyses of the pump station alternative

In order to provide data to evaluate instream flow impacts on habitat in lower Peshastin Creek, a PHABSIM analysis was conducted in 2005 in support of watershed planning efforts (EES Consulting and Thomas R. Payne & Associates 2005). PHABSIM was performed using 9 transects near river miles 2.1 and 2.2. Weighted usable area (WUA) was calculated for each transect. Washington State “standard” criteria were used for the Habitat Suitability Criteria (HSC), with newly collected data from the Chiwawa Basin used to revise and update the HSC for bull trout. A summary of the results is included in Table 9.

Table 9. Summary of results from PHABSIM analysis on lower Peshastin Creek (EES Consulting and Thomas R. Payne & Associates 2005).

Life-Stage	Optimum flow
Steelhead rearing	~100-200 cfs
Chinook rearing	~50 cfs
Bull trout rearing	~20 cfs
Chinook spawning	~75 cfs
Steelhead spawning	~120 cfs

2.9 Reach-Based Ecosystem Indicator (REI) Metrics

REI metrics provide a consistent means of evaluating biological and physical conditions of a watershed in relation to regional standards and known habitat requirements for aquatic biota. These metrics, along with other scientific evaluations, describe the current quality of stream biophysical conditions and can help guide restoration priorities and alternatives. The REI evaluation for the Peshastin Creek Watershed was conducted using field data, observations, and applicable studies produced for Peshastin Creek and other regional watersheds. The indicators used in this REI assessment were adapted from previous assessments conducted by the USBR for the White Pine Reach of Nason Creek (2009) and from the Preston Reach of the Entiat River (2009). The complete list of REI Metrics and threshold values used in this assessment are included in Table 10.

A total of 6 REI general indicators were assessed at the tributary scale (Table 11). Two metrics were found to be in an adequate condition: turbidity and chemical contamination/nutrients. Three metrics were in an at risk condition: disturbance regime, stream flow, and effective drainage network and watershed road density. One metric was in an unacceptable condition: water temperature.

A total of 11 REI general indictors were assessed at the reach scale (Table 12). In Reach 1, 9 of the 11 indicators were in an 'unacceptable' condition including all channel dynamics and riparian vegetation characteristics. This reach has experienced considerable floodplain development and channel modification, and is constrained by multiple roadways and bridges that disconnect stream channels, floodplains, and channel migration zones. Stream flow and water temperature conditions contributed to 'at risk' and 'unacceptable' conditions at the tributary-scale. In Reach 2, 7 of the 11 indicators were rated as 'unacceptable' with the most impaired characteristics being channel dynamics and riparian vegetation. The dominant substrate/fine sediment indicator was rated as 'adequate'. Similar to Reach 1, floodplain development and channel modification occurs throughout the reach. In Reach 3, most indicators were in an 'at risk' condition. Habitat access was in an 'adequate' condition. Valley width is narrower in this reach, resulting in less natural occurrence of floodplains, side-channels, and off-channel features; and therefore less potential for impairment of these habitat types. In Reach 4, 4 indicators were given an 'adequate' condition rating, the most for any reach in the study area. This can be attributed, in part, to reduced floodplain development. Also, as in Reach 3, there is naturally limited off-channel and side-channel habitat. In Reach 5, floodplain development resulted in 7 of 11 indicators rated as 'unacceptable'. All channel dynamics and riparian vegetation characteristics were given an 'unacceptable' condition rating. The only 'adequate' condition was given to the habitat access metric. In Reach 5b/6 several indicators could not be determined because the habitat survey ended at RM 8.4. For the REI metrics that could be determined, 6 were found to be in an unacceptable risk condition. Habitat access was found to be in an acceptable condition.

Table 10. REI Metrics used in the Peshastin Creek Assessment including criteria for condition ratings.

General Characteristics	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Tributary Scale					
Watershed condition	Effective Drainage Network and Watershed Road Density	Increase in Drainage Network/Road Density	Zero or minimum increases in active channel length correlated with human caused disturbance. And road density <1 miles/miles^2	Low to moderate increase in active channel length correlated with human caused disturbances. And road density <1 miles/miles^2	Greater than moderate increase in active channel length correlated with human cuased distrubances. And road density >2.4 miles/miles^2
	Disturbance Regime	Natural/Human Caused	Environmental disturbance is short lived; predictable hydrograph, high quality habitat and watershed complexity providing refuge and rearing space for all life stages or multiple life-history forms. Natural processes are stable.	Scour events, debris torrents, or catastrophic fires are localized events that occur in several minor parts of the watershed. Resiliency of habitat to recover from environmental disturbance is moderate.	Frequent flood or drought producing highly variable and unpredictable flows, scour evnets, debris torrents, or high probability of catastrophic fire exists throughout a major portion of the watershed. The channel is simplified, providing little hydraulic complexity in the form of pools or side channels. Natural processes are unstable.
Flow/ Hydrology	Streamflow	Change in Peak/Base Flows	Magnitude, timing, duration, and frequency of peak flows within a watersed are not altered relative to natural conditions of an undistrubed watershed of similar size, geology, and geography.	Some evidence of altered magnitude, timing, duration, and/or frequency of peak flows relative to natural conditions of an undisturbed watersed of similar size, geology, and geography.	Pronounced changes in magnitude, timing, duration, and/or frequency of peak flows relative to natural conditions of an undisturbed watersed of similar size, geology, and geography.
Water Quality	Temperature	Daily maximum, and 7-day mean maximum temperatures	Bull Trout: Incubation 2-5°C, rearing: 4-10°C, spawning: 1-9°C. Salmon and Steelhead: Spawning June-Sept 15°C, Sept-May 12°C; rearing 15°C, migration 15°C, adult holding 15°C. Or 7-day daily maximum temperature perfromance standards: Salmon spawning 13°C, core summer salmonid habitat 16°C. Salmonid spawning, rearing and migration 17.5°C. Salmonid rearing and migration only 17.5°C.	MWMT in reach during the following life history stages: Incubation <2°C or >6°C; rearing <4°C or >13-15°C; spawning <4°C or >10°C. Temperatures in areas used by adults during the local spawning migration sometimes exceed 15°C. Or 7-day average daily maximum temperature standards exceeded by ≤15%.	MWMT in reach during the following life history stages: Incubation <1°C or >6°C; rearing >15°C; spawning <4°C or >10°C. Temperatures in areas used by adults during the local spawning migration sometimes exceed 15°C. Or 7-day average daily maximum temperature standards exceeded by >15%.
	Turbidity	Turbidity NTU's	Performance Standard: Acute <70 NTU Chronic <50 NTU For streams that naturally exceed these standards: Turbidity should not exceed natural baseline levels at the 95% CL. <15% exceedance., Or Turbidity shall not exceed: 5 NTU over background when the background is 50 NTU or less; or a 10 percent increase in turbidity when the backgorund turbidity is more tha 50 NTU (WDOE -173-201A-200).	15-50% exceedance.	>50% exceedance.

Table 10 continued.

General Characteristics	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
	Chemical Contamination/ Nutrients	Metals/ Pollutants, pH, DO, Nitrogen, Phosphorous	Low levels of chemical contamination from landuse sources, no excessive nutrients, no CWA 303d designated reaches., Or Washington State Department of Ecology standards - 173-201A-200.	Moderate levels of chemical contamination from landuse sources, some excess nutrients, one CWA 303d designated reach.	High levels of chemical contamination from landuse sources, high levels of excess nutrients, more than one CWA 303d designated reach.
Reach-Scale					
Habitat Access	Physical Barriers	Main Channel Barriers	No man-made barriers present in the mainstem that limit upstream of downstream migration at any flow.	Mand-made barriers present in the mainstem that prevent upstream or downstream migration at some flows that are biologically significant.	Man-made barriers present in the mainstem that prevent upstream or downstream migration at multiple or all flows.
Habitat Quality	Substrate	Dominant Substrate/Fine Sediment	Gravels or small cobbles make-up >50% of the bed materials in spawning ares. Reach embeddedness in rearing areas <20%. ≤12% fines (<0.85mm) in spawning gravel or 12% surface fines of ≤6mm	Gravels or small cobbles make-up 30-50% of the bed materials in spawning ares. Reach embeddedness in rearing areas 20-30%. 12-17% fines (<0.85mm) in spawning gravel or 12-20% surface fines of ≤6mm	Gravels or small cobbles make-up <30% of the bed materials in spawning ares. Reach embeddedness in rearing areas >30%. >17% fines (<0.85mm) in spawning gravel or >20% surface fines of ≤6mm
	LWD	Pieces per Mile at Bankfull	>20 pieces/mile >12" diameter > 35 ft length; and adequate sources of woody debris available for both long- and short-term recruitment.	Currenlty levels are being maintained at minimum levels desired for "adequate", but potential sources for long-term woody debris recruitment is lacking to maintain these minimum values.	Current levels are not at those desired values for "adequate", and potential sources of woody debris for short- and/or long-term recruitment are lacking.
	Pools	Pool Frequency and Quality, presence of large pools.	Pool frequency: Number of pools/mile for a given channel width. Channel width between 30-35 ft = 18 pools/mile. Channel width 35-40 ft = 10 pools per mile. Pool have good cover and cool water and only minor reduction in pool volume by fine sediment. Each reach has many large pools >1 m deep with good fish cover.	Pool frequency is similar to values in "functioning adequately", but pools have inadequate cover/temperature and/or there has been a moderate recution of pool volume by fine sediment. Reaches have few large pools (>1m) present with good fish cover.	Pool frequency is considerably lower than values for "adequate condition", also cover/temperature is inadequate, and there has been a major recudtion of pool volume by fine sediment. Reaches have no deep pools (>1m) with good fish cover.
	Off-Channel Habitat	Connectivity with Main Channel	Reach has many ponds, oxbows, backwaters, and other off-channel areas with cover, and side channels are low energy areas. No manmade barriers present along the mainstem that prevent access to off-channel areas.	Reach has some ponds, oxbows, backwaters, and other off-channel areas with cover, and side channels are high energy areas. Manmade barriers present that prevent access to off-channel habitat at some flows that are biologically significant.	Reach has few or no ponds, oxbows, backwaters, and other off-channel areas. Manmade barriers present that prevent access to off-channel habitat at multiple or all flows.

Table 10 continued.

General Characteristics	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Channel	Dynamics	Floodplain Connecivity	Floodplain areas are frequently hydrologically linked to main channel; overbank flows occur and maintain wetland functions, riparian vegetation and succession.	Reduced linkage of wetland, floodplains and riparian areas to main channel; overbank flows are reduced relative to historic frequency, as evidenced by moderate degradation of wetland function, riparian vegetation/succession.	Sever reduction in hydrologic connectivity between off-channel, wetland, floodplain and riparian areas; wetland extent drastically reduced and riparian vegetation/succession altered significantly.
		Bank Stability/Channel Migration	Channel is migrating at or near natural rates.	Limited amount of channel migration is occurring at a faster/slower rate relative to natural rats, but significant change in channel width or planform is not detectable; large woody debris is still being recruited.	Little or no channel migration is occurring because of human actions preventing reqorking of the floodplain and large woody debris recruitment; or channel migration is occurring at an accelerated rate such that channel width has at least doubled, possibly resulting in a channel planform change, and sediment supply has noticeably increased from bank erosion.
		Vertical Channel Stability	No measurable trend of aggradation or incision and no visible change in channel planform.	Measureable trend of aggradation or incision that has the potential to, but not yet caused, disconnection of the floodplain or a visible change in channel planform (e.g. single thread to braided)	Enough incision that the floodplain and off-channel habitat areas have been disconnected; or, enough aggradation that a visible change in channel planform has occurred (e.g. single thread to braided).
Riparian Vegetation	Condition	Structure	>80% species composition, seral stage, and structural complexity are consistent with potential native community.	50-80% species composition, seral stage, and structural complexity are consistent with potential native community.	<50% species composition, seral stage, and structural complexity are consistent with potential native community.
		Disturbance (Human)	>80% mature trees (medium-large) in the riparian buffer zone (defined as a 30 m belt along each bank) that are available for recruitment by the river via channel migration; <20% disturbance in the floodplain (e.g., agriculture, residential, roads, etc.); <2 mi/mi^2 road density in the floodplain.	50-80% mature trees (medium-large) in the riparian buffer zone (defined as a 30 m belt along each bank) that are available for recruitment by the river via channel migration; 20-50% disturbance in the floodplain (e.g., agriculture, residential, roads, etc.); 2-3 mi/mi^2 road density in the floodplain.	<50% mature trees (medium-large) in the riparian buffer zone (defined as a 30 m belt along each bank) that are available for recruitment by the river via channel migration; >50% disturbance in the floodplain (e.g., agriculture, residential, roads, etc.); >3 mi/mi^2 road density in the floodplain.
		Canopy Cover	Trees and shrubs within one site potential tree height distance or 10 m buffer zone have >80% canopy cover that provides thermal shading to the river.	Trees and shrubs within one site potential tree height distance or 10 m buffer zone have 50-80% canopy cover that provides thermal shading to the river.	Trees and shrubs within one site potential tree height distance or 10 m buffer zone have <50% canopy cover that provides thermal shading to the river.

Table 11. REI Ratings for Tributary-Scale Metrics.

General Characteristics	General Indicators	Specific Indicators	Rating	Discussion
Watershed Condition	Effective Drainage Network and Watershed Road Density	Increase in Drainage Network/Road Density	*At Risk Condition*	Road networks in the Basin have increased throughout the late 19th and 20th centuries resulting in a road density of 2.4 miles/mile^2 (USFS 1999). There are also many valley bottom roads that affect drainage patterns, riparian areas, and floodplains. Highway 97, in particular, affects conditions along mainstem Peshastin and Tronsen Creeks from the mouth to the headwaters. In addition to Highway 97, there are numerous forest roads providing access to recreation, logging areas, and mining claims in most tributary drainages. Because of the narrow, steep valleys of many of the tributaries, these roads are often located in sensitive riparian areas.
	Disturbance Regime	Natural/Human Caused	*At Risk Condition*	Anthropogenic disturbance is present throughout the watershed in the form of roads, riparian clearing, logging, mining, grazing, agriculture, and residential development. These activities decrease the ability of the system to respond to natural disturbance regimes such as fire or floods. The channel has a documented decrease in variability, and is shown to be unstable in several areas (USFS 1999, Andonegui 2001).
Flow/Hydrology	Streamflow	Change in Peak/Base Flows	*At Risk Condition*	Streamflow records in the Basin are very short (DOE 2003-2008). Changes to the timing, magnitude, or duration of peak flows over time cannot be demonstrated from this record. Watershed disturbances such as road building and logging have been shown to affect these attributes of the hydrograph in other watersheds, but there is no evidence of these affects in the Peshastin Creek watershed. Low flows are affected by irrigation withdrawal in late July, through the end of the irrigation season in September. A no flow condition has been observed downstream of the Peshastin Canal diversion in some years, and typical low-flow conditions downstream of the diversion may affect fish passage.
Water Quality	Temperature	Daily maximum, and 7-day mean daily maximum temperatures	*Unacceptable Risk Condition*	Peshastin Creek has had an ongoing 303(d) listing for temperature for several years, and is currently managed as part of the TMDL for the Wenatchee River Basin (DOE 2008). USFS temperature studies (2008) report that the daily maximum temperature exceeded 16°C 12 times, and that the 7-day average daily maximum temperature exceeded 14.4°C.
	Turbidity	Turbidity NTU's	*Adequate Condition*	NTU values are within DOE acceptable condition standards set for freshwater quality standards (WAC 173-201A-200). Monitoring records are not adequate to demonstrate long-term trends, or departure from background conditions.
	Chemical Contamination/ Nutrients	Metals/ Pollutants, pH, DO, Nitrogen, Phosphorous	*At Risk Condition*	USFS established a water quality monitoring station at "Site 5" on Peshastin Creek, and monitored multiple constituents during the time period from 10/5/1999 to 9/12/2000. Observed DO levels, pH values, and fecal coliform bacteria counts were within acceptable limits set forth by WAC 173-201A-200. Observed levels of conductivity, NO3-NO2-N, and phosphorus in Peshastin Creek were rated as "At Risk Condition" based on measured phosphorous levels by the USFS at "Site 5" that may approach levels that present eutrophication risk (MacDonald et al. 1991). It should be noted, however, that considerable uncertainty exists with respect to this rating due to the small spatial and temporal scale of sampling.

Table 12. REI Metrics for Reach-Scale Metrics.

General Characteristics	General Indicators	Specific Indicators	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5a	Reach 5b/6
Habitat Access	Physical Barriers	Main Channel Barriers	*At Risk Condition*	*At Risk Condition*	*Adequate Condition*	*Adequate Condition*	*Adequate Condition*	*Adequate Condition*
			Temerature poses a migration barrier during late-summer.	Irrigation diversion at RM 2.5 poses a potential barrier at low flow. Low flow discharge is negatively impacted by upstream diversions.	No anthropogenic barriers in the reach, though downstream diversions for the Peshastin Irrigation canal and Tandy Ditch may limit access to this reach by reducing flow depth and creating barriers.	No anthropogenic barriers in the reach, though downstream barriers may limit access to this reach under certain conditions.	No anthropogenic barriers in the reach, though downstream barriers may limit access to this reach under certain conditions.	No anthropogenic barriers in the reach, though downstream barriers may limit access to this reach under certain conditions.
Habitat Quality	Substrate	Dominant Substrate/Fine Sediment	*At Risk Condition*	*Adequate Condition*	*At Risk Condition*	*At Risk Condition*	*At Risk Condition*	*Unknown*
			Based on pebble counts, small cobbles and gravels comprise 30-50% of bed material at sampled locations (D50 130-92 mm). USFS core sampling found gretaer than 20% material <1mm at one sampled location in the reach.	Based on pebble counts, >50% of the bed substrate is in the gravel or small cobble size classes (D50 64-43 mm). At one site 13% sand composition was observed, <10% sand was observed at the second site.	Based on pebble counts, 30-50% of the bed substrate is in the gravel or small cobble size classes (D50 141-99 mm). At one site 14% sand composition was observed, 5% sand was observed at the second site.	Based on pebble counts, 30-50% of the bed substrate is in the gravel or cobble size classes, however the D50 was relatively large (104-148 mm). At one site 11% sand composition was observed, 3% sand was observed at the second site.	Based on pebble counts, 30-50% of the bed substrate is in the gravel or cobble size classes, however the D50 was relatively large (106-166 mm). At one site 11% sand composition was observed, 3% sand was observed at the second site.	Substrate data is not available for this reach.
	LWD	Pieces per Mile at Bankfull	*Unacceptable Risk Condition*	*Unacceptable Risk Condition*	*Unacceptable Risk Condition*	*At Risk Condition*	*Unacceptable Risk Condition*	*Unacceptable Risk Condition*
			No large wood pieces. 2 pieces per mile medium wood. 24 pieces per mile are small. Total 2 pieces per mile medium or larger wood. Recruitment sources are limited.	8 pieces per mile large wood, 6 pieces per mile medium wood, 26 pieces per mile are small. Total 14 pieces per mile medium or larger wood. Recruitment sources are limited.	5 pieces per mile large wood, no medium wood pieces, 6 pieces per mile are small. Total 5 pieces per mile medium wood or larger. Recruitment sources are limited.	12 pieces per mile large wood, 9 pieces per mile medium wood, 23 pieces per mile small wood. Total 21 pieces per mile medium or larger wood. Recruitment sources are limited.	4 pieces per mile large wood, no medium pieces, 27 pieces per mile small wood. Total 4 pieces per mile medium or larger wood. Recruitment sources are limited.	LWD counts are unavailable for this reach. Site observations and air photo analysis suggest very little to no LWD is present.
	Pools	Pool Frequency and Quality, presence of large pools.	*Unacceptable Risk Condition*	*At Risk Condition*	*Unacceptable Risk Condition*	*At Risk Condition*	*At Risk Condition*	*Unacceptable Risk Condition*
			13 pools per mile, unnacceptable for a 35' wetted width. No deep pools observed, poor cover.	12 pools per mile, adequate for a 38' wetted width. Few deep pools observed, poor cover.	8 pools per mile, unnacceptable for a 39' wetted width. Few deep pools observed, poor cover.	18 pools per mile, adequate for a 36' wetted width. Few deep pools observed, poor cover.	19 pools per mile, adequate for a 31' wetted width. Several deep pools observed, poor cover.	Pool data is unavailable for this reach. Site observations and air photo analysis suggest very little to no pools are present.

Table 12 continued.

General Characteristics	General Indicators	Specific Indicators	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5a	Reach 5b/6
Habitat Quality	Off-Channel Habitat	Connectivity with Main Channel	*Unacceptable Risk Condition*	*Unacceptable Risk Condition*	*At Risk Condition*	*Adequate Condition*	*At Risk Condition*	*Unacceptable Risk Condition*
			No functional off-channel or side-channel habitat. Levees, riprap, bridges, and roads prevent access over a wide-range of flows to the few existing off-channel or side-channel habitat areas.	1% of the reach is in functional side-channel habitat. No functional off-channel habitat. Highway 97, riprap, levees, and bridges present barriers over a wide-range of flows to historical off-channel habitats.	6% of the 1 mile section is side channel habitat. No functional off-channel habitat, though floodplain width is naturally limited. Highway 97 and a levee present barriers over a range of flows to historical off-channel habitat.	2% of the reach is side channel habitat. No functional off-channel habitat. Natural limitations on floodplain width and lateral dynamics preclude these habitat types in this reach.	No functional off-channel or side channel habitat in this reach. Natural limitations on floodplain width and lateral dynamics limit the extent of these habitat types in this reach. Floodplain fill, roads, and a bridge present barriers to historically available habitat.	There are no connected off-channel or side-channel habitats. Historical off channel and side-channel habitat has been reduced due to Highway 97 on the east side of the channel, and levees or spoils piles along the west side of the channel.
Channel	Dynamics	Floodplain Connecivity	*Unacceptable Risk Condition*	*Unacceptable Risk Condition*	*Unacceptable Risk Condition*	*Unacceptable Risk Condition*	*Unacceptable Risk Condition*	*Unacceptable Risk Condition*
			85% of the historic floodplain is disconnected by channel straightening, levees, riprap, bridges, and roads. Very little floodplain inundation by flows less than the 100-yr flood.	47% of the historic floodplain is disconnected by Highway 97, riprap, and bridges. Some relatively frequent floodplain inundation between RM 2.8 and 3.5, and RM 4.5 and 5.0. Severe channel re-routing and floodplain abandonment between RM 3.6 and 3.9.	88% of the historic floodplain is disconnected by a bridge, a levee, riprap, and floodplain development. Very little floodplain inundation by flows less than the 100-yr flood.	26% of the historic floodplain is disconnected. Very little floodplain inundation by flows less than the 100-yr flood.	100% of the historic floodplain is disconnected by a bridge, roads, and floodplain development. Very little floodplain inundation by flows less than the 100-yr flood.	100% of the historic floodplain is disconnected by Highway 97, levees, and spoils piles.
		Bank Stability/Channel Migration	*Unacceptable Risk Condition*	*Unacceptable Risk Condition*	*At Risk Condition*	*Adequate Condition*	*Unacceptable Risk Condition*	*Unacceptable Risk Condition*
			No observed bank erosion. Riprap, levees, and bridges reduce channel migration relative to expected natural rates. No significant woody debris recruitment.	6% (1,200 ft) of bank erosion in the reach. Highway 97, riprap, levees, and bridges reduce channel migration relative to expected natural rates. Complete channel confinement in some areas. No significant woody debris recruitment.	2% (167 ft) of bank erosion in this reach. Natural valley confinement limits lateral channel dynamics. Highway 97 and floodplain development reduce channel migration relative to expected natural rates in isolated areas. No dignificant woody debris recruitment.	No observed bank erosion. Natural valley confinement limits lateral channel dynamics. Highway 97, a bridge, and floodplain development reduce channel migration relative to expected natural rates in isolated areas. No dignificant woody debris recruitment.	4% (425 ft) of bank erosion in this reach. Highway 97, riprap, and floodplain development reduce channel migration relative to expected natural rates. No dignificant woody debris recruitment.	There is considerable bank erosion on the west bank throughout this reach. Bank erosion is exacerbated by the presence of Hwy 97. Channel migration is severely limited by the Highway embankment.

Table 12 continued.

General Characteristics	General Indicators	Specific Indicators	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5a	Reach 5b/6
Channel	Dynamcs	Vertical Channel Stability	*Unacceptable Risk Condition* Current bed elevation results in an incised condition in relation to channel/floodplain connection, particularly in the downstream half of the reach. Note that historical trends in incision or aggradation have not been established.	*At Risk Condition* Current bed elevation results in an incised condition in relation to channel/floodplain connection in straightened areas. Some locations display a natural planform, and connection to side-channel and floodplain surfaces. Note that historical trends in incision or aggradation have not been established.	*At Risk Condition* Valley confinement naturally limits stream curvature resulting in a straight reach with little floodplain connection. Current bed elevation results in an incised condition in relation to channel/floodplain connection. Note that historical trends in incision or aggradation have not been established.	*At Risk Condition* Valley confinement naturally limits stream curvature resulting in a straight reach with little floodplain connection. Current bed elevation results in an incised condition in relation to channel/floodplain connection. Note that historical trends in incision or aggradation have not been established.	*Unacceptable Risk Condition* Current bed elevation results in an incised condition in relation to channel/floodplain connection. Note that historical trends in incision or aggradation have not been established.	*Unacceptable Risk Condition* Highway 97 reduces channel sinuosity and increases channel gradient resulting in the potential for increased sediment transport and bed incision. Note that historical trends in incision or aggradation have not been established.
Riparian Vegetation	Condition	Structure	*Unacceptable Risk Condition* Intact riparian areas have <50% species composition, seral stage, and low complexity compared with the potential of the native community	*Unacceptable Risk Condition* Intact riparian areas have <50% species composition, seral stage, and low complexity compared with the potential of the native community.	*Unacceptable Risk Condition* Intact riparian areas have <50% species composition, seral stage, and low complexity compared with the potential of the native community.	*At Risk Condition* Intact riparian areas have 50-80% species composition, seral stage, and moderate complexity compared with the potential of the native community.	*Unacceptable Risk Condition* Intact riparian areas have <50% species composition, seral stage, and low complexity compared with the potential of the native community.	*Unacceptable Risk Condition* Intact riparian areas have <50% species composition, seral stage, and low complexity compared with the potential of the native community.
		Disturbance (Human)	*Unacceptable Risk Condition* >50% disturbance in the riparian area due to roads, bridges, anddevelopment. 50-80% mature trees available for recruitment.	*Unacceptable Risk Condition* >50% disturbance in the riparian area due to Highway 97, bridges, anddevelopment. 50-80% mature trees available for recruitment.	*At Risk Condition* 20-50% disturbance in the floodplain. 50-80% mature trees available for recruitment.	*Adequate Condition* >20% distrubance in the floodplain. 50-80% mature trees available for recruitment.	*Unacceptable Risk Condition* >50% disturbance in the riparian area due to Highway 97, bridges, and development. 50-80% mature trees available for recruitment.	*Unacceptable Risk Condition* >50% disturbance in the riparian area due to Highway 97, grading, clearing, and development. 50-80% mature trees available for recruitment.
		Canopy Cover	*Unacceptable Risk Condition* <50% canopy cover is provided by trees and shrubs producing minimal thermal shading to the river.	*Unacceptable Risk Condition* <50% canopy cover is provided by trees and shrubs producing minimal thermal shading to the river.	*At Risk Condition* 50-80% canopy cover is provided by trees and shrubs producing some thermal shading to the river.	*At Risk Condition* 50-80% canopy cover is provided by trees and shrubs producing some thermal shading to the river.	*Unacceptable Risk Condition* <50% canopy cover is provided by trees and shrubs producing minimal thermal shading to the river.	*Unacceptable Risk Condition* <50% canopy cover is provided by trees and shrubs producing minimal thermal shading to the river.

3 REACH ASSESSMENT

3.1 Introduction

This section describes the geomorphic and biological processes occurring at the reach-scale and presents site-specific habitat restoration and preservation opportunities in lower Peshastin Creek. The Reach Assessment describes conditions at a finer scale than the tributary-scale assessment. The tributary-scale assessment provides a watershed context for primary controls on hydrology, geomorphology, and ecology within the study area. Tributary-scale processes affect reach-scale conditions in different ways depending on local variations in physical and biological processes and local anthropogenic influences.

3.1.1 Habitat Restoration and Preservation Framework

Selection of habitat restoration and preservation strategies was guided by the habitat objectives set forth in the Upper Columbia Recovery Plan (UCSRB 2007), which are included in the overall Introduction to this report.

Restoration and preservation activities are prioritized according to a process-based hierarchical framework, similar to those presented by Roni et al. (2002), Roni et al. (2005), and utilized by the USBR for other reach assessments in the region (e.g. Lyon and Maguire 2008). The framework used in this assessment emphasizes preservation and process-based restoration as the highest priority, followed by habitat enhancement and stabilization. Protecting functional habitats and stopping further degradation is given the highest priority and is considered an underlying principle. Figure 55 presents the hierarchical framework and terminology used for this assessment.

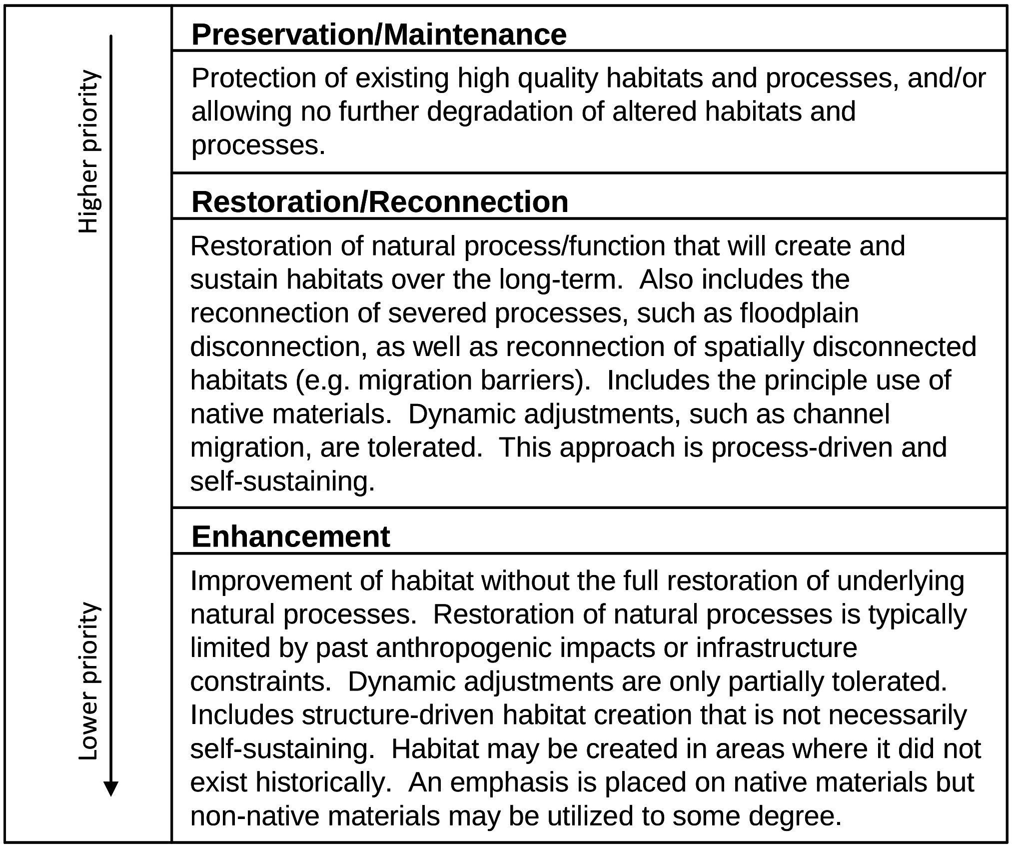

Figure 55. Hierarchical framework, prioritization, and terminology used to categorize and prioritize projects. Adapted from Gilliland et al. (2005) and Skidmore et al. (2009).

3.1.2 Project Types

All of the projects are categorized by project type. The project types are included below with a brief description and examples for each type. The project types are listed in priority order based on the hierarchical strategy presented in Figure 55. Specific priorities will vary depending on site-specific conditions and feasibility considerations.

Protect and Maintain

Protection projects are located in areas that are presently in a connected and functional state, as well as in impacted areas that should be preserved against further degradation. These actions should be considered obligatory when the opportunity arises, and are inherent in all potential actions. In many cases, adequate protection may already be in place through existing laws and regulations. The adequacy and enforcement of these regulations needs to be considered when planning for protection activities

Examples:

- Direct purchase (fee acquisition) of an area of functioning habitat and physical processes, or of an area at risk of further degradation through development.

- Obtaining a conservation easement from a landowner in order to eliminate agricultural uses or grazing within a riparian buffer zone.

Reconnect Stream Channel Processes

Stream channel reconnection projects are located in areas where stream bio-physical processes have been disconnected due to anthropogenic activities. These are areas that have the potential for an increase in habitat quality and a reestablishment of dynamic processes through their reconnection. Restoration actions are focused on reclaiming a component of the system that has been lost, thus regaining habitat and process that was previously a functional part of the river system.

Examples:

- Removal of rip-rap in order to eliminate bank hardening and channelization that restricts channel migration, simplifies the channel, and compromises instream aquatic habitat quality and quantity.
- Removal of a road embankment or levee that has cut-off an older channel alignment in order to reconnect a side-channel or mainstem channel.
- Placement of a LWD jam where wood recruitment rates have been reduced to promote active lateral channel dynamics, such as development of a multi-thread channel system.

Reconnect Floodplain Processes

Floodplain reconnection projects are located in areas where floodplain and channel migration processes have been disconnected due to anthropogenic activities. These are areas that have the potential for an increase in habitat quality and a reestablishment of dynamic processes through their reconnection. Restoration actions are focused on reclaiming a component of the system that has been lost, thus regaining habitat and process that was previously a functional part of the river system.

Examples:

- Removal of a levee that limits floodplain connectivity.
- Selective bridging or breaching of road embankments or levees or enhance floodplain connectivity.
- Removal of floodplain infrastructure or fill that limits floodplain connectivity.

Riparian Restoration

Riparian restoration projects are located in areas where native riparian vegetation communities have been significantly impacted by anthropogenic activities such that riparian functions and connections with the stream are compromised. Restoration actions are focused on restoring native riparian vegetation communities in order to reestablish natural stream stability, stream shading, nutrient exchange, and large woody debris recruitment. Even though it is not explicitly stated, riparian restoration is a recommended component of most restoration projects, particularly within the disturbance limits of the project.

Examples:

- Replanting a riparian buffer area with native forest vegetation.
- Eliminating invasive plant species that are preventing the reestablishment of a native riparian forest community.
- Fencing livestock out of a riparian zone in order to recover natural vegetation and streambank stability conditions.

Instream Habitat Enhancement

Instream habitat enhancement projects are located in active channel areas where there is the potential to increase stream habitat quantity and quality. Instream enhancement projects typically involve active restoration measures that either directly increase key habitat components or indirectly improve habitat through structural enhancements that restore habitat-forming processes (e.g. pool scour from a LWD jam).

Examples:

- Construction of a log-jam to increase in-channel habitat complexity.
- Use of LWD and boulder structures to restore natural rates of channel migration.

Off-channel Habitat Enhancement

Off-channel habitat enhancement projects are located in off-channel areas (e.g. floodplains) where there is the potential to increase the quantity and quality of off-channel habitat. In some cases, the location may not have historically provided this habitat, but has the potential to support the habitat under current hydrologic and geomorphic conditions. Given limited opportunities and constraints in other parts of a reach, this may sometimes be the best option to achieve restoration objectives.

Examples:

- Improving fish connectivity to an existing off-channel habitat area.
- Construction of off-channel features such as alcoves, backwaters, or beaver ponds that are connected to the main channel.
- Addition of LWD cover and complexity in an existing off-channel area.

3.2 Methods

3.2.1 Sub-Reach Delineations

Reaches are further divided into smaller "sub-units". A sub-unit is a distinct segment of active channel (inner zone) or floodplain (outer zone) that comprises unique functional characteristics. A description of conditions and processes operating at the sub-unit scale provides a basis for identifying and describing site specific conditions that informs the project identification and prioritization process.

An inner zone sub-unit is defined as the wetted low-flow channel and all related areas that experience ground-disturbing flow such as secondary channels and active bars. An outer zone sub-unit is defined as the low-lying area adjacent to the channel that may become inundated at higher flow but does not normally experience ground disturbing flow (USBR 2009). Inner zone sub-units were delineated using breaks in geomorphic control such as bedrock constrictions or roadways that result in variations in channel pattern and channel type. Outer zone sub-units were delineated as discrete floodplain areas separated by natural breaks or anthropogenic barriers.

Inner and outer zones may be identified as "disconnected", denoted with a "D" before the IZ (Inner Zone) or OZ (Outer Zone) identifier. A disconnected zone is a zone whose direct connectivity or physical processes have been disconnected from the existing channel or floodplain due to anthropogenic alterations. Inner and outer zones may become disconnected through channel or floodplain manipulations including straightening, ditching, filling, and rip-rap, and through construction of levees, road embankments, or bridges. In addition, outer zones may be disconnected via indirect alterations that affect channel migration and flood inundation processes. These may include upstream or downstream bridge crossings that limit channel migration or land-use induced channel incision that reduces the extent of floodplain inundation.

3.2.2 Project Identification and Prioritization

Projects were identified through a combination of methods, including the following: 1) field surveys of project opportunities, 2) discussions with agency personnel, 3) previous studies, and 4) remote sensing using aerial photography and LiDAR. Location information, general site conditions, and photographs were acquired for each project opportunity area. This information is provided in the maps for each reach summary and in the list of project opportunities (Appendix B).

Projects are prioritized at a coarse-scale based on the hierarchical project prioritization framework described previously (Figure 55).). It is important to note that site-specific conditions, such as landowner cooperation, access and infrastructure constraints, often preclude the implementation of the highest priority measures. However, at this stage, projects are not prioritized according to potential feasibility constraints. A finer-scale project prioritization methodology that incorporates feasibility considerations will be conducted as a subsequent phase of this effort.

3.2.3 Report Organization

This section of the report is organized on a reach basis, with information presented for each individual reach in separate sections. Reach numbers increase in the upstream direction and are presented in numerical order. Thus, the farthest downstream reach (Reach 1) is presented first. Reach descriptions include an overview of habitat and fish use, hydrology, geomorphology, and anthropogenic influences operating within the reach. This information is followed by the reach-scale restoration strategy. The sub-unit and project opportunity summary is included next, which presents the bulk of the information in the sub-unit and project table. Unlike reaches, sub-units are numbered in the downstream direction. Thus, the furthest upstream sub-units are presented first and subsequent summaries proceed in the downstream direction within a given reach. The sub-unit and project tables include a sub-unit description, the restoration strategy within each sub-unit, project opportunities that fall within the sub-unit, and potential constraints. Projects are named using their river mile location, with the approximate midpoint used for long projects. An "R" (right bank), "L" (left bank), or "C" (Channel) designation is also included in the name of the project in order to provide ease of locating the project. Reference to river-left or river-right is always oriented facing the downstream direction.

A comprehensive project opportunity list for the study area, which includes project descriptions and photos, is included as Appendix B.

REACH 1 – REACH ASSESSMENT

3.3 Reach 1 Reach Assessment

3.3.1 Reach Overview

Reach 1 begins at the confluence of Peshastin Creek and the Wenatchee River and extends up to river mile 1.4, which marks the transition of the Peshastin Creek Valley into the broad Wenatchee Creek Valley. The valley in this reach is unconfined. Highway 2 crosses Peshastin Creek in this reach and Highway 97 lies adjacent to the stream along much of the upstream portion of the reach. Land uses include agriculture and rural residential development.

Habitat Conditions and Fish Use

Salmonid use of Reach 1 includes spring Chinook, steelhead, coho, bull trout, westslope cutthroat trout, and non-native brook trout. Reach 1 receives use by Peshastin origin fish as well as fish from other locations within the Wenatchee Basin. Spring Chinook and steelhead use lower Peshastin Creek primarily as a migration corridor to access upstream spawning areas, although limited spawning and rearing use does occur in the reach. Bull trout are believed to use lower Peshastin Creek primarily for migration and possibly limited rearing. The Yakama Nation coordinates a coho re-introduction program in the Wenatchee Basin. Coho are not typically released in Peshastin Creek but coho spawning and rearing in lower Peshastin Creek has been documented during surveys. See Section 2.6 for additional information on fish use in lower Peshastin Creek.

There is limited spawning and rearing habitat in Reach 1. Riffles consist of long, coarse-bedded, plane-bed sections that lack good spawning substrate. Pool quantity is very low and the pools that are available have shallow residual depths and have high velocities at higher flows. Pool tail-outs with spawning-sized material and suitable depths and velocities are not present in the reach. LWD is nearly absent and there are no off-channel rearing areas available. Late summer instream flow levels may be a concern due to upstream flow diversions.

The coarse bed and high frequency of boulders provides areas of localized velocity refuge that may be utilized for rearing by juvenile steelhead and resident trout; but for most species, this reach is suitable only as a migration corridor. Historically, this reach likely played an important role in providing cool water rearing during the summer for Wenatchee River populations. However, reduced habitat complexity, flow withdrawals, and temperature impairments have reduced its ability to provide these functions. See the Habitat Assessment (Section 2.7) for additional information on stream habitat conditions. A summary of the Reach-Based Ecosystem Indicators (REI) is included in Table 13.

Table 13. Reach-Based Ecosystem Indicators (REI) ratings for Reach 1. See Section 2.9 for the complete REI analysis.

General Characteristics	General Indicators	Specific Indicators	Reach 1 Condition
Habitat Access	Physical Barriers	Main Channel Barriers	*At Risk*

General Characteristics	General Indicators	Specific Indicators	Reach 1 Condition
Habitat Quality	Substrate	Dominant Substrate/Fine Sediment	*At Risk*
	LWD	Pieces per Mile at Bankfull	*Unacceptable*
	Pools	Pool Frequency and Quality	*Unacceptable*
	Off-Channel Habitat	Connectivity with Main Channel	*Unacceptable*
Channel	Dynamics	Floodplain Connectivity	*Unacceptable*
		Bank Stability/Channel Migration	*Unacceptable*
		Vertical Channel Stability	*Unacceptable*
Riparian Vegetation	Condition	Structure	*Unacceptable*
		Disturbance (Human)	*Unacceptable*
		Canopy Cover	*Unacceptable*

Hydrology

The hydrology of this reach is affected by several upstream features including the largest diversion in the basin located about 1 mile upstream of the reach. Upstream irrigation diversions result in decreased instream flows during late summer. Low flows in this reach create potential passage barriers to migrating fish. Eighty-six percent of this reach has disconnected floodplain, which limits overbank flood capacity and connectivity of high-flow channels. Due to local and upstream floodplain impacts that affect flood attenuation capacity, flood flows may have shorter travel times and flood peaks may be larger for a given return interval compared to historical conditions. Estimates of flood magnitudes at the mouth of Peshastin Creek at a range of recurrence intervals are included in Table 14.

Table 14. Flood magnitudes for recurrence intervals from 2 to 100 years at the mouth of Peshastin Creek (USBR 2008).

Location	River Mile	Flood Recurrence Interval (ft^3/sec) Q2	Q5	Q10	Q25	Q50	Q100
Mouth	0	1,212	1,856	2,369	3,121	3,765	4,485

Geomorphology

Reach 1 lies within the broad alluvial floodplain valley of the mainstem Wenatchee River. Valley width for Peshastin Creek is unconstrained and a wide alluvial fan has developed over time (Figure 56). The fan deposit is estimated to be about 425 acres, and up to a depth of 100 ft. (MWG 2006). The deposition of this large fan is associated with Pleistocene hydrologic and geomorphic regimes. The modern channel has incised into this material and has established a relatively narrow migration zone and active floodplain restricted to the southern portion of the fan.

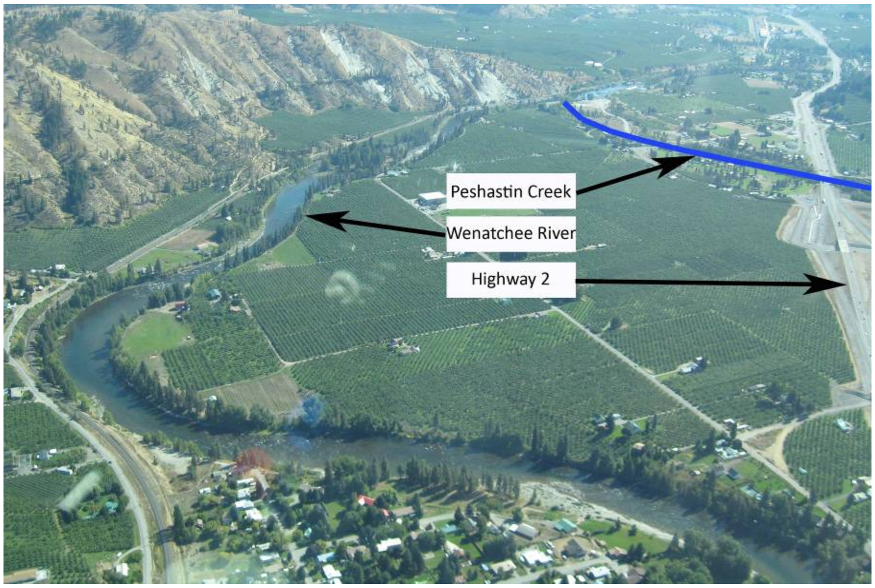

Figure **56. Low elevation oblique aerial photo looking downstream to the southeast of the Wenatchee River valley. The blue line in the upper right corner of the photo shows Peshastin Creek's position on the southern portion of the alluvial fan that comprises the entire area between the Wenatchee River and Peshastin Creek. Photo taken September 24, 2009.**

The channel is dominated by plane-bed morphology (Figure 57). Riffles are the dominant habitat unit type, comprising about 86% of the reach (See Section 2.7). Long riffles are separated by short pool sections that do not exceed 2 ft in residual depth. Streambanks through this reach are composed mainly of unconsolidated glacial outwash ranging in size from boulders to sand. This material is easily erodible and provides a sediment source for the channel in this reach. Bed and bank erosion is limited in some areas by bank armoring and hydromodifications. Channel erosion may be further limited due to the presence of large material of glacial origin. Median grain size in the reach is in the small to medium cobble size class (See Section 2.7).

Historical channel mapping suggests a more sinuous channel in the past. Comparison of the 1891 channel to the 1998 channel suggests a loss of about 242 ft of length. The current sinuosity of the reach is 1.07, the lowest of all five reaches in the study area. Channel straightening is related to human activities including highway construction, bridge construction, and grading associated with agricultural and residential uses. These activities, as well as direct excavation to improve flood conveyance, have resulted in channel incision and disconnection of the floodplain and channel migration zone.

The 1962 aerial photos show that the lower 0.4 mile of stream has been severely altered. This area, which essentially makes up the contemporary delta fan of Peshastin Creek, was historically a multi-thread braided segment that would have experienced frequent adjustments in response to sediment deposition. Multi-thread and interconnected channels, backwaters, and distributary channels would have been common features. Road construction and additional manipulations beginning in the mid-1900s have channelized this lower reach into a more uniform single-thread channel.

Figure 57. Typical plane-bed riffle morphology, upstream view near river mile 0.1. Photo taken August 13, 2009.

Human Alterations

Floodplain development in this reach constrains channel and floodplain processes and affects aquatic habitat. Two bridge crossings (river miles 0.4 and 0.65) and their associated road fills constrain the channel and bisect the floodplain (Figure 58). The bridge crossings limit channel migration and floodplain connections. In all, about 85% of the floodplain is disconnected due to roadways and bridges. In addition, virtually the entire floodplain has been cleared and developed for agriculture, residential, or commercial uses. Disconnection of the historical active channel occurs where the main channel was re-routed downstream of river mile 0.3 following the construction of the Washington Department of Transportation (WDOT) material storage facility. The contemporary channel is now confined to the northern portion of the channel migration zone.

Between river miles 0.65 and 1.1, the interchange between Highways 97 and 2 has been reconfigured, and there is a new alignment for Highway 97 that is not captured by the most recent aerial photos or LiDAR. The new alignment is further from the channel, but a hardened bank remains along the river's edge for about 1,500 feet (Figure 59). Although the new alignment helps to reduce constraints to protection and restoration, the hardened bank remaining along the streamside edge continues to affect channel migration, riparian function, and floodplain processes.

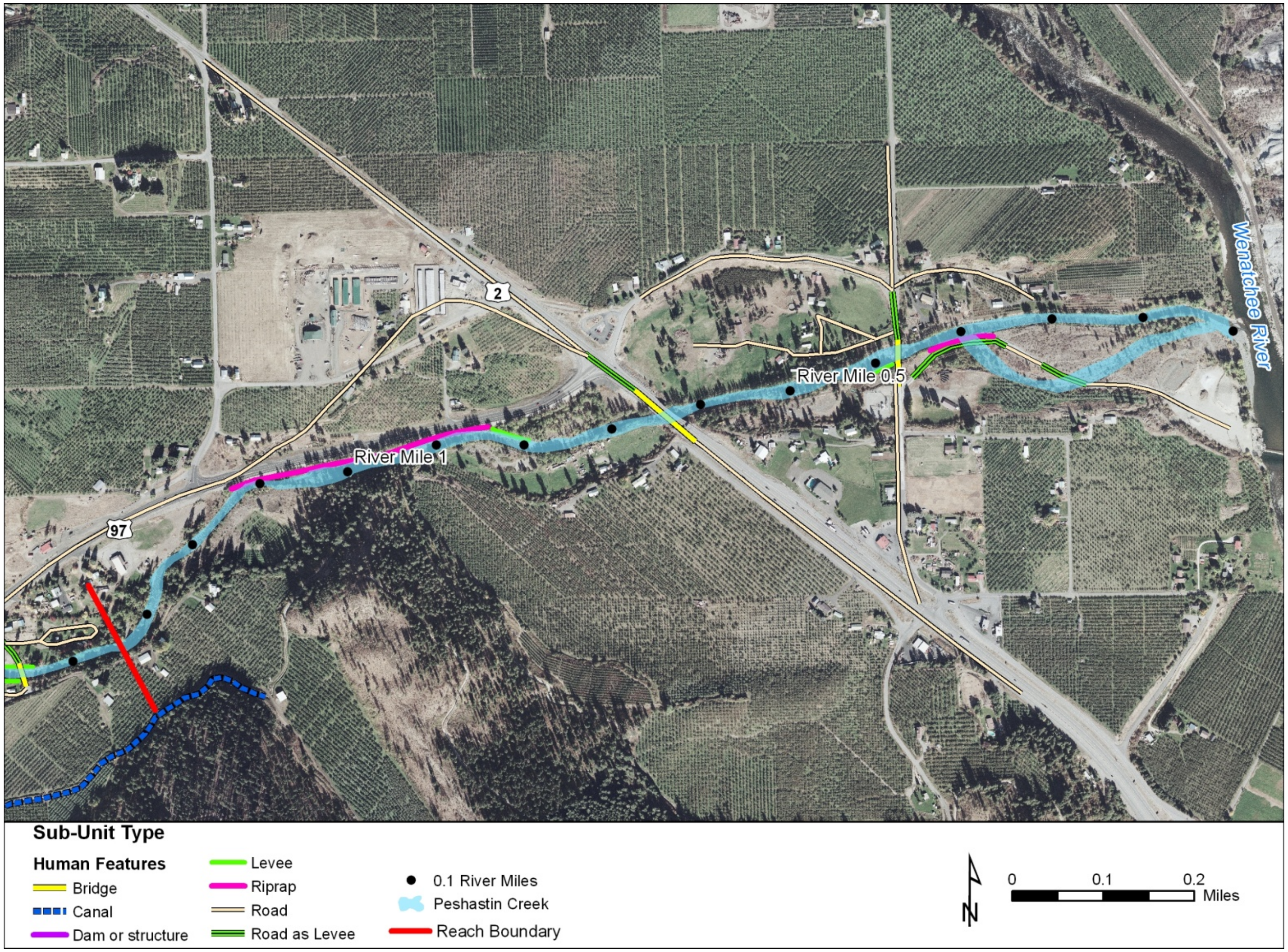

Figure 58. Aerial photo showing human features in Reach 1. Flow is from left to right. Processes are hindered by roadway encroachment, bank hardening, bridge crossings, and floodplain development. The road lines reflect the current alignment of Highway 97, though the photo represents the area before reconfiguration of the highway interchange.

Figure 59. View looking downstream toward the northeast along the former Highway 97 road embankment. Rip-rap was left in place along this channel margin, and enhanced in some locations (January 2010).

3.3.2 Reach-Scale Restoration Strategy

The prioritized reach-scale restoration and preservation strategy for Reach 1 is included below. The strategy focuses first on protecting existing conditions from further impairment. This objective is followed by reconnecting the fundamental bio-physical processes that will create and maintain habitat conditions over the long-term. Instream and off-channel habitat enhancement (rehabilitation) is also included; these projects occur in conjunction with long-term process reconnection and are also applied in cases where long-term process reconnection is constrained by existing human uses.

The high degree of anthropogenic disturbance in Reach 1, and the effects of upstream disturbances, limit the opportunity for protecting functioning habitat and shifts the restoration strategy towards reconnecting isolated habitats and re-establishing river processes. Sustaining habitat-forming processes in perpetuity will depend on addressing large-scale issues in this reach and upstream reaches. Critically low instream flows caused by irrigation diversions that coincide with naturally low flow periods are a primary limiting factor to successful restoration in this reach. Increasing instream flows is a key concern. Channel confining features such as bridge crossings, levees, and road embankments will need to be removed or re-engineered, where feasible, to allow for dynamic physical and biological processes.

1. ***Protect and Maintain***
   - **<u>Prevent Further Degradation</u>**- Opportunities to prevent further degradation should be pursued including purchasing land and water rights in the river corridor, and/or obtaining conservation easements. Water rights acquisition should be focused on increasing instream flow during late summer.

- **Legal Protection**- Existing enforced legal protection is considered an intrinsic component of all potential projects.

2. ***Reconnect Stream Channel Processes***
   - **Instream Flow**- The ultimate success of restoration in this reach relies on increasing instream flow, particularly during the late summer months. Under some conditions, low base-flows create barriers to fish migration that is essential for restoration success throughout the study area. Instream flow analysis has been completed for Peshastin Creek and the results should be considered in restoration planning.
   - **Riprap and Levees**- Stream channel processes can be reconnected by removing barriers and allowing dynamic processes to proceed naturally. Barriers to process and habitat connection such as riprap and levees should be removed or modified. More in-depth risk evaluation will be required to assess the potential to modify or remove barriers such as bridge crossings, roadways, levees and developments on adjacent floodplains and terraces.
   - **Roadways and Bridges**- Highway 2, the Saunders Road Bridge, and smaller roadways that parallel the channel limit channel migration, intercept floodplain processes, and contribute to channel incision. Look for opportunities to address these issues through increasing bridge spans or through potential removal (in the case of the Saunders Road Bridge).

3. ***Reconnect Floodplain Processes***
   - **Floodplain Development and Levees** - There is residential and agricultural development of the floodplain on both sides of the channel throughout the reach. Developments commonly include clearing, fill, roadways, levees or riprap along the channel margin. Where feasible, work should focus on reconnecting these areas through levee removal or modification and reclamation of floodplain surfaces. In many cases, it will be necessary to work with appropriate stakeholders to develop long-term solutions to floodplain impacts.

4. ***Riparian Restoration***
   - **Restore Riparian Areas**- The strategy for riparian restoration in this reach includes revegetation of cleared areas wherever possible including recently re-graded areas associated with the Highway 2/97 interchange, and other near-channel sites.

5. ***In-Stream Habitat Enhancement***
   - **Enhance Habitat Complexity**- Instream large wood is a natural component of this system that has been severely reduced by past land-use practices. Wood creates pool scour, cover, and channel complexity. Place wood in configurations and locations that mimic natural wood deposition processes. These projects are not replacements for process restoration, but are meant to provide intermediate habitat enhancement while process restoration matures.

3.3.3 Sub-Unit and Project Opportunity Summary

Ten sub-units were identified in Reach 1, including two inner zone units, three disconnected inner zone units, two outer zone units, and three disconnected outer zone units (Table 15, Figure 60, Figure 61). Very little floodplain habitat is left intact due to residential and agricultural development. Channel habitat complexity is low (See Habitat Assessment, Section 2.7). A total of seven specific project opportunities are described in the sub-unit sections below (Table 16). There are significant constraints to restoration work, including the presence of municipal infrastructure, transportation corridors, residential development, and agricultural activity. See Figure 60 for the location of project opportunities.

Table 15. Summary of protection and restoration opportunities for Reach 1.

Sub-Unit	River Mile	Acres
IZ-1	0.65 – 1.35	N/A
OZ-1	1.05 – 1.3	4
OZ-2	1.1 – 1.35	8.5
DOZ-1	0 – 1.1	41.5
DOZ-2	0.3 – 0.9	10
DIZ-1	0.65 – 0.85	N/A
IZ-2	0 – 0.65	N/A
DIZ-2	0.5 – 0.65	N/A
DIZ-3	0 – 0.3	N/A
DOZ-3	0 – 0.2	9

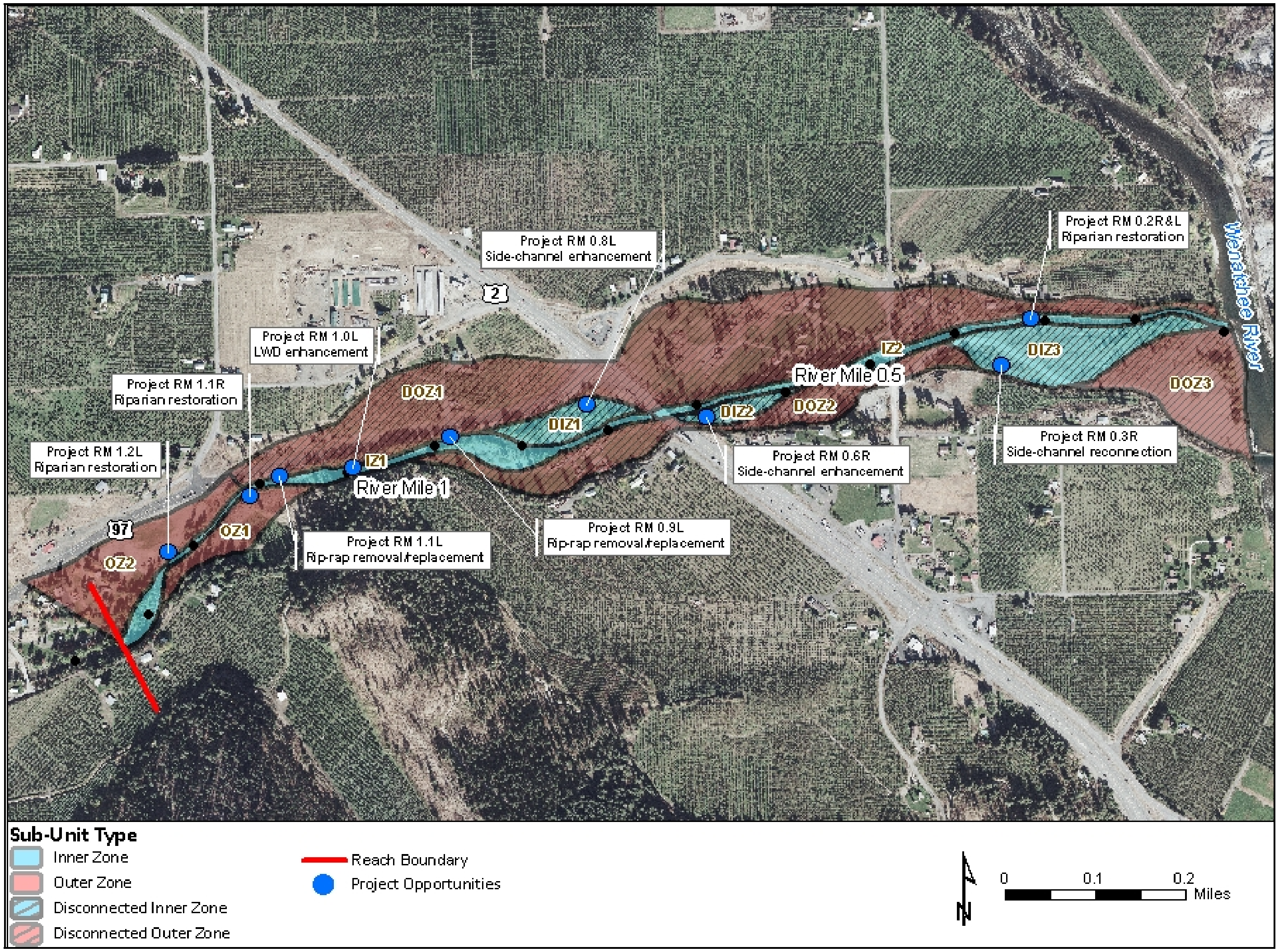

Figure 60. Sub-units and project opportunities in Reach 1. Flow is from west to east

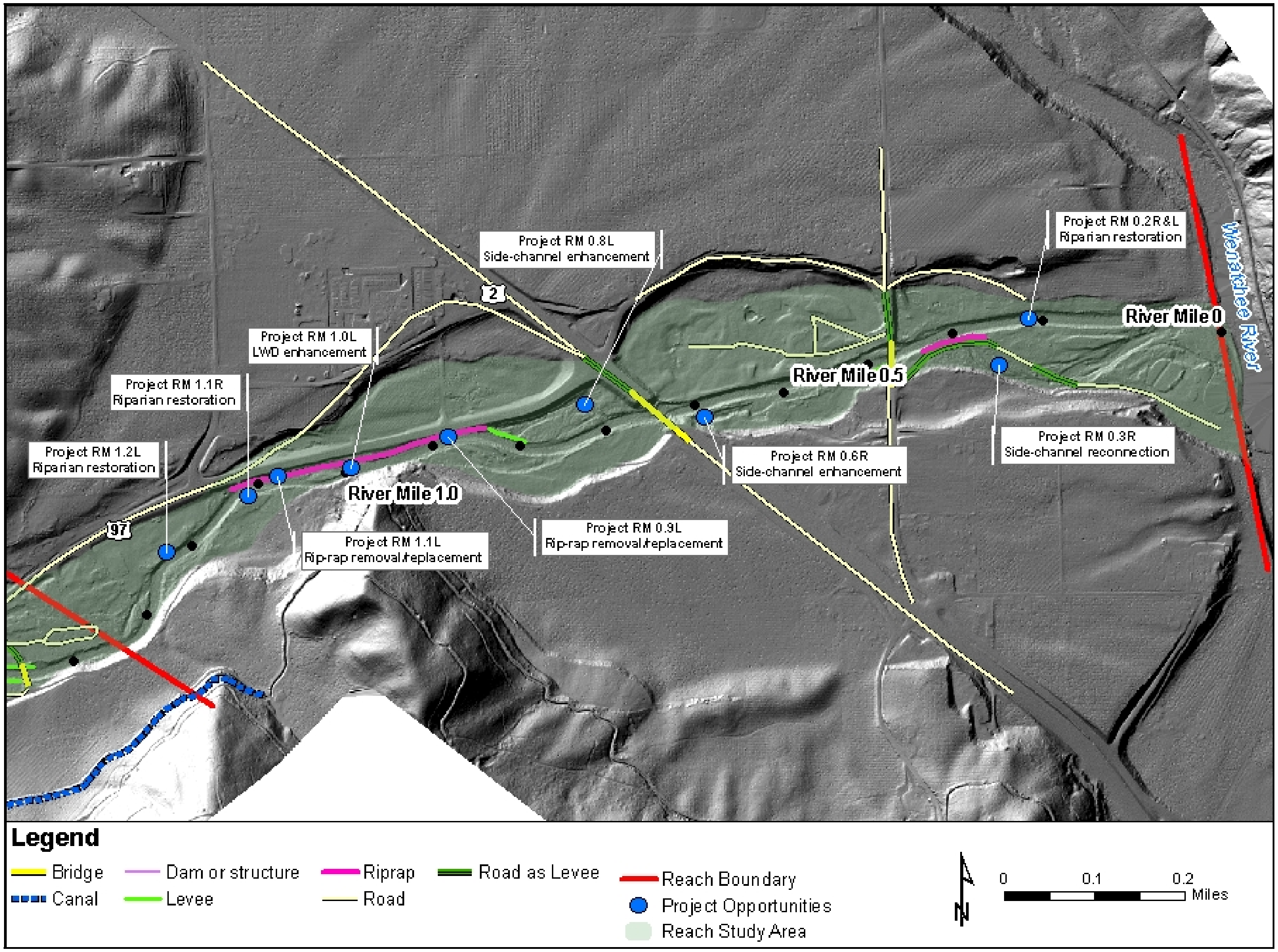

Figure 61. LiDAR hillshade of Reach 1 illustrating topography in relation to human features and project locations in the reach. Flow is from west to east.

Table 16. Summary of Sub-Unit Descriptions, Restoration Strategies, Projects and Constraints for Reach 1.

Sub-Unit	Description	Strategy *(Strategies listed in priority order)*	Projects[1] *(specific identified project opportunities in **bold**)*	Potential Constraints
IZ-1	The channel in this area is incised into glacial outwash and alluvial fan deposits creating a naturally confined floodplain between glacial terraces. Human activity has led to confinement of channel processes with bank hardening associated with roadways (including primarily the old Highway 97 alignment prior to reconstruction of the Hwy 2/Hwy 97 interchange. The adjacent floodplain has been heavily developed for agricultural and residential activities. The combination of these natural and anthropogenic factors has compromised channel and floodplain connections. Historical channel analysis suggests that channel pattern has been maintained since 1962, but is probably less sinuous than in 1937. The bed morphology is plane-bed and is dominated by riffles. Bed material is coarse with frequent boulders across the channel and a lack of spawning size material.	Protect and Maintain Reconnect Stream Channel Processes In-stream Habitat Enhancement	***Project RM 0.9L*** Rip-rap removal/replacement ***Project RM 1.1L*** Rip-rap removal/replacement ***Project RM 1.0C*** LWD enhancement *Work to address impacts related to bank hardening (e.g. riprap removal)*	The new Highway 97 alignment runs north of the current channel. Restoration of channel migration is constrained by risks to the highway. Highway 2 Bridge crossing at river mile 0.65. Residential development on both sides of the channel.
OZ-1	Disturbance is high on this floodplain surface with very little riparian habitat provided. The riparian vegetation has been cleared for agriculture, except for a thin strip along the stream edge. There do not appear to be any levees or rip-rap creating direct physical barriers to geomorphic or hydrologic connection.	Protect and Maintain Riparian Restoration	***Project RM 1.1R*** Expand riparian buffer *Work to address impacts of floodplain development (riparian restoration, off-channel habitat restoration)*	Agricultural development.

Table 16. Summary of Sub-Unit Descriptions, Restoration Strategies, Projects and Constraints for Reach 1.

Sub-Unit	Description	Strategy *(Strategies listed in priority order)*	Projects[1] *(specific identified project opportunities in **bold**)*	Potential Constraints
OZ-2	Conditions in OZ2 are similar to OZ1. Disturbance is greater here than in OZ1 potentially due to greater access on this side of the river. The riparian zone and floodplain have been cleared and residential development covers most of the area in addition to agriculture.	Protect and Maintain Riparian restoration	**Project RM 1.2L** Native plant revegetation *Work to address the impacts of floodplain development (riparian restoration, off-channel habitat restoration)*	Church/community center property with recreational access to stream.
DOZ-1	This zone comprises the majority of the river left floodplain/former floodplain along most of Reach 1. Approximately 0.3 miles of Highway 97 was recently re-routed away from the stream as part of a reconfiguration of the Hwy 2/Hwy 97 interchange. The former highway fill was removed and replanted. However, much of the former rip-rap remains along the streambank, disconnecting the channel migration zone. Two bridge crossings (river miles 0.4 and 0.65) and their associated road fills bisect and disconnect the floodplain in this zone. The bridges prohibit hydrologic and geomorphic connection between the channel and floodplain by interrupting overbank flow, restricting channel migration, and limiting access to off-channel habitats. Much of the floodplain and riparian zone in this area has been cleared and is now in mixed agricultural and residential use, further limiting floodplain processes and contributing to potential water quality impairment when large overbank floods occur.	Protect and Maintain Reconnect Floodplain Processes Riparian Restoration	*Work to address impacts related to riprap, roadways, bridges, and floodplain development (e.g. riprap removal/ modification, revegetation)*	Highway 2 Bridge and road fill bisects the sub-unit laterally Local road (Saunders Road) bridge and fill bisects the sub-unit laterally Bank armoring near river mile 0.9 Considerable rural residential and agricultural development throughout the floodplain

Table 16. Summary of Sub-Unit Descriptions, Restoration Strategies, Projects and Constraints for Reach 1.

Sub-Unit	Description	Strategy *(Strategies listed in priority order)*	Projects[1] *(specific identified project opportunities in **bold**)*	Potential Constraints
DOZ-2	This sub-unit extends along the right side of the river and includes a large area between the two bridge crossings. The bridge crossings create upstream and downstream barriers to hydrologic and geomorphic processes as described for DOZ-1. At each crossing, rip-rap is used to stabilize the channel position. This rip-rap disconnects dynamic channel/floodplain interactions from taking place laterally, and the roadways create longitudinal barriers across the entire surface. In addition to these process barriers, the floodplain surface has been cleared and developed for residential and agricultural purposes, and riparian buffers are narrow and lack mature native species.	Protect and Maintain Reconnect Floodplain Processes Riparian Restoration	*Work to address impacts related to riprap, roadways, bridges, and floodplain development (e.g. riprap removal/ modification, revegetation)*	Highway 2 bridge and fill bisects the sub-unit laterally Local road (Saunders Road) bridge and fill bisects the sub-unit laterally Considerable rural residential and agricultural development throughout the floodplain
DIZ-1	This sub-unit is located on the river-left side immediately upstream of the Highway 2 Bridge. This zone represents a former inner zone area that has been disconnected as a result of highway and bridge construction. There is currently a flood overflow channel that is accessed via a culvert under a small push-up levee at the upstream end of the unit. The flood channel continues nearly the full length of the unit.	Protect and Maintain Reconnect Stream Channel Processes	***Project RM 0.8L*** Side-channel reconnection	Highway 2 Bridge affects flood inundation levels and geomorphic processes

Table 16. Summary of Sub-Unit Descriptions, Restoration Strategies, Projects and Constraints for Reach 1.

Sub-Unit	Description	Strategy *(Strategies listed in priority order)*	Projects[1] *(specific identified project opportunities in **bold**)*	Potential Constraints
IZ-2	IZ-1 stretches 0.65 miles from the Highway 2 Bridge to the mouth. Channel complexity is lower in IZ-2 compared to IZ-1. Pool frequency is low and bed morphology is plane-bed. The channel has been simplified and straightened compared to historical conditions, resulting in the conversion of a multi-thread channel (evident in the 1962 aerial photos) to a single-thread, straightened, and uniform incised channel. The Highway 2 and Saunders Road Bridges cross this zone at river miles 0.65 and 0.4, respectively.	Protect and Maintain Riparian Restoration	***Project RM 0.2R&L*** Expand riparian buffer	Residential and agricultural development. Local roadways parallel the channel for most of the length.
DIZ-2	This sub-unit is located on the river-right side immediately downstream of the Highway 2 Bridge. This zone represents a former inner zone area that has been abandoned, potentially related to a past reconfiguration of the Highway 2 Bridge and associated road fill. The 1962 aerial photos show the main channel in this location, which had greater sinuosity than the current straightened channel.	Protect and Maintain Reconnect Stream Channel Processes	***Project RM 0.6 R*** Side-channel reconnection *Work to address the impacts of the Highway 2 Bridge (e.g. increase the span)*	Highway 2 Bridge affects inundation levels and geomorphic processes.
DIZ-3	This inner zone sub-unit is disconnected from IZ-2 by a roadway at river mile 0.3. There is a gravel road that leads across the sub-unit to a WDOT materials storage area near river mile 0.1. The road embankment directly blocks the upstream end of a channel that was active in 1975. This channel now appears to be completely disconnected from the main channel, significantly reducing channel complexity in this location.	Protect and Maintain Reconnect Stream Channel Processes	***Project RM 0.3R (Alt. 1)*** Full side-channel reconnection ***Project RM 0.3R (Alt. 2)*** Side-channel and off-channel connection enhancement	WDOT roadway, rip-rap, culverts, and material storage facility throughout the sub-unit.

Table 16. Summary of Sub-Unit Descriptions, Restoration Strategies, Projects and Constraints for Reach 1.

Sub-Unit	Description	Strategy *(Strategies listed in priority order)*	Projects[1] *(specific identified project opportunities in **bold**)*	Potential Constraints
DOZ-3	This outer zone sub-unit is located downstream of DIZ-3, and is the location of the WDOT material storage yard. The WDOT access road and road embankment disconnect channel processes from this sub-unit. The original elevation of the floodplain surface has likely been raised as a result of grading and filling associated with the storage yard.	Protect and Maintain Reconnect Floodplain Processes Riparian Restoration	*Work to address impacts related to channelization, roadways, and floodplain development (e.g. revegetation)*	WDOT access road, road embankment, culverts, and fill across the entire sub-unit.

[1]*For additional information on specific identified project opportunities, see Peshastin Project Opportunities list in Appendix B.*

REACH 2 – REACH ASSESSMENT

3.4 Reach 2 Reach Assessment

3.4.1 Reach Overview

Reach 2 is the longest reach within the study area. The reach lies within an unconfined valley. Highway 97 abuts the river along much of this reach and has had significant impacts on channel planform, riparian, and floodplain conditions. Agriculture and residential development occur throughout the valley in this reach. The largest irrigation diversion is located within this reach (river mile 2.5) and consists of a low-head dam and associated diversion structure. The inflow pipe from Icicle Creek crosses the channel in this reach at approximately RM 2.0.

Habitat Conditions and Fish Use

Salmonid use of Reach 2 includes spring Chinook, steelhead, coho, bull trout, westslope cutthroat trout, and non-native brook trout. Spring Chinook and steelhead use lower Peshastin Creek primarily as a migration corridor to access upstream spawning areas, although limited spawning and rearing use does occur in the reach. Bull trout are believed to use lower Peshastin Creek primarily for migration and possibly limited rearing. The Yakama Nation coordinates a coho re-introduction program in the Wenatchee Basin. Coho are not typically released in Peshastin Creek but coho spawning and rearing in lower Peshastin Creek has been documented during surveys. See Section 2.6 for additional information on fish use in lower Peshastin Creek.

There is limited spawning and rearing habitat in Reach 2. Many of the riffles consist of long, coarse-bedded, plane-bed sections that lack good spawning substrate. Pools are infrequent and tend to be of low quality. Several pools have adequate depth and cover, and a few pools have long tail-outs with good spawning habitat, but the majority of pools have shallow residual depths and minimal cover and LWD habitat. Pool quality tends to be higher in the upstream portion of the reach. LWD quantities are very low throughout the reach and there is minimal side-channel habitat (1%). Summer instream flow levels may be reduced due to the Tandy Ditch (RM 4.9) and the Peshastin Canal (RM 2.5) irrigation diversions that occur within this reach. The Peshastin Canal dam may affect fish passage conditions at some flow levels; although it has recently (2005) undergone modifications to enhance fish passage conditions. Water diversions and a lack of stream shade contribute to elevated summer water temperatures that may reduce the quality of summer rearing habitat. See the Habitat Assessment (Section 2.7) for additional information on stream habitat conditions. A summary of the Reach-Based Ecosystem Indicators (REI) is included in Table 17.

Table 17. Reach-Based Ecosystem Indicators (REI) ratings for Reach 2. See Section 2.9 for the complete REI analysis.

General Characteristics	General Indicators	Specific Indicators	Reach 2 Condition
Habitat Access	Physical Barriers	Main Channel Barriers	*At Risk*
Habitat Quality	Substrate	Dominant Substrate/Fine Sediment	*Adequate*

General Characteristics	General Indicators	Specific Indicators	Reach 2 Condition
	LWD	Pieces per Mile at Bankfull	*Unacceptable*
	Pools	Pool Frequency and Quality	*At Risk*
	Off-Channel Habitat	Connectivity with Main Channel	*Unacceptable*
Channel	Dynamics	Floodplain Connectivity	*Unacceptable*
		Bank Stability/Channel Migration	*Unacceptable*
		Vertical Channel Stability	*At Risk*
Riparian Vegetation	Condition	Structure	*Unacceptable*
		Disturbance (Human)	*Unacceptable*
		Canopy Cover	*Unacceptable*

Hydrology

The two major irrigation diversions in the Basin are located in Reach 2. The Tandy Ditch diversion is located at the upstream end of the reach near river mile 4.9. The Peshastin Canal diversion is located at the downstream end of the reach near river mile 2.5. The Peshastin Canal has a max capacity of about 40 cfs, which can be a relatively large loss during low flow periods from late July to mid-September. This flow loss leads to critically low flow in the late summer that may create a barrier to migrating fish in Reach 2 and Reach 1. The long-term success of many of the proposed projects within and upstream of Reach 2 may depend on increasing instream flow. Mill Creek enters Peshastin Creek near the upstream end of the reach but contributes a nominal amount of flow. Several other ephemeral tributaries are located throughout the reach.

About 48% of the total floodplain area in the reach has been disconnected from the channel, mainly due to Highway 97. Construction of Highway 97 also resulted in straightening and constricting the channel in places. These types of alterations can lead to reduced channel width-to-depth ratios, increased energy in the channel at high flow, reduced flood peak attenuation, and increased peak magnitude for a given event (Table 18).

Table 18. Flood magnitudes for recurrence intervals from 2 to 100 years at the upstream end of Reach 2 (USBR 2008).

Location	River Mile	Flood Recurrence Interval (ft^3/sec) Q2	Q5	Q10	Q25	Q50	Q100
Upstream of Mill Creek	5	1,007	1,543	1,969	2,595	3,130	3,728

Geomorphology

There is uncertainty regarding the distance that glacial ice extended down the Peshastin Valley. Long (1951) found evidence of glacial till and glacial ice extending out of the Ingalls Creek Valley and down the Peshastin valley approximately 5 to 6 miles near the 1,200 foot elevation level, which places his estimate near river mile 3.0. However, Hopkins (1966) and Porter (1969) concluded that the farthest extent of ice was probably near river mile 5.0 based on glacial deposits and valley morphology. The valley has been filled with glacially derived sediment, the percentage of this material derived from ablation till compared to glacial outwash likely increases in the up valley direction and may transition from glacial outwash to till in the upper segments of Reach 2.

Following glacial retreat, Peshastin Creek incised vertically into valley fill, contacting sandstone bedrock below glacial deposits in some locations. The stream subsequently adjusted laterally, leaving high glacial terraces at the margins of the historical (pre-Highway 97) floodplain. Post glacial floodplain widths averaged 718 feet in this part of the valley. Alluvial fan and debris flow deposits overlie the glacial outwash. With the exception of short channel segments, the channel is not confined by bedrock. However, lateral migration is currently controlled in many areas by glacially deposited boulders that cannot be moved by contemporary discharge, in addition to rip-rap that protects Highway 97, houses, and bridges.

The contemporary channel has been substantially altered compared to what existed before European settlement. Channel excavation, straightening, floodplain filling, bridges, and highway construction have reduced sinuosity and floodplain connectivity. Channel slope has increased due to a decrease in channel length. A steeper slope increases sediment transport capacity, and can lead to channel incision and further disconnection between the channel and floodplain. The current sinuosity of 1.12 is average for the study area, but historical sinuosity appears to have been greater. The current channel configuration was established by at least 1962. Channel straightening has occurred mainly as a result of improvements to Highway 97 as described in the next section.

Human Alterations

Highway 97 is the dominant barrier to process and habitat connection in this reach. The total length of roadway parallel to the channel in this reach is 3.34 miles. There is over 6,600 feet of road embankment that impinges directly on the north side of the channel (Figure 62). The road, and associated bank hardening, creates a severe limitation to what would otherwise be a laterally extensive floodplain across the valley. Channel straightening associated with the roadway has the potential to steepen the channel, increase sediment transport capacity, and cause incision. Aside from road infrastructure, there are 1,283 feet of other levees in the reach. About 91% of the total area of outer zone sub-units is disconnected from hydrologic and geomorphic processes by the roadway. There are 5 bridge crossings in this reach, located at river miles 5.0, 3.85, 3.05, 1.95, and 1.45. Each of these crossings divides the floodplain and creates a longitudinal barrier to process and habitat connection. The entire valley bottom, including all outer zone sub-units and adjacent terrace surfaces, have been cleared and developed for agriculture and residential uses. Maps of human features are included in Figure 63 and Figure 64.

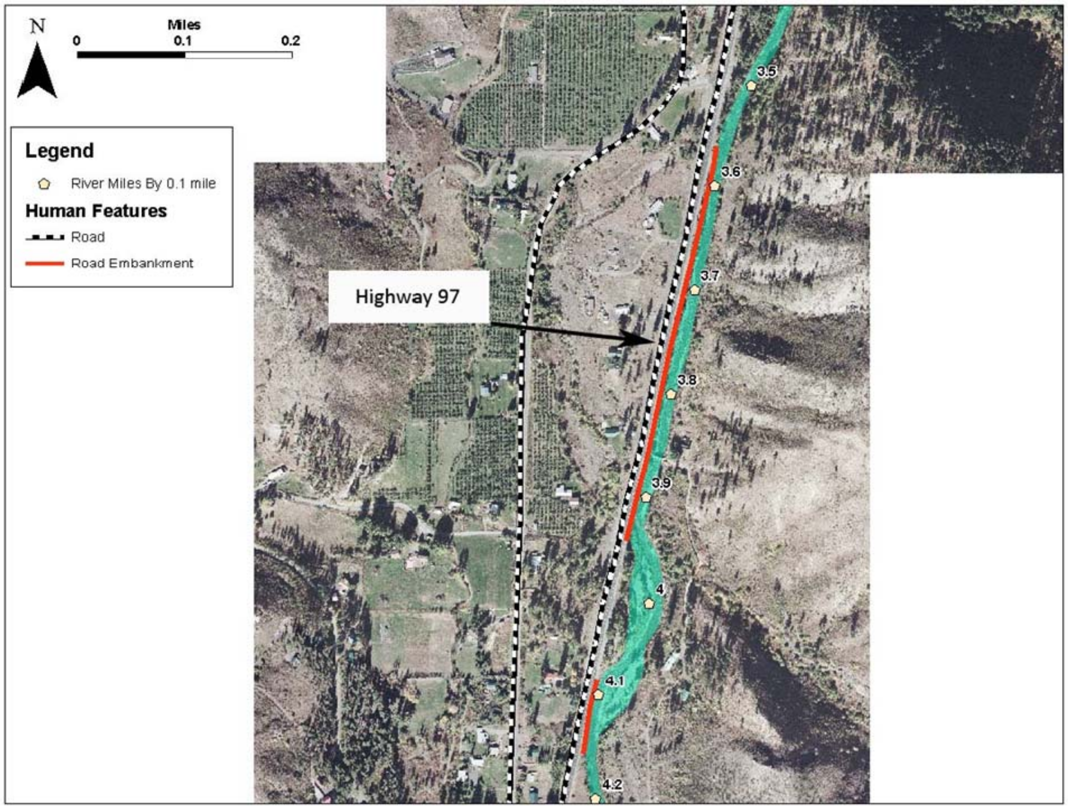

Figure 62. Aerial photo depicting the impact of Highway 97 on channel and floodplain processes for a 0.8 mile portion of Reach 2. Flow is from south to north.

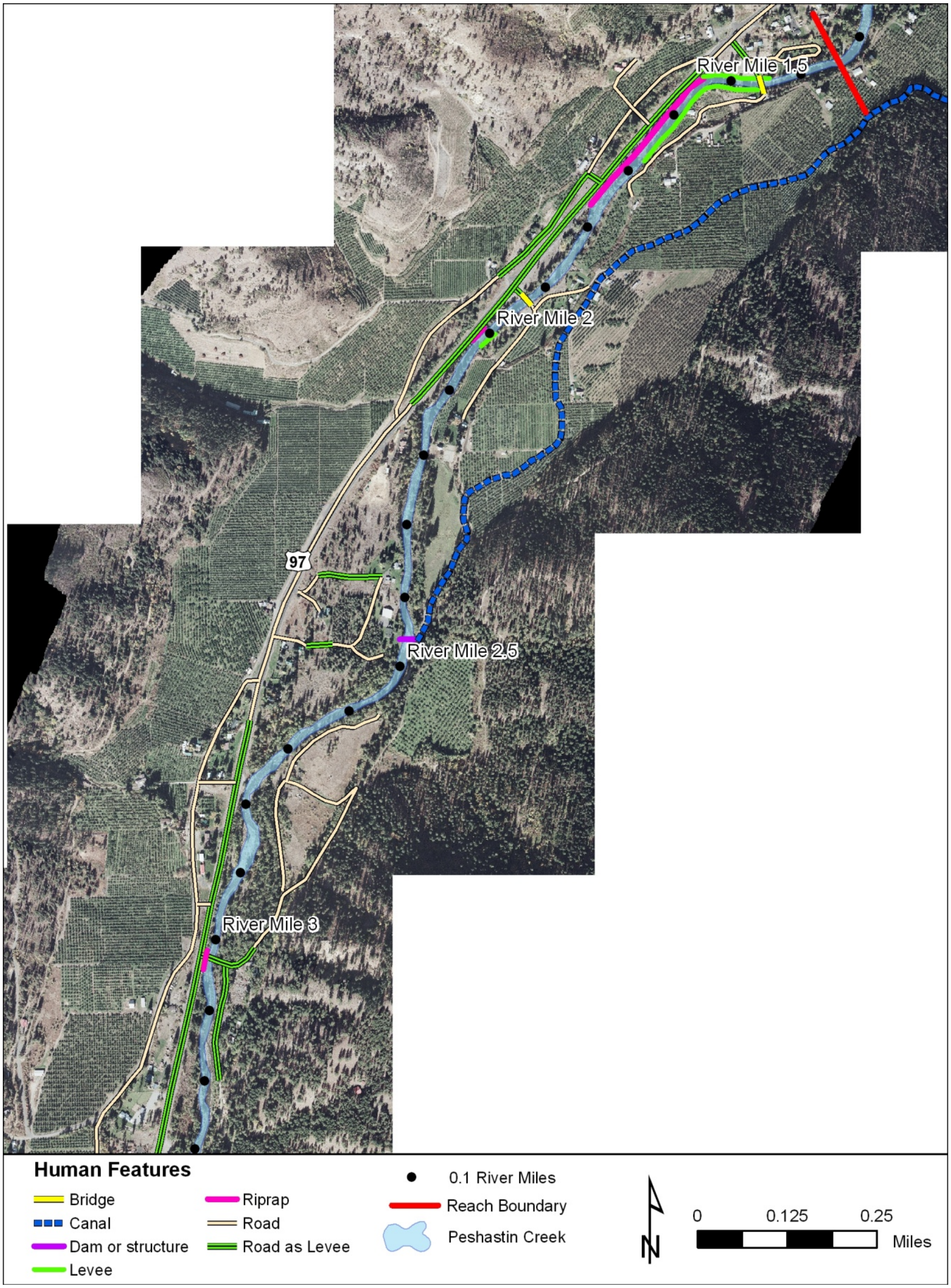

Figure 63. Human features in Reach 2 (downstream portion). Flow is from south to north.

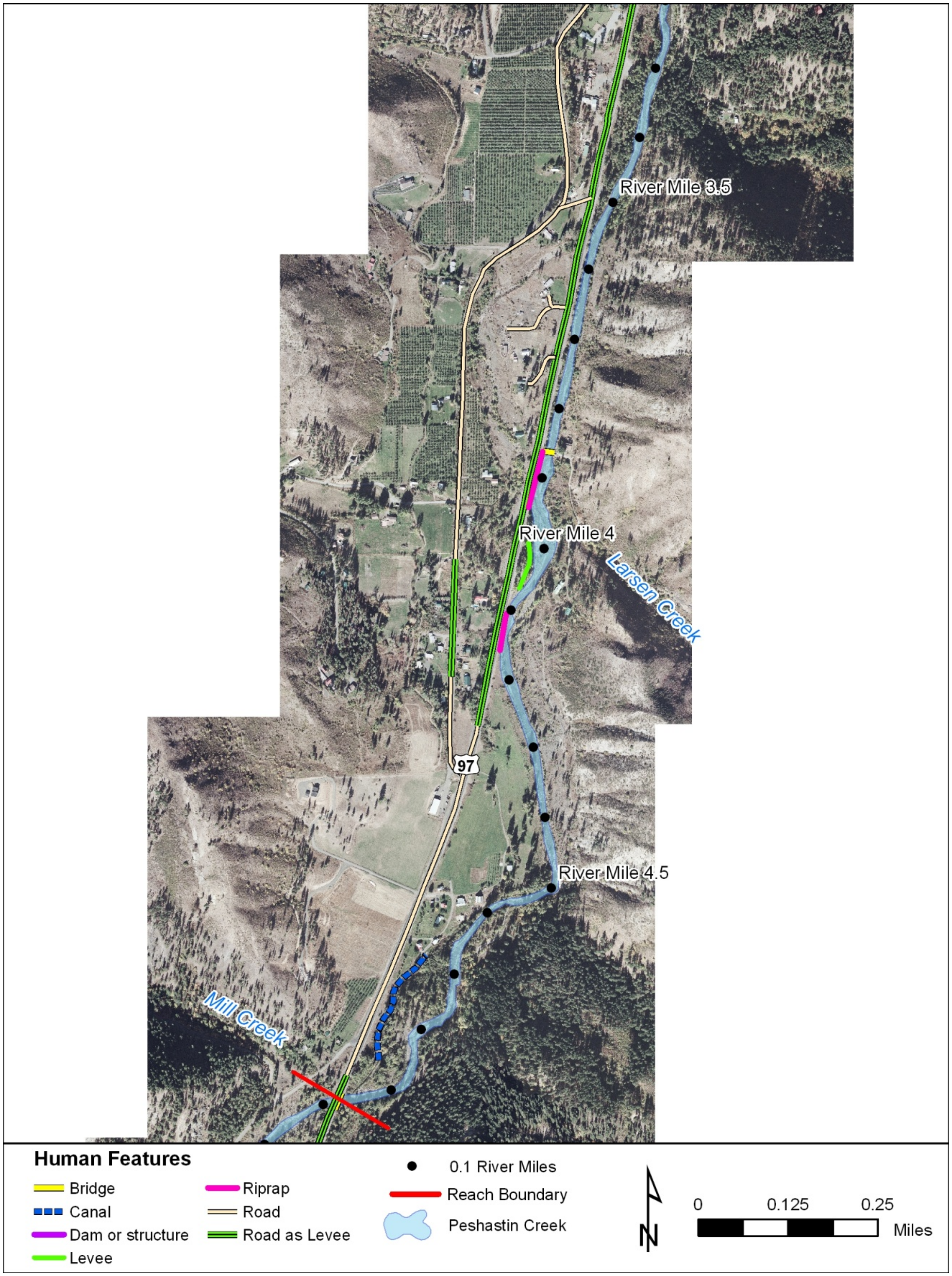

Figure 64. Human features in Reach 2 (upstream portion). Flow is from south to north.

3.4.2 Reach-Scale Restoration Strategy

The prioritized reach-scale restoration and preservation strategy for Reach 2 is included below. The strategy focuses first on protecting existing conditions from further impairment. This objective is followed by reconnecting the fundamental bio-physical processes that will create and maintain habitat conditions over the long-term. Instream and off-channel habitat enhancement (rehabilitation) is also included; these projects occur in conjunction with long-term process reconnection and are also applied in cases where long-term process reconnection is constrained by existing human uses.

The success of process restoration and habitat reconnection in this reach is hampered by the presence of Highway 97 as a continuous lateral barrier and by two irrigation diversions that significantly reduce summer baseflows. These are chronic issues requiring significant study and planning to determine feasible restoration options. Protection is limited by the advanced state of impairment of the river corridor. However, providing protection wherever possible is critical to limiting further degradation and all protection opportunities should be pursued.

1. ***Protect and Maintain***
   - **Prevent Further Degradation**- Opportunities to prevent further degradation should be pursued including purchasing land and water rights in the river corridor, and/or obtaining conservation easements. Water rights acquisition should be focused on increasing instream flow during late summer.
   - **Legal Protection**- Existing enforced legal protection is considered an intrinsic component of all potential projects.

2. ***Reconnect Stream Channel Processes***
   - **Instream Flow**- The ultimate success of restoration in this reach relies on increasing instream flow, particularly during the late summer months. There are two irrigation diversions in this reach. Under some conditions, low base-flows create barriers to fish migration that is essential for restoration success throughout the study area. Instream flow analysis has been completed for Peshastin Creek and the results should be considered in restoration planning.
   - **Riprap and Levees**- Stream channel processes can be reconnected by removing barriers and allowing dynamic processes to proceed naturally. Barriers to process and habitat connection such as riprap and levees should be removed or modified. More in-depth risk evaluation will be required to assess the potential to modify or remove barriers such as bridge crossings, roadways, levees and developments on adjacent floodplains and terraces.
   - **Highway 97**- Highway 97 is a large-scale, persistent barrier to river processes in this reach. Work with appropriate stakeholders to develop options for alleviating the detrimental effects of the highway. Potential alternatives range from selective bridging to full re-location of the highway. Full process restoration may require re-routing the highway onto nearby roads such as Campbell Road. The scale, cost, and social hurdles associated with any of these options will require an extensive planning and analysis process.

- **Other Roadways and Bridges**- Other roadways and bridges are located throughout the reach. These features limit channel migration, intercept floodplain processes, and contribute to channel incision. Look for opportunities to address these issues through increasing bridge spans or through potential removal or re-location.

3. ***Reconnect Floodplain Processes***
    - **Highway 97-** Highway 97 is the primary feature resulting in floodplain disconnection. Addressing highway impacts will require in-depth study and planning with appropriate stakeholders (see discussion above).
    - **Floodplain Development and Levees** - There is residential and agricultural development of the floodplain on both sides of the channel throughout the reach. Developments commonly include clearing, fill, roadways, levees or riprap along the channel margin. Where feasible, work should focus on reconnecting these areas through levee removal or modification and reclamation of floodplain surfaces. In many cases, it will be necessary to work with appropriate stakeholders to develop long-term solutions to floodplain impacts.

4. ***Riparian Restoration***
    - **Restore Riparian Areas**- The strategy for riparian restoration in this reach includes expanding the riparian corridor wherever possible and revegetating cleared areas.

5. ***In-Stream Habitat Enhancement***
    - **Enhance Habitat Complexity**- Instream large wood is a natural component of this system that has been severely reduced by past land-use practices. Wood creates pool scour, cover, and channel complexity. Place wood in configurations and locations that mimic natural wood deposition processes. These projects are not replacements for process restoration, but are meant to provide intermediate habitat enhancement while process restoration matures.

6. ***Off-Channel Habitat Enhancement***
    - **Enhance Off-Channel Habitat Complexity**- Enhancing off-channel habitat while Highway 97 remains in its current configuration requires working within the confines of Highway 97 to increase quality and connectivity of existing side-channel and alcove habitat features.

3.4.3 Sub-Unit and Project Opportunity Summary

Twenty-one sub-units have been identified in this reach including 5 inner zone sub-units, 3 disconnected inner zone sub-units, 4 outer zone sub-units, and 9 disconnected outer zone sub-units (Table 19, Figure 65, Figure 66, Figure 67, and Figure 68).

A total of 22 specific projects have been identified in this reach (Table 20). There are many infrastructure constraints to restoration work, including the presence of Highway 97, local roadways, levees, bank armoring, agricultural practices, and rural residential development. Where feasible, opportunities to re-establish a connection between channel and floodplain habitat should be considered high priority.

Table 19. Summary of sub-units and project opportunities in Reach 2.

Sub-Unit	River Mile	Acreage
IZ-1	4.5 – 5.0	N/A
OZ-1	4.6 – 5.0	6
OZ-2	4.76 – 4.85	1
OZ-3	4.5 – 4.7	2
DOZ-1	4.15 – 4.6	10
IZ-2	3.9 – 4.5	N/A
OZ-4	4.05 – 4.45	8
DOZ-2	4.0 – 4.25	6
DIZ-1	3.55 – 4.1	N/A
DOZ-3	3.6 – 4.1	21
IZ-3	3.55 – 3.95	N/A
DOZ-4	3.0 - 3.7	28
IZ-4	2.15 – 3.55	N/A
DOZ-5	2.7 – 3.2	12
DOZ-6	2.7 – 3.0	11
DOZ-7	2.2 – 2.8	26
DOZ-8	1.4 – 2.45	23
DIZ-2	1.95 – 2.2	N/A
IZ-5	1.35 – 2.15	N/A
DOZ-9	1.35 – 2.0	22
DIZ-3	1.5 – 1.75	N/A

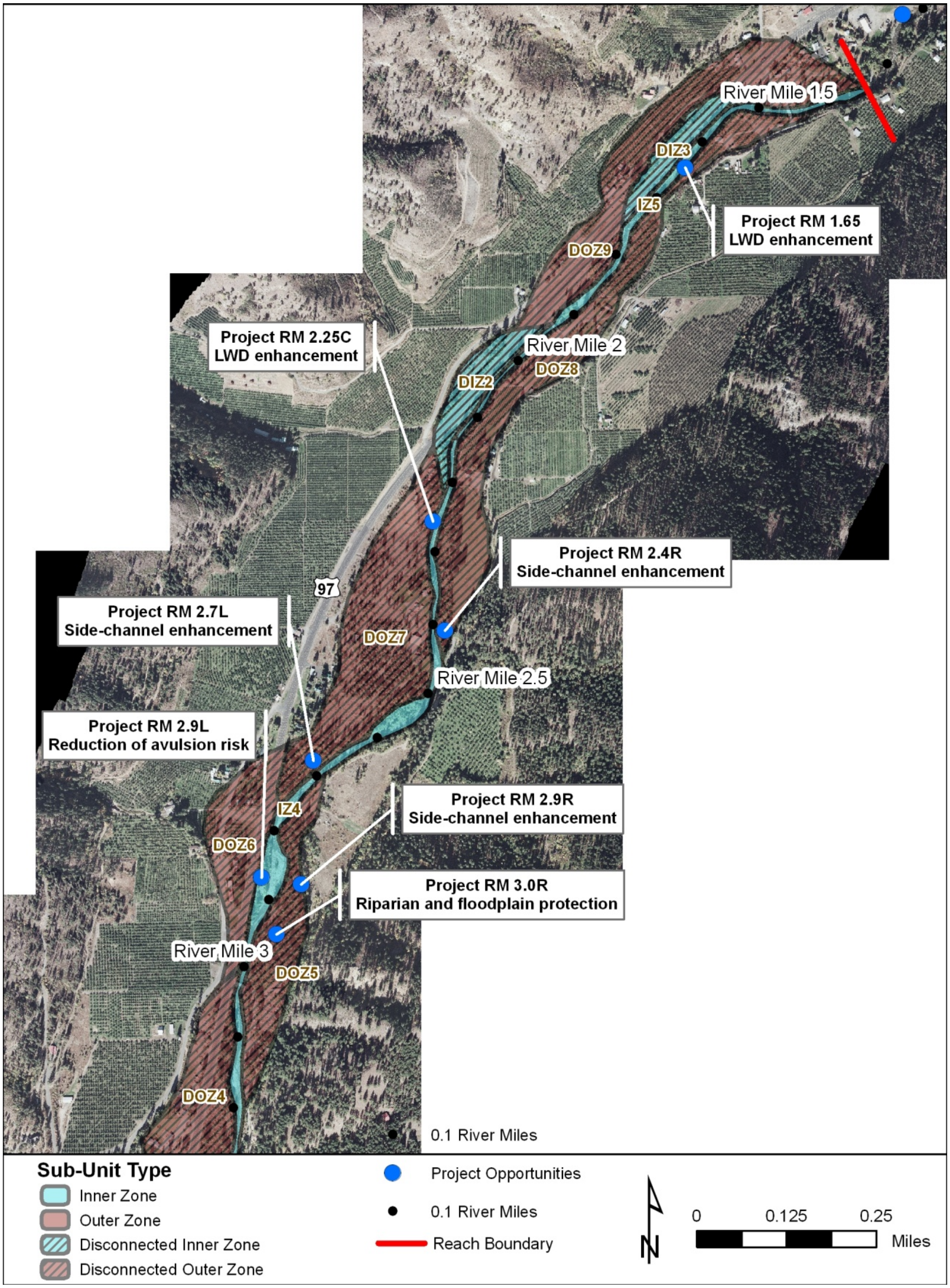

Figure 65. Sub-units and project opportunities in Reach 2 (downstream Portion). Flow is from south to north

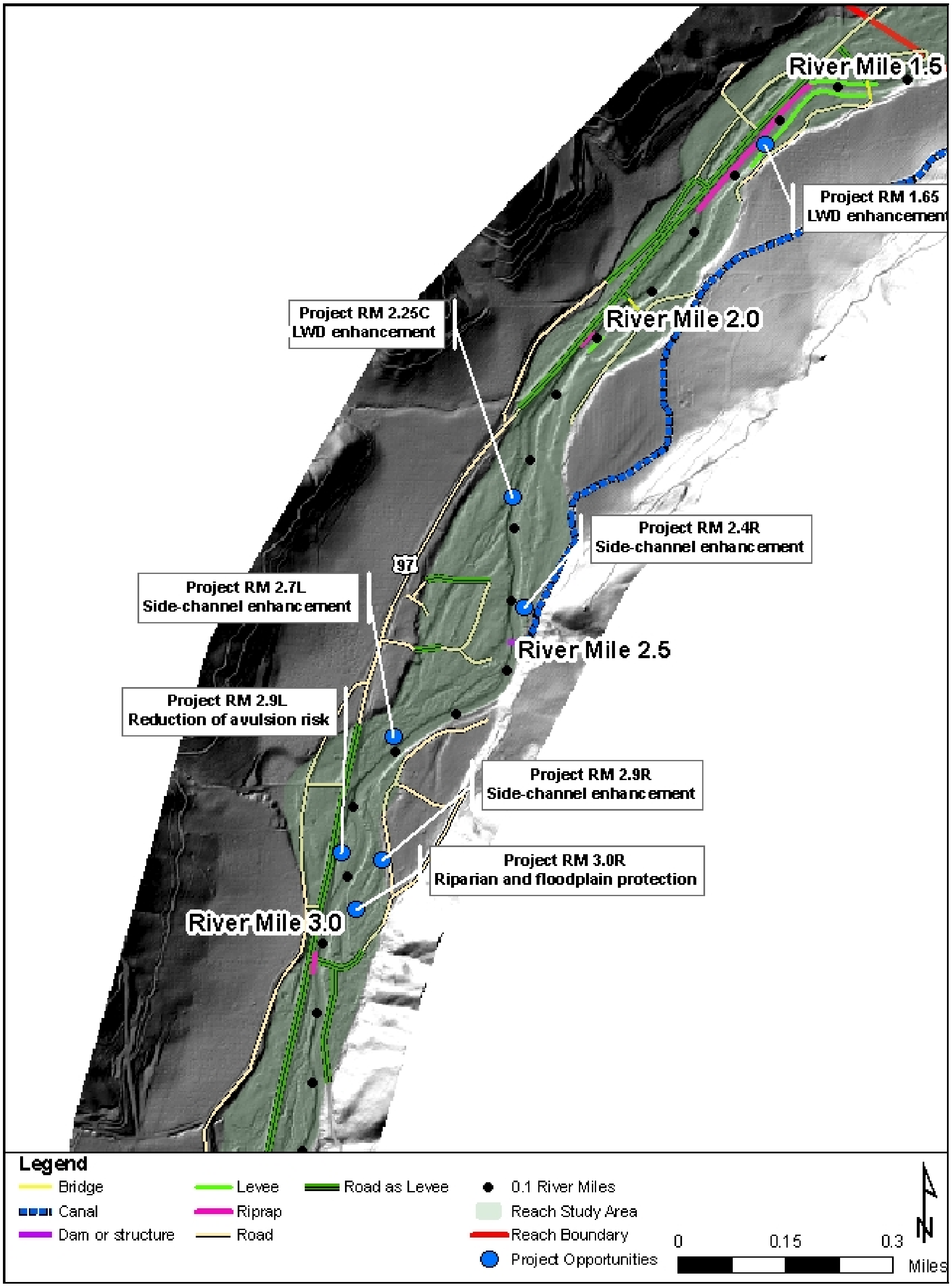

Figure 66. LiDAR hillshade of Reach 2 illustrating topography in relation to human features and project locations in the downstream portion of the reach. Flow is from south to north.

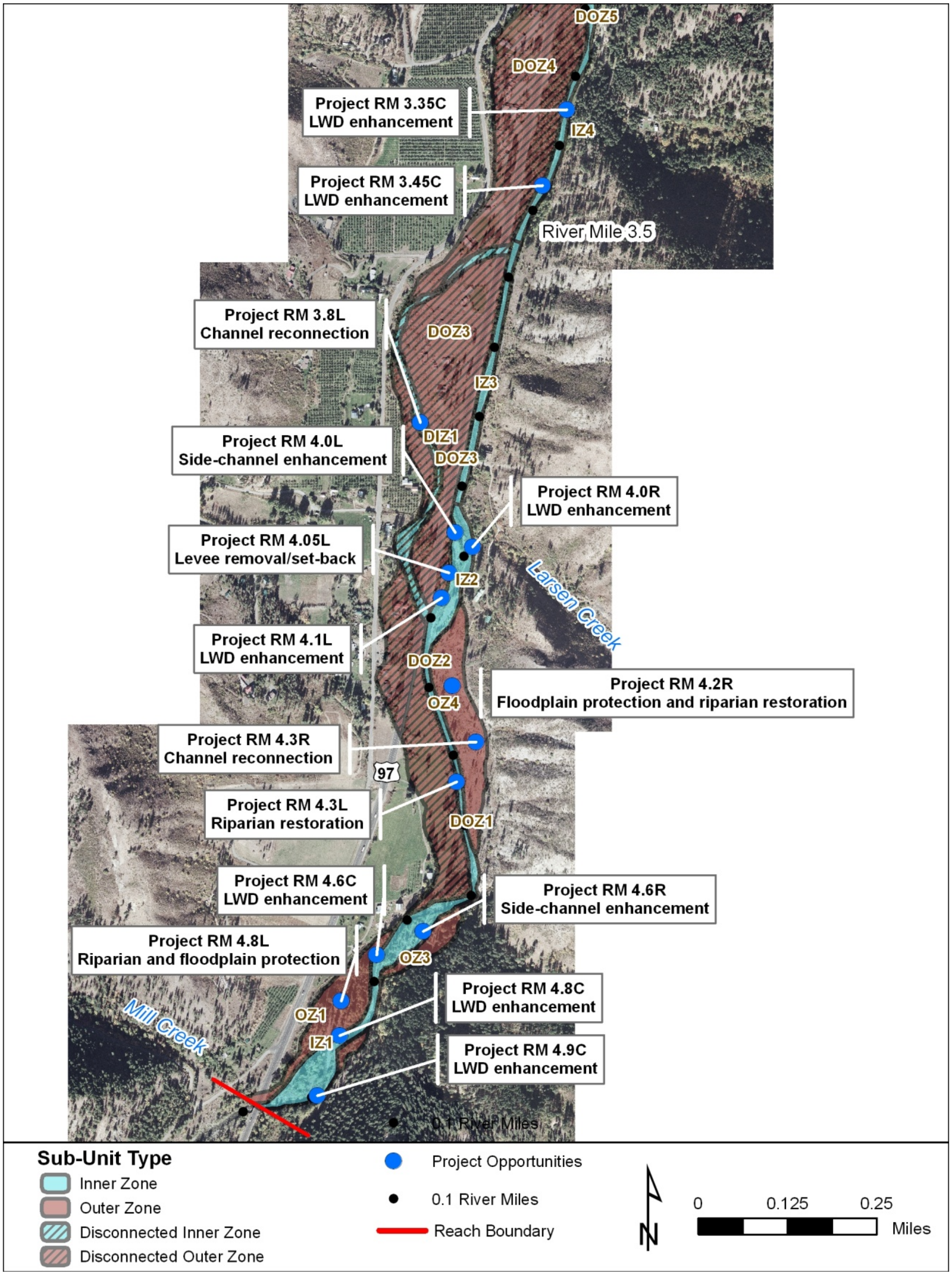

Figure 67. Sub-units and project opportunities in Reach 2 (upstream portion). Flow is from south to north.

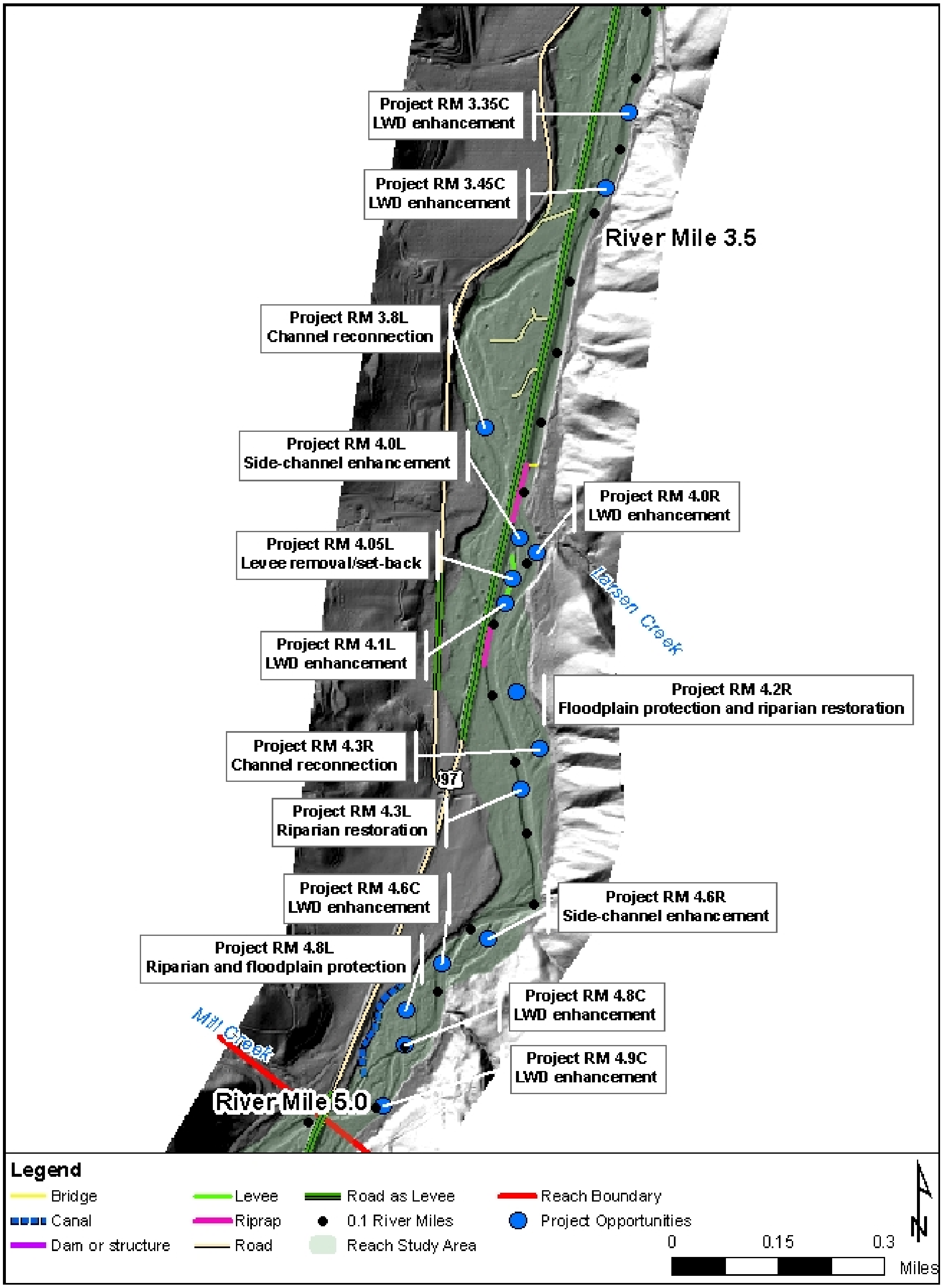

Figure 68. LiDAR hillshade of Reach 2 illustrating topography in relation to human features and project locations in the upstream portion of the reach. Flow is from south to north.

Table 20. Summary of Sub-Unit Descriptions, Restoration Strategies, Projects and Constraints for Reach 2.

Sub-Unit	Description	Strategy *(Strategies are listed in priority order)*	Projects[1] *(specific identified projects are in **bold**)*	Potential Constraints
IZ-1	This inner zone has no artificial constraint from the roadway or levees. This is one of a few inner zone units in the entire study area with multiple active channel threads at low flow, and connection to high flow channels. This is valuable habitat to protect from further degradation. Floodplain sub-units to the northwest and southeast are relatively un-developed providing a connection between the channel and floodplain, as well as habitat continuity between the channel and adjacent riparian habitat.	Protect and Maintain In-stream Habitat Enhancement	***Project RM 4.9C*** LWD habitat enhancement ***Project RM 4.8C*** LWD habitat enhancement ***Project RM 4.6C*** LWD habitat enhancement ***Project RM 4.6R*** Side-channel habitat enhancement	Residential development along the left side at downstream end of the sub-unit
OZ-1	This outer zone sub-unit lies to the northwest of IZ-1 and provides intact hydrologic and geomorphic connectivity. There are no levees or other bank protection that would create a direct limitation to physical processes. The intact riparian forest provides habitat connectivity without significant agricultural or residential development. Highway 97 is set back off the floodplain surface onto the adjacent terrace. However, an irrigation canal (Tandy Ditch) runs along the roadside edge for the entire length of this unit.	Protect and Maintain	***Project RM 4.8L*** Riparian and floodplain habitat protection	Residential development along the left side at the downstream end of the sub-unit. Tandy Ditch operations and ownership.

Table 20. Summary of Sub-Unit Descriptions, Restoration Strategies, Projects and Constraints for Reach 2.

Sub-Unit	Description	Strategy *(Strategies are listed in priority order)*	Projects[1] *(specific identified projects are in **bold**)*	Potential Constraints
OZ-2	This is a small outer zone sub-unit that extends along the southeast side of IZ-1. The riparian forest in this unit is relatively undisturbed, and abuts a steep hillslope forested with conifers that provides direct riparian/upland connection including access to a small drainage that enters the main channel just downstream of this unit. This type of habitat connectivity from active channel, through the riparian zone, to the uplands is rare in the study area.	Protect and Maintain		No anthropogenic constraints. Access may be an issue due to location.
OZ-3	This outer zone sub-unit is similar to OZ-2. The riparian zone is intact, and the unit provides habitat connection between the main channel, a secondary channel, and adjacent uplands. This sub-unit borders the side-channel enhancement project at RM 4.6R.	Protect and Maintain		No anthropogenic constraints. Access may be an issue due to location.
DOZ-1	This outer zone sub-unit begins to display some of the disturbance patterns that are more common throughout the reach, such as grading and clearing for agriculture. A narrow buffer exists between the channel and the pasture, but only sparse riparian vegetation remains in this area. Although this terrace still functions as a flood terrace at some flows, LiDAR data indicates filling and grading that has likely impacted floodplain connectivity. Clearing and agricultural use further compromises full connectivity to the river.	Protect and Maintain Reconnect Floodplain Processes Riparian Restoration	***Project RM 4.3L*** Expand riparian buffer (left bank). *Work to address floodplain disconnection*	Residential and agricultural uses

Table 20. Summary of Sub-Unit Descriptions, Restoration Strategies, Projects and Constraints for Reach 2.

Sub-Unit	Description	Strategy *(Strategies are listed in priority order)*	Projects[1] *(specific identified projects are in **bold**)*	Potential Constraints
IZ-2	This sub-unit comprises a predominately straight section of channel with plane-bed morphology and coarse bed material. Pools are relatively frequent, but they are short, poorly developed, and lack aquatic habitat complexity. There is one meander sequence at the downstream end that adds some planform diversity to the sub-unit. However, meander migration at this location is constrained by rip-rap along the Highway 97 embankment on river left and by alluvial fan and landslide deposits on river-right. On the inside of the meander near river mile 4.05 (river-left bank), a levee limits connectivity to a flood overflow channel.	Protect and Maintain Reconnect Stream Channel Processes In-Stream Habitat Enhancement Off-Channel Habitat Enhancement	***Project RM 4.05L*** Levee removal/set-back ***Project RM 4.1L*** LWD enhancement. ***Project RM 4.0R*** LWD enhancement. ***Project RM 4.0L*** Side-channel enhancement	Levee on river left from river mile 4.0-4.1 Highway 97 parallels the left side of the channel at the downstream end of the sub-unit Residential development on both sides of the channel at the downstream end
OZ-4	This outer zone sub-unit is not currently developed, though it appears that it may have been cleared in the past. There are no significant barriers to hydrologic or geomorphic processes, and the LiDAR data suggests that high flow events access this surface, though the frequency of inundation has not been determined. There is an unimproved roadway along the hillslope side of the sub-unit. There is sparse vegetation that appears to be primarily upland species, with some riparian vegetation along the channel edge. The riparian habitat quality is currently low in this unit, but the lack of human development adds value to any protection measures.	Protect and Maintain Reconnect Stream Channel Processes	***Project RM 4.2R*** Floodplain protection and riparian restoration ***Project RM 4.3R*** Stream channel reconnection	Unimproved roads across surface. Limited access, except across private property.

Table 20. Summary of Sub-Unit Descriptions, Restoration Strategies, Projects and Constraints for Reach 2.

Sub-Unit	**Description**	**Strategy** *(Strategies are listed in priority order)*	**Projects**[1] *(specific identified projects are in **bold**)*	**Potential Constraints**
DOZ-2	This outer zone sub-unit is disconnected from the channel by Highway 97. The roadway runs directly along the channel bank for most of the streamside edge of this unit providing essentially no riparian zone adjacent to the channel and no connection between channel and floodplain processes. Vegetation has been cleared from this surface with residential development and light industrial uses covering the majority of the area.	Protect and Maintain Reconnect Floodplain Processes	Work to address disconnection caused by highway, bridges (eg. road relocation, increase bridge span, replace culverts)	Highway 97 parallels the sub-unit and disconnects the floodplain surface from the channel Residential development throughout the sub-unit
DIZ-1	This disconnected inner zone is a former channel location prior to highway construction. The disconnected channel extends approximately 3,350 feet. Highway 97 currently blocks the upstream and downstream ends of this channel. The new channel location has been straightened and directly abuts the highway along this section (see description for IZ-3). This is one of the longest and most severe channel re-alignments that has occurred in the study area.	Reconnect Stream Channel Processes	***Project RM 3.8L*** Stream channel reconnection	Expensive and large-scale project Requires re-routing the highway, or new bridge construction (2 bridges) Potential private land issues in old floodplain/channel area Residential development throughout the adjacent floodplain

Table 20. Summary of Sub-Unit Descriptions, Restoration Strategies, Projects and Constraints for Reach 2.

Sub-Unit	Description	Strategy *(Strategies are listed in priority order)*	Projects[1] *(specific identified projects are in **bold**)*	Potential Constraints
DOZ-3	Highway 97 completely disconnects floodplain and channel migration processes in DOZ-3. The highway abuts the stream on the east side of this sub-unit and completely disconnects this former floodplain (and main channel) area. The area has also been cleared for rural residential uses.	Reconnect Floodplain Processes	***See project in DIZ-1***	Highway 97 divides the unit longitudinally Rural residential development and clearing throughout the sub-unit
IZ-3	IZ-3 is a straight and uniform section of channel directly confined by the Highway 97 embankment on the river-left bank (west side of stream). The hillslope confines the channel on the river-right bank (east side of stream) throughout most of the length of the unit. This section of stream was re-routed in the past to facilitate highway construction. The old, now abandoned, channel is located to the west of the highway. There is a bridge crossing at river mile 3.85. Channel morphology is plane-bed, with some pool development near the upstream end. There is very little hydraulic habitat complexity currently provided in this sub-unit.	Protect and Maintain Reconnect Stream Channel Processes	***See project RM 3.8L***	Highway 97 parallels the sub-unit to the left Bridge at river mile 3.85 Residential development on both sides of stream

Table 20. Summary of Sub-Unit Descriptions, Restoration Strategies, Projects and Constraints for Reach 2.

Sub-Unit	Description	Strategy *(Strategies are listed in priority order)*	Projects[1] *(specific identified projects are in **bold**)*	Potential Constraints
DOZ-4	Highway 97 disconnects floodplain and channel migration processes in DOZ-4. Over 700 acres in the western portion of the sub-unit are completely disconnected due to the highway. This area has been cleared and developed for residential uses. There are 250 acres located between the highway and the channel. This area contains relatively intact riparian vegetation; however, floodplain processes and channel migration are affected by the presence of the highway, which abuts the channel at the upstream and downstream ends of the unit.	Protect and Maintain Reconnect Floodplain Processes	*Look for opportunities to address floodplain disconnection (eg. re-route, bridge or place culverts under Highway 97)*	Highway 97 divides the unit longitudinally Residential development throughout the western portion of the sub-unit
IZ-4	This sub-unit extends from RM 3.55 to 2.15. The highway is located away from the channel for most of the reach, except for a 500 ft segment near RM 3.0. There is a private bridge crossing at this location. The Peshastin Canal diversion dam is located at RM 2.45. From river mile 3.2 and 2.75, there are alternating bar sequences and high local sinuosity. This unit may be a depositional area for sediment transported through the straight channel section immediately upstream, and this dynamic may account for some of the observed bar development and lateral movement.	Protect and Maintain Instream Habitat Enhancement	***Project RM 2.9L*** Reduction of avulsion risk ***Project RM 3.45L*** LWD enhancement ***Project RM 2.25C*** LWD enhancement.	Highway 97 parallels the channel, abutting directly for several hundred feet Residential development mostly near the downstream end Peshastin Canal diversion dam at river mile 2.45 Private bridge near river mile 3.0
DOZ-5	The upstream portion of this floodplain has been subjected to floodplain filling, roads, and residential development. A bridge accesses the unit from the west, and leads to a small network of unimproved roads/driveways. Downstream of the road, there is no development and the riparian forest is relatively intact.	Protect and Maintain Off-Channel Habitat Enhancement	***Project RM 3.0R*** Riparian and floodplain protection ***Project RM 2.9R*** Side-channel enhancement/ reconnection	Historical fill, levees and residential development in upstream portion of unit Bridge near river mile 3.0

Table 20. Summary of Sub-Unit Descriptions, Restoration Strategies, Projects and Constraints for Reach 2.

Sub-Unit	Description	Strategy (*Strategies are listed in priority order*)	Projects[1] (*specific identified projects are in* **bold**)	Potential Constraints
DOZ-6	The DOZ-6 floodplain has been completely disconnected from the mainstem due to Highway 97. There has also been considerable fill associated with agricultural and rural residential development.	Protect and Maintain	*Identify opportunities to address floodplain disconnection (eg. re-route roads, bridges, install culverts, riparian restoration).*	Historical fill, residential development, and agricultural development throughout the sub-unit Highway 97 parallels the sub-unit and completely disconnects it from the active channel
DOZ-7	This unit has been subjected to clearing and rural residential development. There are areas of intact riparian and floodplain vegetation, although large areas have been converted to open lawn or pasture. There are minor levees associated with driveways that bisect several high-flow channels.	Protect and Maintain Reconnect Floodplain Processes Off-Channel Habitat Enhancement	***Project RM 2.7L*** Side-channel enhancement *Work to address floodplain disconnection (eg. levee removal/setback, road relocation).*	Historical fill, levees and residential development in portions of the sub-unit Highway 97 parallels the sub-unit
DOZ-8	This floodplain sub-unit, which extends from RM 1.45 to 2.45, has been almost entirely cleared and converted to agriculture and rural residential uses. There are two bridge crossings, one at river mile 1.95 and the other at river mile 1.45. The Peshastin Canal and diversion dam are located at the upstream end of this sub-unit.	Protect and Maintain Reconnect Floodplain Processes Off-Channel Habitat Enhancement	***Project RM 2.4R*** Side-channel enhancement *Work to address floodplain disconnection (eg. levee remoal, increase bridge span, floodplain restoration)*	Bridges at river miles 1.95 and 1.45 Levees, agricultural practices, roadways, residential development, and historical filling of floodplain channels and depressions.

Table 20. Summary of Sub-Unit Descriptions, Restoration Strategies, Projects and Constraints for Reach 2.

Sub-Unit	Description	Strategy *(Strategies are listed in priority order)*	Projects[1] *(specific identified projects are in **bold**)*	Potential Constraints
DIZ-2	This sub-unit is the former Peshastin Creek mainstem channel that was cut-off as a result of highway construction. Over 1,000 feet of channel was cut-off and the new straightened channel now runs along the road embankment. There is little restoration opportunity here short of re-routing the highway into the old alignment or building bridges to pass water into the old channel, which would have limited effectiveness because much of the highway fill lies within the old channel itself. For these reasons, restoration opportunities are viewed as very unlikely at this time and so are not included here.	Protect and Maintain Reconnect Stream Channel Processes	*Work to address disconnection(re-route or place culverts under Highway 97).*	The highway has cut-off the historical channel and much of the historical channel has been filled as a result.
IZ-5	IZ-5 extends from RM 1.35 to 2.15. Highway 97 creates a direct constraint to lateral channel migration, high-flow access to the floodplain, and habitat complexity. There are nearly 4,000 ft of hardened road embankment and levees along the channel in this sub-unit. Two bridge crossings at river miles 1.95 and 1.45 contribute additional constraints to channel dynamics.	Protect and Maintain In-stream Habitat Enhancement	***Project RM 1.65C*** LWD enhancement.	The highway has cut-off the historical channel Highway 97 parallels the channel, abutting directly for 3,000 feet Bridges near river mile 1.95 and 1.45
DOZ-9	Highway 97 parallels the channel for the entire length of the unit, posing a significant barrier to hydrologic and geomorphic process. At river miles 1.95 and 1.45, roads laterally bisect the floodplain surface to access the other side of the river; these create barriers to riparian and floodplain processes within the river-left floodplain. Outside of the road right-of-way, the sub-unit has been developed for agricultural and rural residential uses.	Protect and Maintain Reconnect Floodplain Processes	*Work to address floodplain disconnection (eg. re-route, bridge, or place culverts under Highway 97).*	Highway 97 parallels the channel Local roads and bridges at river miles 1.95 and 1.45 Residential and agricultural development

Table 20. Summary of Sub-Unit Descriptions, Restoration Strategies, Projects and Constraints for Reach 2.

Sub-Unit	Description	Strategy *(Strategies are listed in priority order)*	Projects[1] *(specific identified projects are in **bold**)*	Potential Constraints
DIZ-3	This sub-unit is similar to DIZ-2. This sub-unit represents a former Peshastin Creek mainstem channel that was cut-off as a result of highway construction. Over 1,200 feet of channel was cut-off and the new straightened channel now runs along the road embankment. There is little restoration opportunity here short of re-routing the highway into the old alignment or building bridges to pass water into the old channel. For these reasons, restoration opportunities are viewed as very unlikely at this time and so are not included here.	Protect and Maintain Reconnect Stream Channel Processes	*Work to address disconnection of the inner zone (eg.re-route, bridge or place culverts under Highway 97)*	The highway has cut-off the historical channel and much of the historical channel has been filled as a result.

[1]*For additional information on specific identified project opportunities, see Peshastin Project Opportunities list in Appendix B.*

REACH 3 – REACH ASSESSMENT

3.5 Reach 3 Reach Assessment

3.5.1 Reach Overview

Reach 3 begins near the Highway 97 crossing at river mile 5.0 and extends one mile up to river mile 6.0 where the highway abuts the stream channel. The reach is bounded by the Mill Creek confluence at the downstream end and the Camas Creek confluence at the upstream end. This reach has a greater degree of valley confinement compared to other reaches, which limits the degree of agricultural uses. The primary land use is rural residential development.

Habitat Conditions and Fish Use

Salmonid use of Reach 3 includes spring Chinook, steelhead, coho, bull trout, westslope cutthroat trout, and non-native brook trout. Spring Chinook and steelhead use lower Peshastin Creek primarily as a migration corridor to access upstream spawning areas, although limited spawning and rearing use does occur in the reach. Bull trout are believed to use lower Peshastin Creek primarily for migration and possibly limited rearing. The Yakama Nation coordinates a coho re-introduction program in the Wenatchee Basin. Coho are not typically released in Peshastin Creek but coho spawning and rearing in lower Peshastin Creek has been documented during surveys. See Section 2.6 for additional information on fish use in lower Peshastin Creek.

There is limited spawning and rearing habitat in Reach 3. Many of the riffles consist of long, coarse-bedded, plane-bed sections that lack good spawning substrate. Pools are infrequent but several pools are deep and have good tail-out habitat for spawning. In particular, a sequence of pools from river mile 5.4 to 5.6 have long tail-outs with suitable depth and velocity for Chinook and steelhead spawning. These same pools have good depth for juvenile rearing. Most of the other pools have shallow residual depths and all pools have minimal cover and LWD habitat. LWD quantities are very low throughout the reach. The coarse bed and high frequency of boulders provides areas of localized velocity refuge that may be utilized for rearing by juvenile steelhead and resident trout. This reach has the greatest amount of side-channel habitat (6%) of all of the reaches in the study area, and these localized areas likely provide diverse juvenile rearing opportunities. See the Habitat Assessment (Section 2.7) for additional information on stream habitat conditions. A summary of the Reach-Based Ecosystem Indicators (REI) is included in Table 21.

Table 21. Reach-Based Ecosystem Indicators (REI) ratings for Reach 3. See Section 2.9 for the complete REI analysis.

General Characteristics	General Indicators	Specific Indicators	Reach 3 Condition
Habitat Access	Physical Barriers	Main Channel Barriers	*Adequate*
Habitat Quality	Substrate	Dominant Substrate/Fine Sediment	*At Risk*
	LWD	Pieces per Mile at Bankfull	*Unacceptable*
	Pools	Pool Frequency and Quality	*Unacceptable*

General Characteristics	General Indicators	Specific Indicators	Reach 3 Condition
	Off-Channel Habitat	Connectivity with Main Channel	*At Risk*
Channel	Dynamics	Floodplain Connectivity	*Unacceptable*
		Bank Stability/Channel Migration	*At Risk*
		Vertical Channel Stability	*At Risk*
Riparian Vegetation	Condition	Structure	*Unacceptable*
		Disturbance (Human)	*At Risk*
		Canopy Cover	*At Risk*

Hydrology

Reach 3 has a relatively unaltered hydrologic regime. There are no significant flow withdrawals within or upstream of the reach. Peak flows occur in the spring as a result of snowmelt, with occasional fall and winter peaks associated with rain or rain-on-snow events. Flows decrease in June and early July, and low flows occur August through September. Historical logging, mining, and grazing practices throughout the contributing watershed have the potential to alter hydrologic response to storm events.

Estimates of flood flow magnitudes are presented in Table 22. Comparing flood flow estimates at the upstream and downstream ends of the reach indicates a flow contribution of several hundred cubic feet per second (cfs) within the reach.

Table 22. Flood magnitudes for recurrence intervals from 2 to 100 years at the upstream and downstream end of Reach 3 (USBR 2008).

Location	River Mile	Flood Recurrence Interval (ft^3/sec)					
		Q2	Q5	Q10	Q25	Q50	Q100
Peshastin Above Mill Creek (downstream end)	5	1,007	1,543	1,969	2,595	3,130	3,728
Peshastin above Camas Creek (upstream end)	6.1	895	1,371	1,750	2,306	2,781	3,312

Geomorphology

Reach 3 is naturally confined in a relatively narrow canyon from river mile 6.0 to river mile 5.0. Average valley width is 485 feet in Reach 3, compared to 715 feet in Reach 2. Hopkins (1966) and Porter (1969) reported that the farthest glacial advance was to the downstream end of Reach 3 at river mile 5.0, placing it upstream of where Long (1951) estimated glacial advance near river mile 3.0. The existing channel has incised through glacial till and outwash. Segments of the channel contact sandstone bedrock from approximately RM 5.55 to 5.7.

The channel has less potential for lateral adjustment than in wider valley sections downstream. The floodplain margin is bound by bedrock, glacial lag deposits, alluvial fan deposits, and debris flow deposits. Mapping of historical channel locations shows that channel position has changed little since 1975. Aerial photos prior to 1975 were not available. Highway 97 was completed prior to 1975, and it is likely that some degree of channel relocation occurred due to the highway construction; however, the highway is located at the base of the hillslope for most of the reach, indicating limited impingement on the channel.

Reach 3 has moderate sinuosity (1.12) and the lowest slope in the study area (0.014). The bed consists primarily of cobble and boulder. Bed morphology consists of long plane-bed boulder-bed segments as well as step-pool segments. Bedrock is present throughout the reach and forms sculpted bedrock pools, especially near the upstream end of the reach (Figure 69).

Figure 69. View looking toward the southeast in the upstream direction near river mile 5.5. At this location, bedrock controls play a role in pool formation. Photo taken in August 2009.

Human Alterations

The human impacts to Reach 3 appear less substantial than in downstream reaches, primarily as a result of limited valley width and lack of opportunity for agricultural development. However, proportionally the impacts are similar, with about 88% of the historic floodplain disconnected in this reach. Highway 97 has had the most significant impact at the downstream end of Reach 3, where it bisects the floodplain and crosses the channel (Figure 70). The highway bridge and fill disconnects the floodplain upstream and downstream of the roadway. For most of the reach, Highway 97 runs along the hillslope edge and does not disconnect the channel from the floodplain. However, the road impinges on the channel at the upstream end of the reach, compromising streambank habitat and riparian function.

There are push-up levees made up of local material that have been constructed to protect private property from flooding. Floodplain connection is also degraded by approximately 100 feet of levee near river mile 5.2 that blocks the upstream end of a former floodplain high-flow channel. There is an old road and concrete bridge abutments near river mile 5.25. Although there is no longer a bridge in this location, the concrete abutments continue to constrict the channel.

There is a considerable amount of rural residential and industrial development along this reach.

The greatest impact is between river miles 5.2 and 5.7 (Figure 71). In this area, much of the riparian area and floodplain has been cleared. LiDAR data also suggests considerable filling and grading of the floodplain in this area. A map of human features is included in Figure 72.

Figure 70. View toward the northeast in the downstream direction near river mile 5.0. The bridge at this location limits local channel dynamics, and floodplain connection downstream. Photo taken in August, 2009.

Figure 71. View to the northeast in the downstream direction at the river right floodplain near river mile 5.6. This floodplain area has been cleared and residentially developed. Photo taken in August 2009.

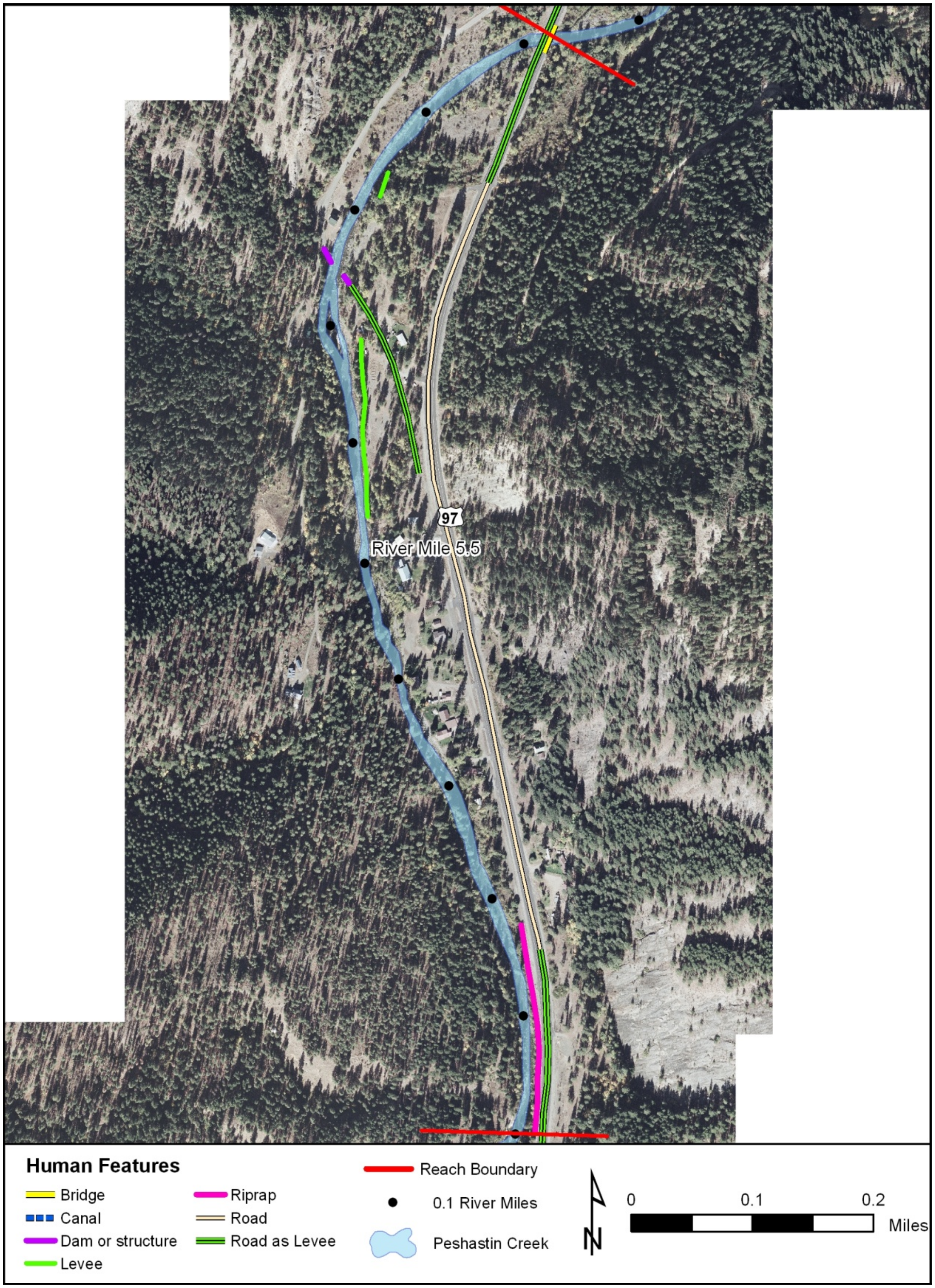

Figure 72. Human features in Reach 3. Flow is from south to north.

3.5.2 Reach-Scale Restoration Strategy

The prioritized reach-scale restoration and preservation strategy for Reach 3 is included below. The strategy focuses first on protecting existing conditions from further impairment. This objective is followed by reconnecting the fundamental bio-physical processes that will create and maintain habitat conditions over the long-term. Instream and off-channel habitat enhancement (rehabilitation) is also included; these projects occur in conjunction with long-term process reconnection and are also applied in cases where long-term process reconnection is constrained by existing human uses.

This reach has undergone less development than other reaches in the study area and has fewer impacts from Highway 97 and flow diversion. The focus of the restoration strategy should be to maintain the current level of function while striving to restore locations that have been negatively impacted. These areas include levees near residential developments, and a section of highway near the downstream end of the reach that bisects a floodplain surface. There are several potential opportunities to achieve these goals.

1. ***Protect and Maintain***
   - **Prevent Further Degradation**- Opportunities to prevent further degradation should be pursued including purchasing land in the river corridor and/or obtaining conservation easements.
   - **Legal Protection**- Existing enforced legal protection is considered an intrinsic component of all potential projects.

2. ***Reconnect Stream Channel Processes***
   - **Riprap and Levees**- There are a few levees and armored banks within this reach. Stream channel processes can be reconnected by removing or modifying these barriers.
   - **Highway 97**- Highway 97 crosses the reach at the downstream end (RM 5) and abuts the reach for ~1,000 feet at the upstream end. Look for opportunities to re-route the highway and/or extend the bridge span near RM 5 in order to reconnect channel migration processes.

3. ***Reconnect Floodplain Processes***
   - **Floodplain Development and Levees** - There is rural residential development of the floodplain on the east side of the channel throughout the reach. These developments include occasional clearing, fill, roadways, and levees. Where feasible, work should focus on reconnecting these areas through levee removal or modification and reclamation of floodplain surfaces. In many cases, it will be necessary to work with appropriate stakeholders to develop long-term solutions to floodplain impacts.
   - **Highway 97**- Highway 97 crosses the reach at the downstream end (RM 5) and abuts the reach for ~1,000 feet at the upstream end. Look for opportunities to re-route the highway and/or extend the bridge span near RM 5 in order to reconnect

floodplain processes.

4. ***Riparian Restoration***
   - **Restore Riparian Areas**- The strategy for riparian restoration in this reach includes expanding the riparian corridor wherever possible and revegetating cleared areas.

5. ***In-Stream Habitat Enhancement***
   - **Enhance Habitat Complexity**- Instream large wood is a natural component of this system that has been severely reduced by past land-use practices. Wood creates pool scour, cover, and channel complexity. Place wood in configurations and locations that mimic natural wood deposition processes. These projects are not replacements for process restoration, but are meant to provide intermediate habitat enhancement while process restoration matures.

3.5.3 Sub-Unit and Project Opportunity Summary

Seven sub-units were identified in Reach 3 including two inner zone sub-units, two outer zone sub-units, and three disconnected outer zone sub-units (Table 23, Figure 73, Figure 74). Reach 3 is less impacted by human alterations than Reach 2 downstream. The greater confinement limits the amount of off-channel restoration opportunities. A total of 9 specific projects have been identified in this reach that compliment the restoration strategies outlined in the previous section (Table 24).

Table 23. Summary of sub-units and project opportunities in Reach 3.

Sub-Unit	River Mile	Acreage
IZ-1	5.45 – 6.0	N/A
OZ-1	5.65 – 5.95	2
DOZ-1	5.2 – 5.9	17
OZ-2	5.3 – 5.5	2
IZ-2	5.0 – 5.45	N/A
DOZ-2	5.0 – 5.25	3
DOZ-3	4.9 – 5.2	9

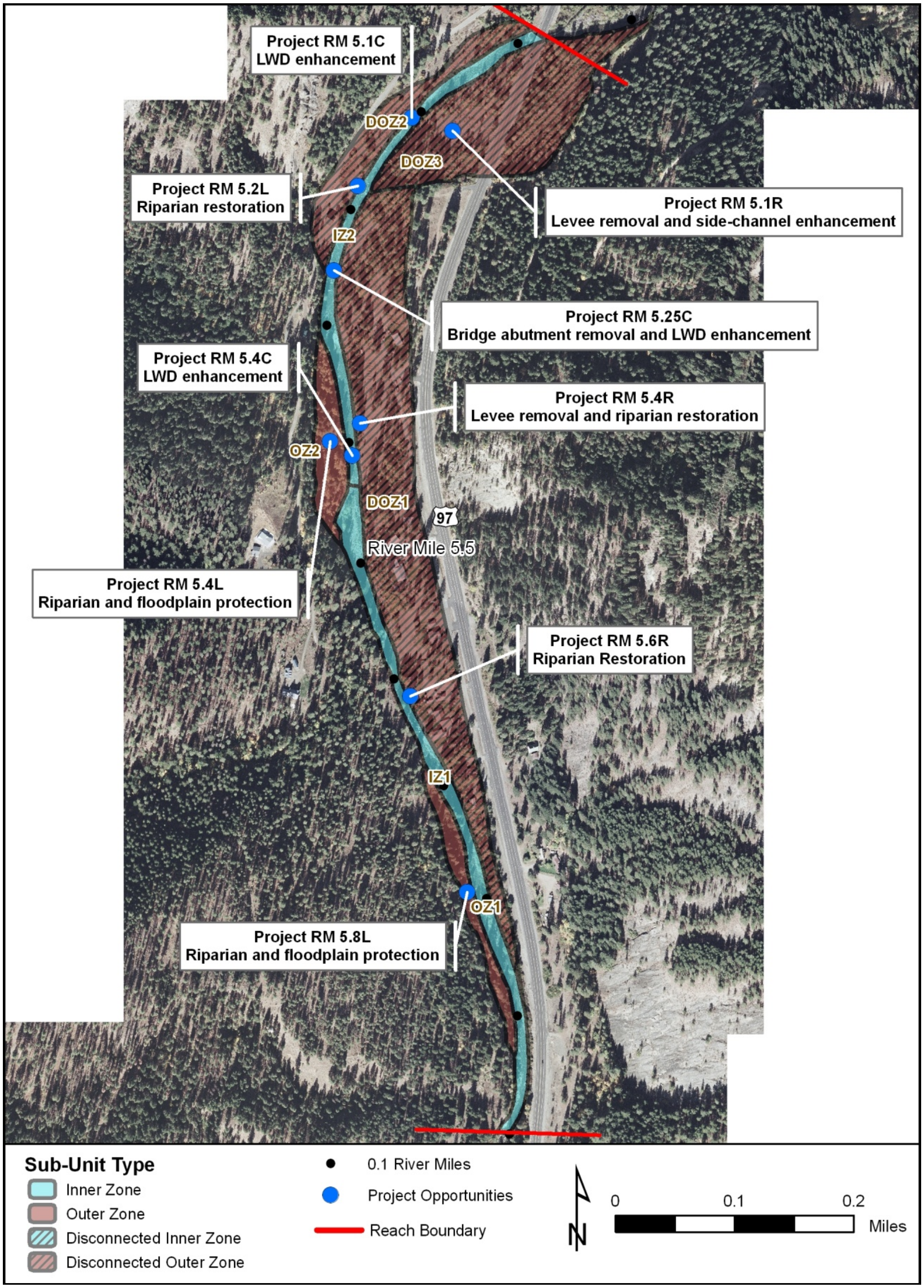

Figure 73. Sub-units and project opportunities in Reach 3. Flow is from south to north.

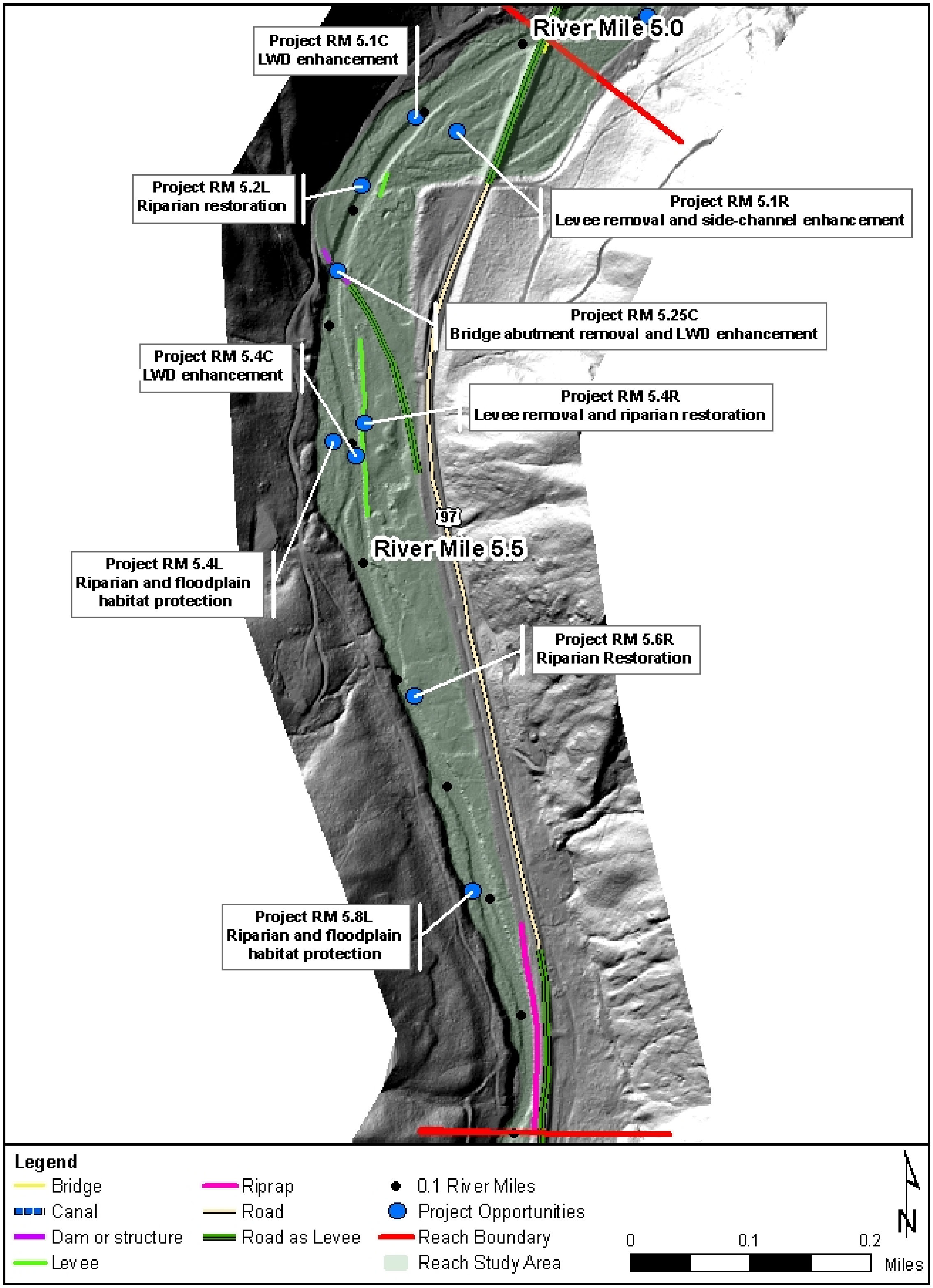

Figure 74. LiDAR hillshade of Reach 3 illustrating topography in relation to human features and project locations in the reach. Flow is from south to north.

Table 24. Summary of Sub-Unit Descriptions, Restoration Strategies, Projects and Constraints for Reach 3.

Sub-Unit	Description	Strategy *(Strategies are listed in priority order)*	Projects[1] *(specific identified projects are in* ***bold****)*	Potential Constraints
IZ-1	This sub-unit is a mostly straight, plane-bed segment broken by two bedrock controlled pools at the downstream end. The river-left bank directly abuts the hillslope, with little or no riparian buffer. Along the river-right bank, there is residential development within the floodplain and portions of the riparian area. Channel complexity is low. There is one split flow location at river mile 5.85 that extends about 210 feet.	Protect and Maintain		Highway 97 parallels the sub-unit for the upstream 0.2 miles Residential development along right side of the channel Power transmission line crosses river near RM 5.9
OZ-1	This left-bank sub-unit consists of a narrow floodplain terrace that is bounded by the hillslope to the west and the stream channel to the east. It consists of an intact riparian and floodplain forest. There is an old access road on the hillslope side of the sub-unit (status unknown).	Protect and Maintain	***Project RM 5.8L*** Riparian and floodplain habitat protection	The sub-unit is isolated and no constraints to protection have been identified
DOZ-1	This floodplain sub-unit covers 55% of the total outer zone area mapped in Reach 3. Large portions of the floodplain have been developed for rural residential and industrial uses. The remaining riparian habitat is fragmented and degraded. Highway 97 runs parallel to DOZ-1 along the toe of the hillslope.	Protect and Maintain Reconnect Floodplain Processes Riparian Restoration	***Project RM 5.4R*** Levee removal/set-back and riparian restoration ***Project RM 5.6R*** Riparian restoration	Rural residential and industrial development throughout Private landowners and landscaping/lawn maintenance Highway 97 parallels the sub-unit but is located against the hillslope toe.
OZ-2	This floodplain sub-unit is similar to OZ-1. It is a small, undeveloped terrace at the toe of a bedrock hillslope. There is an access road that traverses the hillslope to the west. The access onto this surface is unknown.	Protect and Maintain	***Project RM 5.4L*** Riparian and floodplain habitat protection	The sub-unit is relatively isolated and no constraints have been identified

Table 24. Summary of Sub-Unit Descriptions, Restoration Strategies, Projects and Constraints for Reach 3.

Sub-Unit	Description	Strategy *(Strategies are listed in priority order)*	Projects[1] *(specific identified projects are in **bold**)*	Potential Constraints
IZ-2	This sub-unit is located between river mile 5.0 and 5.45. The channel is dominated by plane-bed riffles. Adjacent floodplains are somewhat wider on both sides of this sub-unit relative to the active channel upstream. Floodplain development decreases adjacent to this sub-unit; however, the Highway 97 Bridge creates a constraint on channel and floodplain processes at the downstream end. Habitat complexity and channel morphology in this sub-unit are similar to IZ-1.	Protect and Maintain Reconnect Stream Channel Processes Instream Habitat Enhancement	***Project RM 5.25C*** Bridge abutment removal and LWD enhancement ***Project RM 5.4C*** LWD enhancement ***Project RM 5.1C*** LWD enhancement.	Residential development along right side Highway 97 Bridge crossing at river mile 5.0 Powerline crossings (RM 5.2)
DOZ-2	This sub-unit comprises a floodplain terrace on the west side (river-left) of the stream channel. There is a roadway that forms the western boundary of the sub-unit and impinges on the floodplain in some areas. There is some development in this floodplain and much of it has been cleared. The LiDAR data suggests that this floodplain area may have been subjected to filling and grading in the past.	Protect and Maintain Reconnect Floodplain Processes Riparian Restoration	***Project RM 5.2L*** Riparian restoration *Work to address impacts of floodplain disconnection (floodplain restoration, road relocation)*	A roadway forms the western boundary of the sub-unit Minor residential development

Table 24. Summary of Sub-Unit Descriptions, Restoration Strategies, Projects and Constraints for Reach 3.

Sub-Unit	**Description**	**Strategy** *(Strategies are listed in priority order)*	**Projects**[1] *(specific identified projects are in **bold**)*	**Potential Constraints**
DOZ-3	This floodplain sub-unit is on the inside of a large meander arc created by the northeast curvature of IZ2. This area is hydrologically and geomorphically disconnected from the channel by a levee at river mile 5.19, and by the Highway 97 corridor which bisects the sub-unit. On the streamside of the road the surface, the floodplain is still accessible to overbank flooding and other physical processes. However, the levee severs a floodplain channel connection that would provide valuable ecological function in PC3.	Protect and Maintain Reconnect Floodplain processes	***Project RM 5.1R*** Levee removal and side-channel enhancement.	Highway 97 bisects the floodplain surface Bridge crossing at river mile 5.0

[1]*For additional information on specific identified project opportunities, see Peshastin Project Opportunities list in Appendix B.*

REACH 4 – REACH ASSESSMENT

3.6 Reach 4 Reach Assessment

3.6.1 Reach Overview

Reach 4 lies within a moderately confined valley with valley wall constrictions at the upstream and downstream ends. The reach is bounded by the Camas Creek confluence at the downstream end and the Allen Creek confluence at the upstream end. Highway 97 parallels the reach and lies adjacent to the channel in 2 locations. There is a private bridge crossing near river mile 6.5. There are residences along this reach although much of the reach is undeveloped.

Habitat Conditions and Fish Use

Salmonid use of Reach 4 includes spring Chinook, steelhead, coho, bull trout, westslope cutthroat trout, and non-native brook trout. Spring Chinook and steelhead use lower Peshastin Creek primarily as a migration corridor to access upstream spawning areas, although limited spawning and rearing use does occur in the reach. Bull trout are believed to use lower Peshastin Creek primarily for migration and possibly limited rearing. The Yakama Nation coordinates a coho re-introduction program in the Wenatchee Basin. Coho are not typically released in Peshastin Creek but coho spawning and rearing in lower Peshastin Creek has been documented during surveys. See Section 2.6 for additional information on fish use in lower Peshastin Creek.

Much of this reach is too coarse for high quality spawning habitat. Many of the riffles consist of long, coarse-bedded, plane-bed sections that lack good spawning substrate. There are, however, several pools with long tail-outs with suitable spawning material made up of gravels and small cobbles. The coarse bed and high frequency of boulders provides areas of localized velocity refuge that may be utilized for rearing by juvenile steelhead and resident trout. There are also several deep pools that offer good juvenile rearing and adult holding habitat, although LWD cover is lacking. See the Habitat Assessment (Section 2.7) for additional information on stream habitat conditions. A summary of the Reach-Based Ecosystem Indicators (REI) is included in Table 25.

Table 25. Reach-Based Ecosystem Indicators (REI) ratings for Reach 4. See Section 2.9 for the complete REI analysis.

General Characteristics	General Indicators	Specific Indicators	Reach 4 Condition
Habitat Access	Physical Barriers	Main Channel Barriers	*Adequate*
Habitat Quality	Substrate	Dominant Substrate/Fine Sediment	*At Risk*
	LWD	Pieces per Mile at Bankfull	*At Risk*
	Pools	Pool Frequency and Quality	*At Risk*
	Off-Channel Habitat	Connectivity with Main Channel	*Adequate*
Channel	Dynamics	Floodplain Connectivity	*Unacceptable*
		Bank Stability/Channel Migration	*Adequate*

General Characteristics	General Indicators	Specific Indicators	Reach 4 Condition
		Vertical Channel Stability	*At Risk*
Riparian Vegetation	Condition	Structure	*At Risk*
		Disturbance (Human)	*Adequate*
		Canopy Cover	*At Risk*

Hydrology

Reach 4 has a relatively unaltered hydrologic regime. There are no significant flow withdrawals within or upstream of the reach. Peak flows occur in the spring as a result of snowmelt, with occasional fall and winter peaks associated with rain or rain-on-snow events. Flows decrease in June and early July, and low flows occur August through September. Historical logging, mining, and grazing practices throughout the contributing watershed have the potential to alter hydrologic response to storm events. Estimates of flood flow magnitudes are presented in Table 26.

Table 26. Flood magnitudes for recurrence intervals from 2 to 100 years for the downstream end of Reach 4 (USBR 2008).

Location	River Mile	Flood Recurrence Interval (ft^3/sec)					
		Q2	Q5	Q10	Q25	Q50	Q100
Peshastin above Camas Creek	6.1	895	1,371	1,750	2,306	2,781	3,312

Geomorphology

This reach is relatively sinuous (1.15) and steep (0.020), and has the narrowest valley width in the study area (260 ft). The upstream end of the reach is defined by a narrow bedrock channel. Glacial till deposits fill the widening valley downstream. The channel has incised through these deposits, but has not adjusted laterally to create a significant floodplain due to immobile boulder lag deposits. About midway through the reach, near river mile 6.7, a wider floodplain develops and continues to the downstream end of the reach at river mile 6.0. Bedrock and glacial deposits constrain channel location and valley width throughout the reach. A large landslide deposit generated from hillslopes to the northwest forms a valley constriction at the downstream end of the reach.

Mapping of historical channels shows very little change in channel pattern between 1962 and 1998. Older channels appear to have been slightly wider, especially at meander apexes. In the upstream portion of the reach between river mile 7.4 and 6.6, the bed is mainly boulder step-pool (Figure 75), with some long plane-bed riffles. In the lower portion of the reach, between river miles 6.6 and 6.0, plane-bed morphology dominates, but it is interrupted by a few long bedrock controlled pools (Figure 76) and short segments of step-pool sequences.

Figure 75. View looking toward the northeast in the downstream direction near river mile 7.0. The photo shows typical bed morphology of the reach. Photo taken in August 2009.

Figure 76. Bedrock pool near river mile 6.2. Photo taken in August 2009.

Human Alterations

There is scattered residential development primarily along the river-right bank throughout the reach (Figure 77). However, relative to downstream reaches, there is a low degree of human alteration in Reach 4 with about 26% floodplain disconnection. A bridge crossing at river mile 6.45 limits local channel dynamics (Figure 78). Highway 97 cuts off an old glacial channel (possibly an historical, post-glacial mainstem channel location) between river miles 6.5 and 7.3;

this channel is considered to be outside of the contemporary floodplain for this analysis. The highway is located outside of the active floodplain and riparian zone except for at the downstream end of the reach where the highway abuts the main channel. Figure 79 shows all human features in Reach 4.

Figure 77. View looking toward the southwest in the upstream direction near river mile 6.25. Residential development along the right side of the valley has impacted the riparian area. Photo taken in August 2009.

Figure 78. View looking toward the southwest in the upstream direction near river mile 6.45. This narrow private bridge creates hydraulic and geomorphic constraints on the channel and floodplain. Photo taken in August 2009.

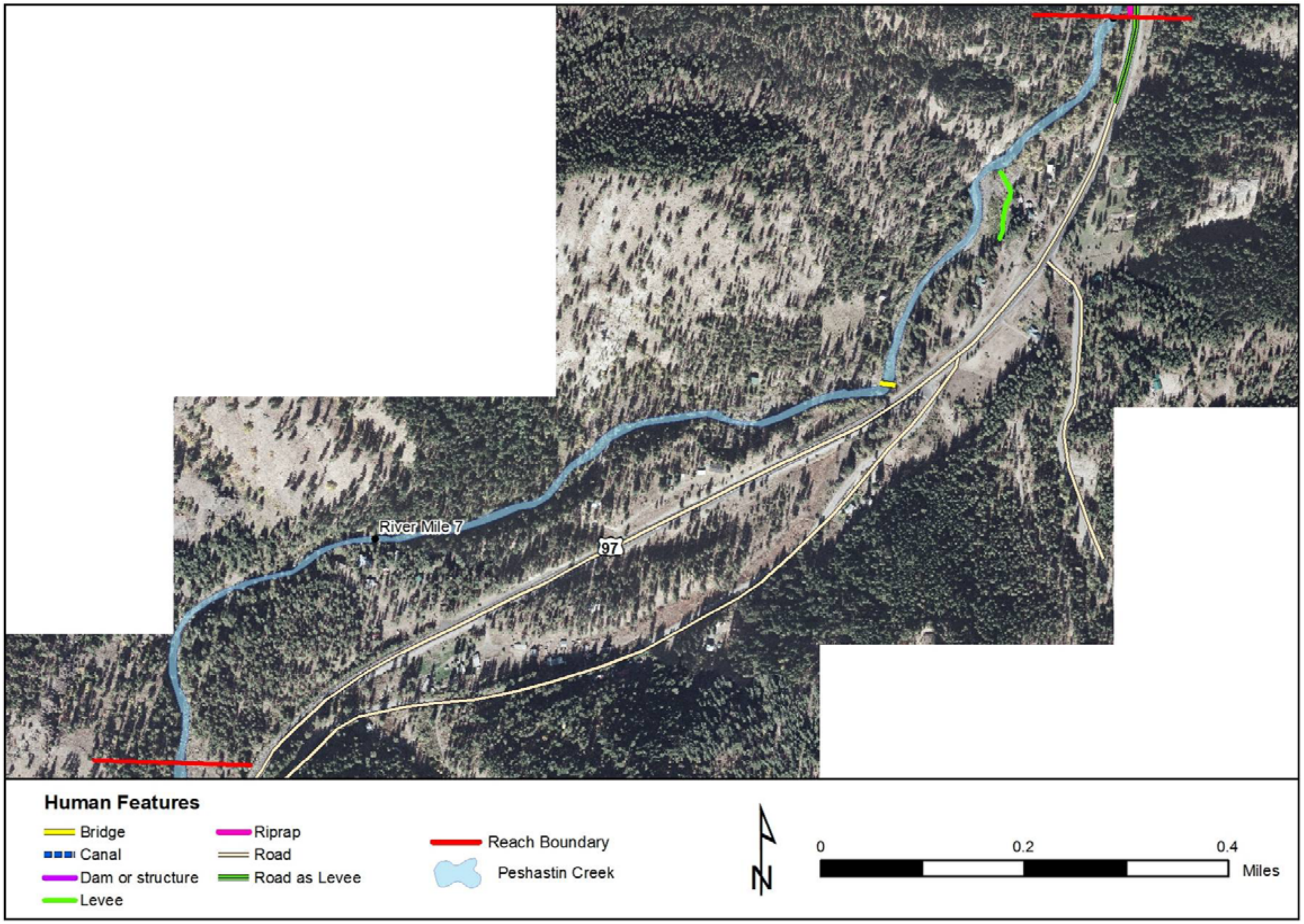

Figure 79. Human features in Reach 4. Flow is from west to east.

3.6.2 Reach-Scale Restoration Strategy

The prioritized reach-scale restoration and preservation strategy for Reach 4 is included below. The strategy focuses first on protecting existing conditions from further impairment. This objective is followed by reconnecting the fundamental bio-physical processes that will create and maintain habitat conditions over the long-term. Instream and off-channel habitat enhancement (rehabilitation) is also included; these projects occur in conjunction with long-term process reconnection and are also applied in cases where long-term process reconnection is constrained by existing human uses.

The naturally confined nature of this reach has precluded substantial development, making preservation and maintenance the most effective tool. Active restoration opportunities include potential LWD placements that will provide critical instream habitat components that are lacking throughout the system. Addressing upstream impacts throughout the watershed should be an ongoing effort to ensure the successful rehabilitation of reaches in the study area.

1. ***Protect and Maintain***
   - **Prevent Further Degradation**- Opportunities to prevent further degradation should be pursued including purchasing land in the river corridor and/or obtaining conservation easements.
   - **Legal Protection**- Existing enforced legal protection is considered an intrinsic component of all potential projects.

2. ***Reconnect Stream Channel Processes***
   - **Bridge Crossing and Levee**– There is a bridge crossing near RM 6.45 that likely affects lateral channel dynamics and creates a hydraulic constriction. However, the river has been stable at this location since the 1930s based on the aerial photo record. Assess specific impacts of the crossing and if warranted, look for opportunities to remove the bridge or create a longer span to address these issues. The levee at RM 6.2 likely limits the potential for development of multi-thread channels in this area. Work to find solutions to remove or modify this feature to improve stream channel processes.

3. ***Reconnect Floodplain Processes***
   - **Levee** – The levee near RM 6.2 affects floodplain connectivity. Work to find solutions to remove or modify this feature to improve floodplain processes.

4. ***Riparian Restoration***
   - **Restore Riparian Areas**- The strategy for riparian restoration in this reach includes expanding the riparian corridor wherever possible and revegetating cleared areas.

5. ***In-Stream Habitat Enhancement***
   - **Enhance Habitat Complexity**- Instream large wood is a natural component of this system that has been severely reduced by past land-use practices. Wood

creates pool scour, cover, and channel complexity. Place wood in configurations and locations that mimic natural wood deposition processes. These projects are not replacements for process restoration, but are meant to provide intermediate habitat enhancement while process restoration matures.

3.6.3 Sub-Unit and Project Opportunity Summary

Nine sub-units were identified in Reach 4 including two inner zone sub-units, one disconnected inner zone sub-unit, five outer zone sub-units, and one disconnected outer zone sub-unit (Table 27, Figure 80, Figure 81). Development in Reach 4 is less than in other reaches but in some areas has resulted in impaired riparian and floodplain function, particularly in the downstream portion of the reach on the river-right side. In general, channel habitat complexity and quality is low. A total of 4 specific projects have been identified in this reach (Table 28).

Table 27. Summary of sub-units and project opportunities in Reach 4.

Sub-Unit	River Mile	Acreage
IZ-1	6.75 – 7.36	N/A
OZ-1	7.04 – 7.28	3
IZ-2	6.0 – 6.75	N/A
OZ-2	6.25 – 6.75	6
OZ-3	6.6 – 6.71	1
OZ-4	6.46 – 6.53	0.5
OZ-5	6.25 – 6.45	2
DOZ-1	5.97 – 6.25	4
DIZ-1	6.15 – 6.24	N/A

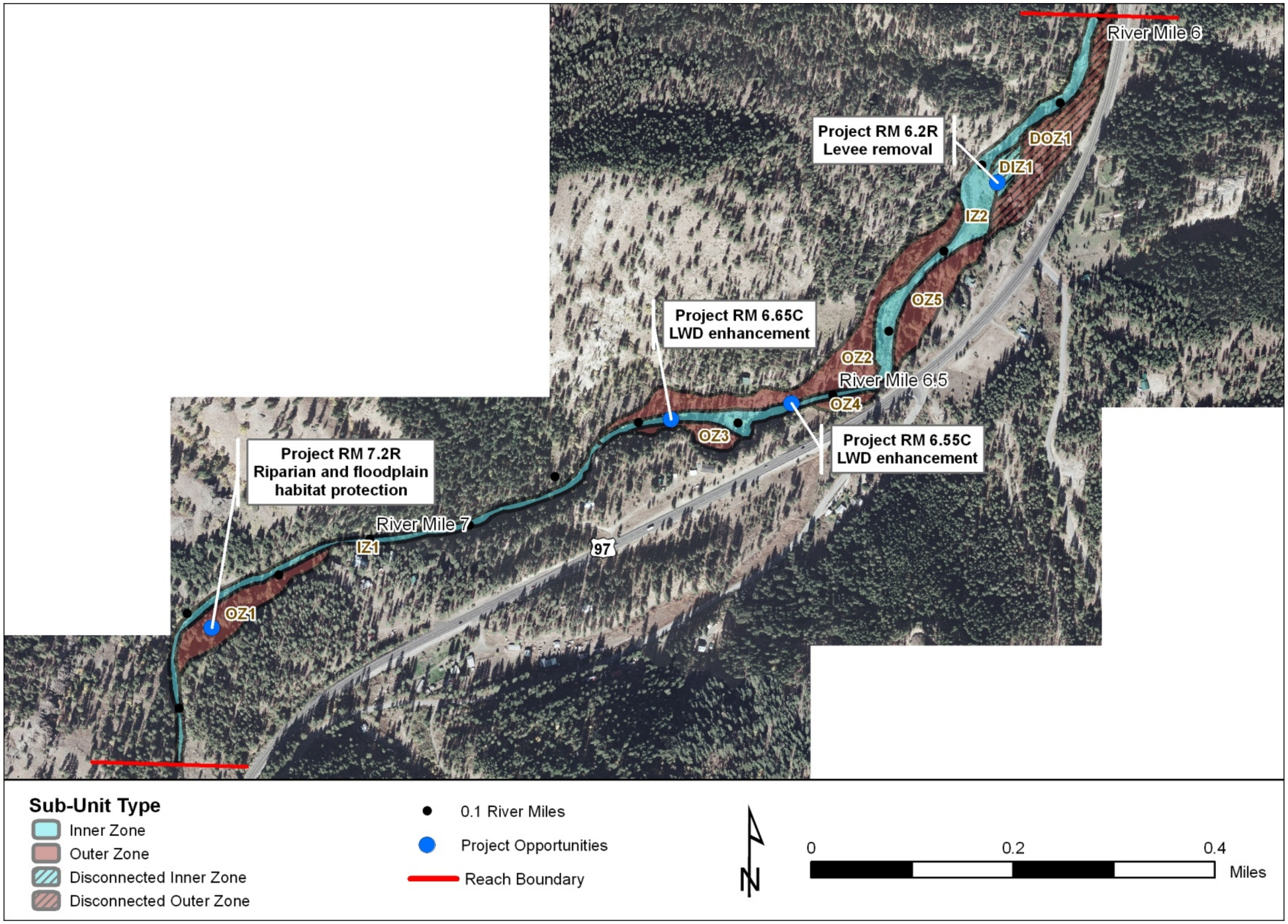

Figure 80. Sub-units and project opportunities in Reach 4. Flow is from west to east..

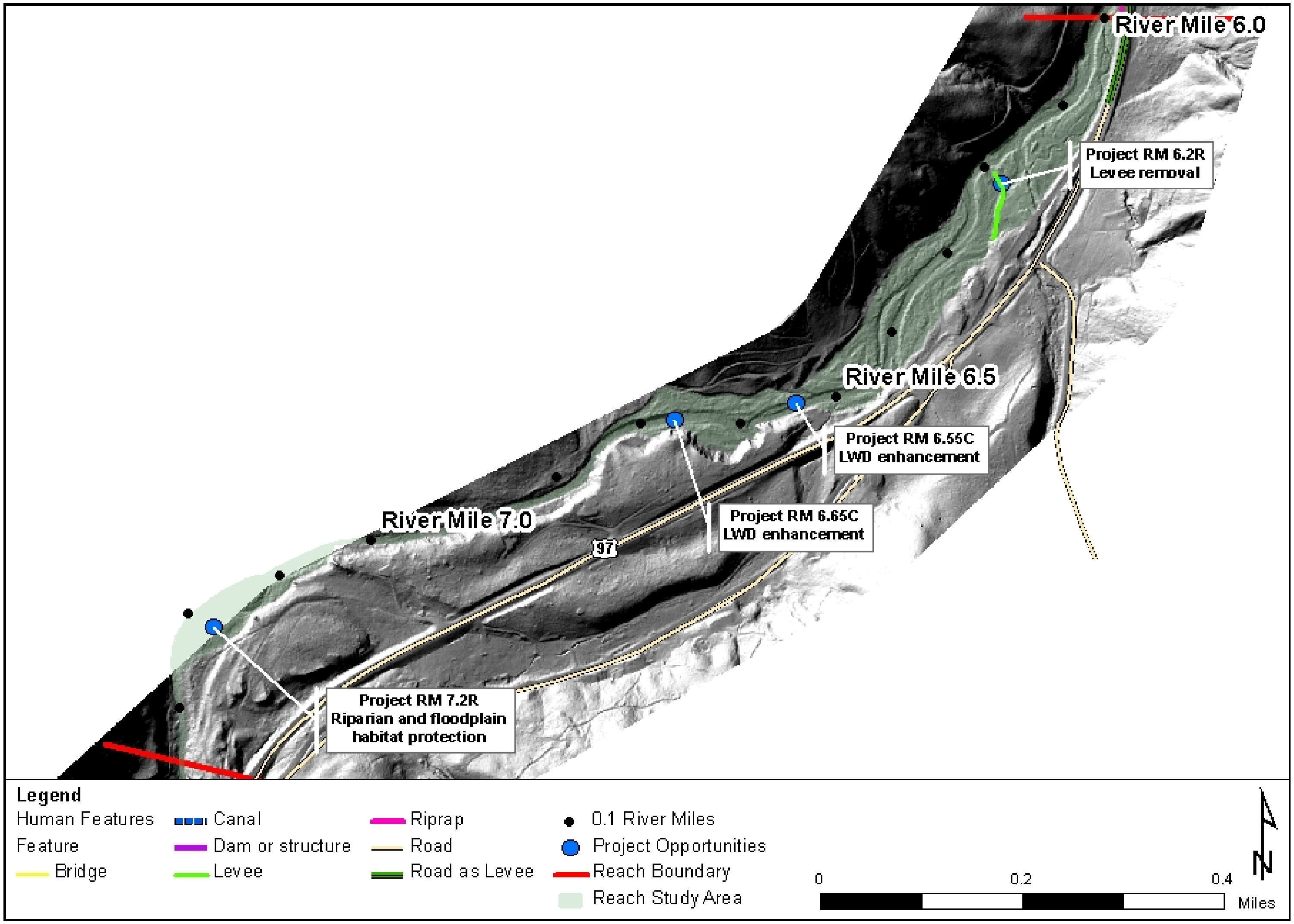

Figure 81. LiDAR hillshade of Reach 4 illustrating topography in relation to human features and project locations in the reach. Flow is from west to east.

Table 28. Summary of Sub-Unit Descriptions, Restoration Strategies, Projects and Constraints for Reach 4.

Sub-Unit	Description	Strategy *(Strategies are listed in priority order)*	Projects[1] *(specific identified projects are in **bold**)*	Potential Constraints
IZ-1	This inner zone sub-unit is naturally confined with limited floodplain formation or opportunity for lateral adjustment. Bedrock and glacial till compose the banks on both sides of the channel. The bed alternates between step-pool and plane-bed channel type. The step-pool morphology provides more frequent pools than downstream in IZ-2); however, pools are generally poorly developed, with shallow residual depths and a lack of cover habitat except for large boulders. There is some residential development on the river-right hillslope, but this does not present a direct constraint to channel or floodplain processes.	Protect and Maintain		There are few anthropogenic constraints on protection or restoration in this sub-unit
OZ-1	This is a small sub-unit that comprises the only floodplain available adjacent to IZ-1. The surface is inaccessible, and undeveloped. Riparian vegetation appears to be intact. Continuity with upland habitats is compromised due to houses and roads that fragment the upland landscape to the southeast.	Protect and Maintain	***Project RM 7.2R*** – Riparian and floodplain habitat protection	The sub-unit is isolated and no constraints to protection have been identified.
IZ-2	Channel and valley complexity increases in this sub-unit relative to IZ-1. The channel has access to a wider floodplain and is slightly more sinuous. Pool frequency diminishes in this sub-unit relative to IZ-1. Bedrock outcrops pose lateral channel constraints. A bridge crossing at river mile 6.45 creates a constraint on hydraulic and geomorphic processes). There is residential development of adjacent floodplain surfaces, particularly along the right bank. Highway 97 begins to encroach on the channel near the downstream end of the sub-unit.	Protect and Maintain Instream Habitat Enhancement	***Project RM 6.65C*** – LWD habitat enhancement. ***Project RM 6.55C*** – LWD habitat enhancement	Residential development along river right Highway 97 parallels the sub-unit near the downstream 0.1 miles Private bridge crossing at river mile 6.45

Table 28. Summary of Sub-Unit Descriptions, Restoration Strategies, Projects and Constraints for Reach 4.

Sub-Unit	Description	Strategy *(Strategies are listed in priority order)*	Projects[1] *(specific identified projects are in **bold**)*	Potential Constraints
OZ-2	This sub-unit comprises the left-bank floodplain terrace between river mile 6.25 and 6.75. The surface is mainly undeveloped except for a private road that bisects the unit and provides access to a few residences located within and just outside the floodplain. Riparian forest vegetation is mostly intact, with occasional clearing related to roads and residences.	Protect and Maintain		Private road and residential development
OZ-3	This is a small area of undeveloped floodplain along river right at the base of a glacial terrace. Riparian vegetation is relatively undisturbed on this surface. This surface appears to be hydrologically connected to the channel.	Protect and Maintain		This sub-unit is relatively isolated and there are no significant constraints
OZ-4	This is a small area of undeveloped floodplain along river-right at river mile 6.5. Riparian forest vegetation is relatively undisturbed on this surface. This surface appears to be hydrologically connected to the channel.	Protect and Maintain		The highway embankment lies adjacent to this sub-unit to the southeast

Table 28. Summary of Sub-Unit Descriptions, Restoration Strategies, Projects and Constraints for Reach 4.

Sub-Unit	Description	Strategy *(Strategies are listed in priority order)*	Projects[1] *(specific identified projects are in **bold**)*	Potential Constraints
OZ-5	This sub-unit comprises the river-right floodplain terrace just downstream of the private bridge at river mile 6.45. There is no substantial development within the sub-unit; however, there is residential development that directly abuts this sub-unit to the southeast and there is evidence of vehicle access into the sub-unit. Minor filling and grading may have occurred in the past in the southeast portion of the sub-unit. This sub-unit was not given a disconnected designation because it appears to be hydrologically connected to the mainstem during flood events.	Protect and Maintain		Residential development adjacent to the sub-unit and vehicle access within the sub-unit
DOZ-1	This sub-unit consists of multiple residences and a network of unimproved roadways that fragment this terrace. Most of the development extends from river mile 6.1 to 6.25. There has been significant clearing of riparian and floodplain vegetation. There is a push-up levee (assumed to be made of only locally derived material) near river mile 6.2 that extends over 300 feet and affects the hydrologic connectivity of this terrace. The downstream portion of the sub-unit may have greater hydrologic and geomorphic connectivity than the upstream portion, except for at the very downstream extent where Highway 97 begins to constrain the channel.	Protect and Maintain Reconnect Floodplain Processes	See Project RM 6.2R in DIZ-1	Rural residential development between river miles 6.1-6.25 Highway 97 abuts the sub-unit along the downstream portion of the sub-unit

Table 28. Summary of Sub-Unit Descriptions, Restoration Strategies, Projects and Constraints for Reach 4.

Sub-Unit	Description	Strategy *(Strategies are listed in priority order)*	Projects[1] *(specific identified projects are in **bold**)*	Potential Constraints
DIZ-1	This small sub-unit is located on the river-right side near river mile 6.2. This area is considered disconnected due to a push-up levee (assumed to be made of only locally derived material) that extends over 300 feet and affects the hydrologic connectivity of this sub-unit.	Protect and Maintain Reconnect Stream Channel Processes	This small sub-unit is located on the river-right side near river mile 6.2. This area is considered disconnected due to a push-up levee (assumed to be made of only locally derived material) that extends over 300 feet and affects the hydrologic connectivity of this sub-unit.	Adjacent residential development and flooding concerns

[1]*For additional information on specific identified project opportunities, see Peshastin Project Opportunities list in Appendix B.*

REACH 5A – REACH ASSESSMENT

3.7 Reach 5a Reach Assessment

3.7.1 Reach Overview

Reach 5a extends from river mile 7.35 to approximately river mile 8.4. The Allen Creek confluence is at the downstream end of the reach. The reach extends 1.1 miles upstream to just upstream of the Ingalls Creek Road crossing. Residential development is extensive along the valley bottom throughout the reach, with many streamside homes. There is a campground and trailer park that lies adjacent to the stream along the river-right bank near river mile 8.0.

Habitat Conditions and Fish Use

Salmonid use of Reach 5a includes spring Chinook, steelhead, coho, bull trout, westslope cutthroat trout, and non-native brook trout. Spring Chinook and steelhead use lower Peshastin Creek primarily as a migration corridor to access upstream spawning areas, although limited spawning and rearing use does occur in the reach. Bull trout are believed to use lower Peshastin Creek primarily for migration and possibly limited rearing. The Yakama Nation coordinates a coho re-introduction program in the Wenatchee Basin. Coho are not typically released in Peshastin Creek but coho spawning and rearing in lower Peshastin Creek has been documented during surveys. See Section 2.6 for additional information on fish use in lower Peshastin Creek.

Much of this reach is too coarse for high quality spawning habitat. Many of the riffles consist of long, coarse-bedded, plane-bed sections that lack good spawning substrate. There are a few pools with suitable tail-outs for spawning, but even in these locations substrate may be too coarse for spawning. The coarse bed and high frequency of boulders provides areas of localized velocity refuge that may be utilized for rearing by juvenile steelhead and resident trout. There are also several deep pools that offer good juvenile rearing and adult holding habitat, although LWD cover is lacking. The bedrock controlled, narrow meandering section near RM 7.7 provides diverse pool-riffle and alcove habitat that likely supports juvenile rearing, adult holding, and spawning. See the Habitat Assessment (Section 2.7) for additional information on stream habitat conditions. A summary of the Reach-Based Ecosystem Indicators (REI) is included in Table 29.

Table 29. Reach-Based Ecosystem Indicators (REI) ratings for Reach 5a. See Section 2.9 for the complete REI analysis.

General Characteristics	General Indicators	Specific Indicators	Reach 5a Condition
Habitat Access	Physical Barriers	Main Channel Barriers	*Adequate*
Habitat Quality	Substrate	Dominant Substrate/Fine Sediment	*At Risk*
	LWD	Pieces per Mile at Bankfull	*Unacceptable*
	Pools	Pool Frequency and Quality	*At Risk*
	Off-Channel Habitat	Connectivity with Main Channel	*At Risk*
Channel	Dynamics	Floodplain Connectivity	*Unacceptable*

General Characteristics	General Indicators	Specific Indicators	Reach 5a Condition
		Bank Stability/Channel Migration	*Unacceptable*
		Vertical Channel Stability	*Unacceptable*
Riparian Vegetation	Condition	Structure	*Unacceptable*
		Disturbance (Human)	*Unacceptable*
		Canopy Cover	*Unacceptable*

Hydrology

Reach 5a has a relatively unaltered hydrologic regime. Peak flows occur in the spring as a result of snowmelt, with occasional fall and winter peaks associated with rain or rain-on-snow events. Flows decrease in June and early July, and low flows occur August through September. Historical logging, mining, and grazing practices have occurred in the contributing watershed and have the potential to alter hydrologic response to storm events. Ingalls Creek, however, which enters Peshastin Creek just upstream of the reach, is relatively unaltered by human intervention and retains a natural hydrologic regime. Ingalls Creek contributes 65% of the flow to Peshastin Creek and likely has a moderating effect on the altered hydrologic conditions in the mainstem basin. Estimates of flood flow magnitudes are presented inTable 30. Comparing flood flow estimates upstream and downstream of the reach indicates a flow contribution of nearly 500 cubic feet per second (cfs) at the 2-year flood event (Q2).

Table 30. Flood magnitudes for recurrence intervals from 2 to 100 years at river mile 6.1 (downstream of the reach) and river mile 9.2 (upstream of the reach) (USBR 2008).

Location	River Mile	Flood Recurrence Interval (ft^3/sec) Q2	Q5	Q10	Q25	Q50	Q100
Peshastin above Camas Creek	6.1	895	1,371	1,750	2,306	2,781	3,312
Peshastin above Ingalls Creek	9.2	412	631	806	1,062	1,280	1,525

Geomorphology

Repeated glaciations during the Pleistocene, with significant ice flow contribution from Ingalls Creek, eroded a wide valley with an average width of 722 feet (Figure 82). The average gradient through the reach is 0.021. The majority of the valley is filled with unconsolidated glacial deposits and more recent alluvial fan deposits and colluvium. The modern channel has incised through these materials and has laterally adjusted to form a floodplain with an average width of 253 feet. Channel pattern has been constant since at least 1962. Older aerial photography was not available this far up the drainage. The channel is the most sinuous in the study area with one long-amplitude meander bend at the upstream end, and a serious of more tortuous (bedrock) meanders near the downstream end that locally control upstream grade from river mile 7.7 upstream to river mile 8.0.

Ingalls Creek, the most significant tributary in the basin, flows into Peshastin Creek 0.8 miles upstream of the reach. From the Pleistocene to the present, geomorphic and hydrologic interactions between the mainstem of Peshastin Creek and Ingalls Creek are responsible for much of the channel and floodplain form in the reach. Ingalls Creek is a steep drainage from a high-altitude basin located in the Alpine Lake Wilderness. A high percentage of Peshastin Creek's annual snowmelt runoff comes from Ingalls Creek, providing the potential contribution of granitic sediment and large wood from the unlogged riparian forest of the Ingalls Creek drainage.

Figure 82. View looking downstream at Reach 5a. The channel of Peshastin Creek is highlighted in blue. Ingalls Creek enters just upstream of the bottom left corner of the photo. Photo taken in September 2009.

Human Alterations

Floodplain development has a significant impact on physical processes and habitat quality in Reach 5a, resulting in 100% disconnection of the historic floodplain in this reach. At the downstream end of the reach, the river has incised into conglomerate bedrock and adjacent development on the rim of the river canyon has little effect on geomorphic processes. At river mile 7.7, the valley widens and there is floodplain development on both sides of the river. A campground and RV park is located along the river-right bank with cleared areas for RV parking and stream access. There are permanent residences in the floodplain on the river-left bank, with intermittent clearing for views, stream access, and recreation. Riparian vegetation is mainly intact as a narrow strip, but significant clearing has occurred farther from the channel associated with roadways and recreational areas. There is a bridge (Ingalls Creek Road) at the upstream end of the reach. The channel is straight and uniform in this area. Upstream of the bridge the stream channel has been straightened alongside Highway 97. See Figure 83 for a map of human features.

Figure 83. Human features in Reach 5a. Flow is from south to north.

3.7.2 Reach-Scale Restoration Strategy

The prioritized reach-scale restoration and preservation strategy for Reach 5a is included below. The strategy focuses first on protecting existing conditions from further impairment. This objective is followed by reconnecting the fundamental bio-physical processes that will create and maintain habitat conditions over the long-term.

There are multiple factors contributing to compromised habitat and river process in this reach. Floodplain development, bridge crossings, and Highway 97 become factors as the valley widens. The restoration strategy is focused on recovering riparian vegetation wherever possible, and mitigating non-essential structures affecting hydraulics and channel processes. It is also necessary to address the impacts of floodplain development, the upstream impacts of Highway 97, and other watershed factors contributing to degraded river function.

1. ***Protect and Maintain***
   - **Prevent Further Degradation**- Opportunities to prevent further degradation should be pursued including purchasing land in the river corridor and/or obtaining conservation easements.
   - **Legal Protection**- Existing enforced legal protection is considered an intrinsic component of all potential projects.

2. ***Reconnect Stream Channel Processes***
   - **Riprap-** There is a grouted riprap bank near RM 8.15 that impacts stream channel processes and riparian function. Work to find solutions to remove or modify the bank to enhance channel process and habitat conditions.

3. ***Reconnect Floodplain Processes***
   - **Floodplain Development** - There is rural residential development of the floodplain on both sides of the channel throughout the reach. In addition, there is an RV park and camping area that extends along the east floodplain and covers approximately 1,000 feet of creek frontage. A sand and gravel maintenance yard is located just upstream of the RV camp. These developments include occasional clearing, fill, and roadways. Where feasible, work should focus on reconnecting these areas through reclamation of floodplain surfaces. In many cases, it will be necessary to work with appropriate stakeholders to develop long-term solutions to floodplain impacts.

4. ***Riparian Restoration***
   - **Restore Riparian Areas**- The strategy for riparian restoration in this reach includes expanding the riparian corridor wherever possible and revegetating cleared areas.

3.7.3 Sub-Unit and Project Opportunity Summary

Five sub-units were identified in this reach including two inner zone sub-units and three disconnected outer zone sub-units (Table 31, Figure 84, Figure 85).A total of 3 specific projects have been identified in this reach (Table 32). These projects follow components of the restoration strategy outlined in the previous section.

Table 31. Summary of sub-units and project opportunities in Reach 5a.

Sub-Unit	River Mile	Acreage
IZ-1	7.75-8.38	N/A
DOZ-1	8.15 – 8.38	7
DOZ-2	7.82 – 8.22	11
DOZ-3	7.71 – 8.01	9
IZ-2	7.35 – 7.75	N/A

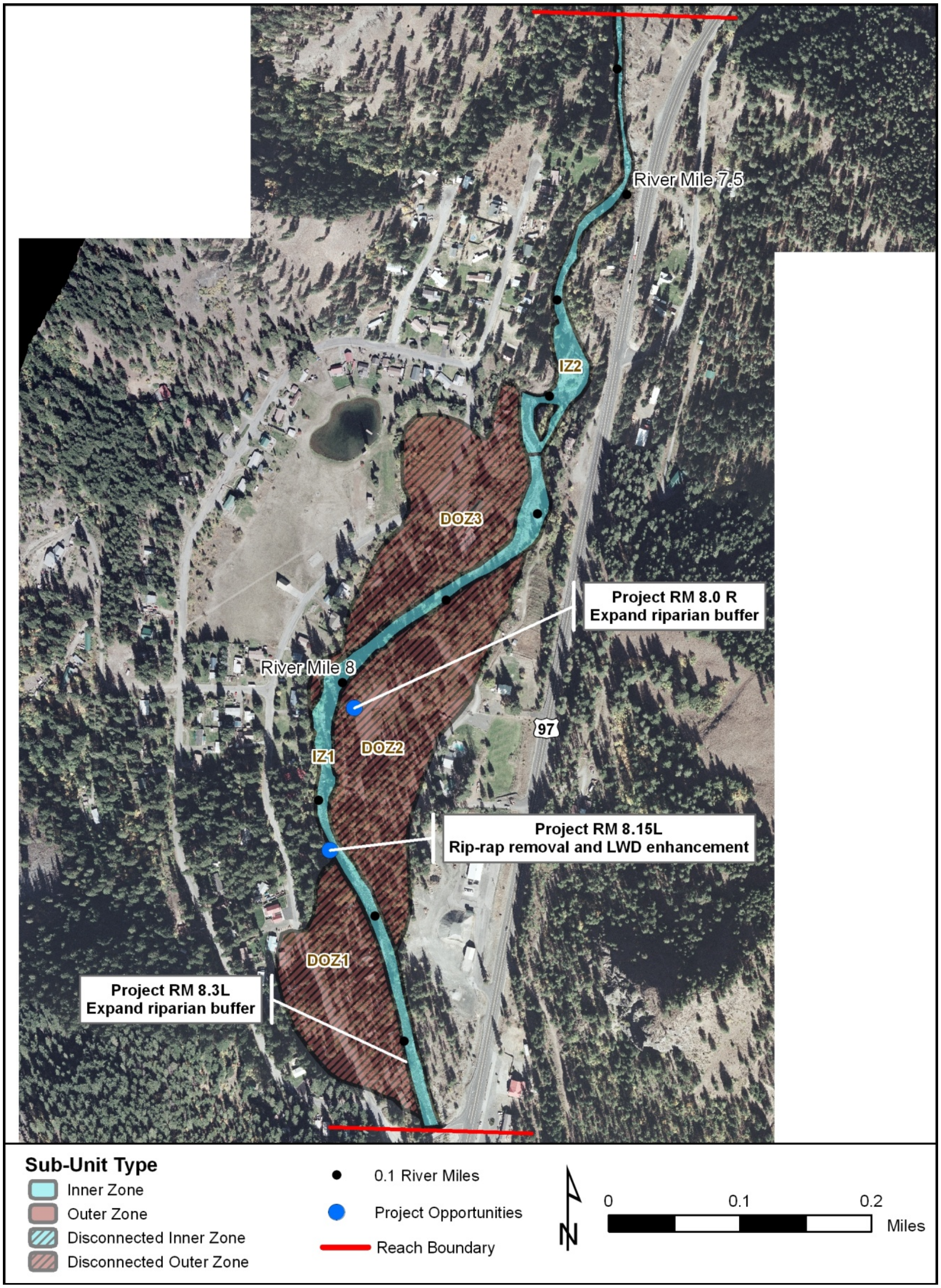

Figure 84. Sub-units and project opportunities in Reach 5a. Flow is from south to north.

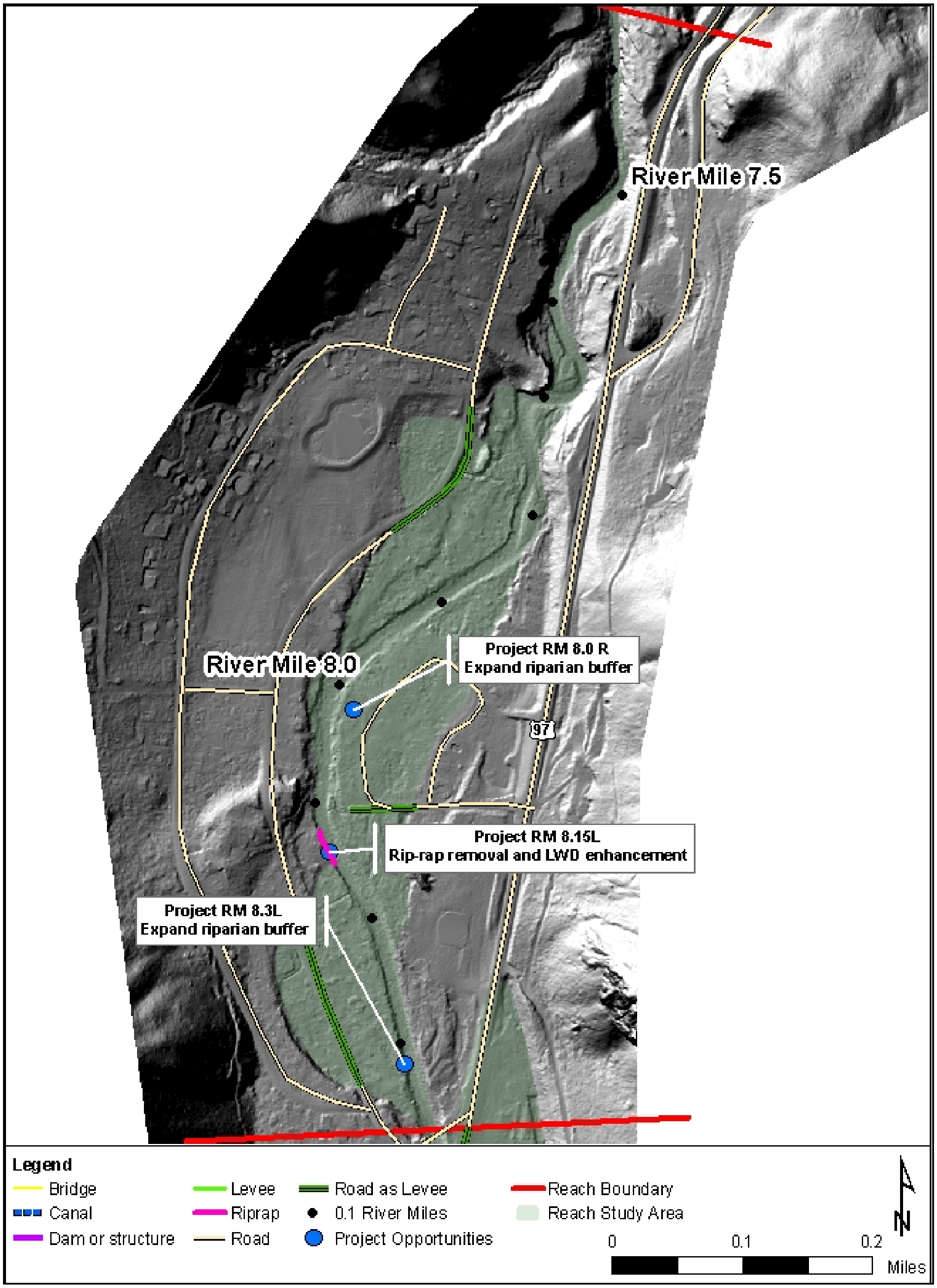

Figure 85. LiDAR hillshade of Reach 5a illustrating topography in relation to human features and project locations in the reach. Flow is from south to north.

Table 32. Summary of Sub-Unit Descriptions, Restoration Strategies, Projects and Constraints for Reach 5a.

Sub-Unit	Description	Strategy *(Strategies are listed in priority order)*	Projects[1] *(specific identified projects are in **bold**)*	Potential Constraints
IZ-1	This sub-unit extends from river mile 7.75 to 8.38. There is very little complexity in terms of channel pattern or bed morphology. Bed morphology is predominantly plane-bed with cobble/boulder substrate. There are two long plane-bed riffle units that make up nearly 70% of the channel length. The channel is constrained at the upstream end of the sub-unit by a bridge crossing at river mile 8.38. There is one location of grouted rip-rap that protects private property near river mile 8.15.	Protect and Maintain Riparian Restoration Reconnect Stream Channel Processes	***Project RM 8.3L –*** Expand riparian buffer ***Project RM 8.15R –*** Rip-rap removal and LWD habitat enhancement.	Bank armoring in places to protect private property from erosion Residential and recreational floodplain development on both sides of the river Private residential development. Riparian projects would require the cooperation of willing landowners. Bridge crossing at river mile 8.38
DOZ-1	This sub-unit is heavily disturbed by residential development. This former floodplain surface has been filled, graded, and developed. Riparian forest vegetation has been cleared around dwellings and near the stream for views, lawns, and stream access. A road bisects the sub-unit and parallels the river approximately 250 feet away from the channel.	Protect and Maintain		Private residential development. Riparian projects would require the cooperation of willing landowners Roadway that bisects the sub-unit longitudinally Significant fill and grading of the floodplain
DOZ-2	This sub-unit lies on the inside of a long meander bend. The surface has been almost entirely developed as a recreational location. There are RV parking locations, campsites, and fields cleared out of the riparian area, as well as unimproved access roads throughout. Significant fill and grading has occurred in this area and some of the roadways serve as levees. In many areas, there is only a narrow buffer of intact riparian forest.	Protect and Maintain Reconnect Floodplain Processes Riparian Restoration	***Project RM 8.0R –*** Expand riparian buffer *Work to address floodplain disconnection (eg. road relocation, floodplain habitat restoration)*	Recreational development of most of the sub-unit including open camping areas, RV camp spots, and open fields and lawns Roadways throughout the sub-unit Significant fill and grading of the floodplain

Table 32. Summary of Sub-Unit Descriptions, Restoration Strategies, Projects and Constraints for Reach 5a.

Sub-Unit	Description	Strategy *(Strategies are listed in priority order)*	Projects[1] *(specific identified projects are in* ***bold****)*	Potential Constraints
DOZ-3	This floodplain sub-unit has experienced a substantial amount of residential development. Significant fill and grading has occurred in this area and some of the roadways serve as levees. There is a roadway that bisects this sub-unit longitudinally. A large bedrock promontory forms the downstream limit of this sub-unit.	Protect and Maintain Reconnect Floodplain Processes	*Work to address floodplain disconnection (eg. road relocation, floodplain habitat restoration)*	Significant residential development of the entire surface Paved roadway that bisects the sub-unit longitudinally Significant fill and grading of the floodplain
IZ-2	The channel in this sub-unit is influenced by bedrock, with bedrock outcrops or large colluvium deposits constraining the channel in many locations. The channel pattern is more sinuous than upstream. Bedrock plays a role in increasing pool quality and frequency. Step-pool sequences are more common than in other reaches in the study area. With natural constraints on lateral channel dynamics, there is virtually no floodplain adjacent to the channel in this sub-unit.	Protect and Maintain		Residential development at the upstream end of the sub-unit There are no significant anthropogenic constraints. Access may be difficult due to the natural topography

[1]*For additional information on specific identified project opportunities, see Peshastin Project Opportunities list in Appendix B.*

REACH 5B/6 – REACH ASSESSMENT

3.8 Reach 5b/6 Reach Assessment

3.8.1 Reach Overview

Reach 5b/6 flows through a moderately confined valley that extends from river mile 8.4 to approximately river mile 9.3. Two tributaries join the channel in the reach: Ingalls Creek at RM 9.2 (boundary between Reach 5b and 6) and Hansel Creek midway through Reach 5b. The alignment of Highway 97 has resulted in straightening of the channel through this reach and disconnection of processes and habitat throughout.

Habitat Conditions and Fish Use

Salmonid use of Reach 5b and 6 includes spring Chinook, steelhead, coho, bull trout, westslope cutthroat trout, and non-native brook trout. Spring Chinook and steelhead use lower Peshastin Creek primarily as a migration corridor to access upstream spawning areas, although limited spawning and rearing use does occur in the reach. Bull trout are believed to use lower Peshastin Creek primarily for migration and possibly limited rearing. The Yakama Nation coordinates a coho re-introduction program in the Wenatchee Basin. Coho are not typically released in Peshastin Creek but coho spawning and rearing in lower Peshastin Creek has been documented during surveys. See Section 2.6 for additional information on fish use in lower Peshastin Creek.

Reaches 5b and 6 were not included in the 2009 habitat survey. Based on field observations, conditions in these reaches are very similar to the upstream portion of Reach 5a just downstream. The channel is steep and made up of coarse material with very little suitable spawning habitat. Pools make up only a small portion of the available habitat and LWD is nearly absent. A summary of the Reach-Based Ecosystem Indicators (REI) is included in Table 33.

Table 33. Reach-Based Ecosystem Indicators (REI) ratings for Reach 5b/6. See Section 2.9 for the complete REI analysis.

General Characteristics	General Indicators	Specific Indicators	Reach 5b/6 Condition
Habitat Access	Physical Barriers	Main Channel Barriers	*Adequate*
Habitat Quality	Substrate	Dominant Substrate/Fine Sediment	*Unknown*
	LWD	Pieces per Mile at Bankfull	*Unacceptable*
	Pools	Pool Frequency and Quality	*Unacceptable*
	Off-Channel Habitat	Connectivity with Main Channel	*Unacceptable*
Channel	Dynamics	Floodplain Connectivity	*Unacceptable*
		Bank Stability/Channel Migration	*Unacceptable*
		Vertical Channel Stability	*Unacceptable*
Riparian Vegetation	Condition	Structure	*Unacceptable*
		Disturbance (Human)	*Unacceptable*

General Characteristics	General Indicators	Specific Indicators	Reach 5b/6 Condition
		Canopy Cover	*Unacceptable*

Hydrology

Reach 5b/6 is above all major diversions in the basin. Ingalls Creek enters at the upstream end of Reach 5b and contributes about 65% of the annual flow of Peshastin Creek. Hansel Creek enters at RM 8.65 and contributes a much smaller percentage of flow. The Ingalls Creek Basin is largely unaltered as much of the basin lies within the Alpine Lakes Wilderness area. The reach is dominated by snowmelt hydrology, particularly the portion downstream of the Ingalls Creek confluence (Reach 5b). There have been significant modifications to upstream mainstem tributaries that could alter their respective hydrologic regimes. These alterations include logging, mining, and the construction of Highway 97.

Estimates of peak flow magnitudes for recurrence intervals ranging from 2 years to 100 years are presented inTable 34. Comparing flood flow estimates upstream and downstream of the reach indicates a flow contribution of nearly 500 cubic feet per second (cfs) at the 2-year flood event from Ingalls Creek (Q2).

Table 34. Flood magnitudes for recurrence intervals from 2 to 100 years at river mile 6.1 (downstream of the reach) and river mile 9.2 (upstream boundary of the reach) (USBR 2008).

		Flood Recurrence Interval (ft^3/sec)					
Location	**River Mile**	**Q2**	**Q5**	**Q10**	**Q25**	**Q50**	**Q100**
Peshastin above Camas Creek	6.1	895	1,371	1,750	2,306	2,781	3,312
Peshastin above Ingalls Creek	9.2	412	631	806	1,062	1,280	1,525

Geomorphology

The upstream end of the reach is at the point where a bedrock canyon opens up just above the confluence of Ingalls Creek. Upstream of that point, bedrock on both sides of the valley limits floodplain width to less than 200 ft through a steep canyon. Erosion by Pleistocene alpine glaciers from the Ingalls Creek drainage expands valley width downstream of the confluence. The majority of the valley is filled with unconsolidated glacial deposits and more recent alluvial fan deposits and colluvium.

The historical channel pattern was moderately sinuous with long wavelength, low amplitude meanders whose lateral migration was limited by the alluvial fan of Ingalls creek to the west and a glacial terrace to the east. There is topographic evidence of high flow channel networks in the adjacent floodplain. The construction of Highway 97 re-aligned the channel into a straight path with little or no connection to the floodplain. The modern channel is steep and narrow, with step-pool and plane-bed morphology. Pool features are short in these sequences. Bed material is cobble and boulder. The highway embankment forces the creek against the toe of a high glacial terrace on river-left at several locations in the reach, which is causing severe erosion of this feature. Tributary interactions at Hansel Creek are also affected by Highway 97. Spoils piles create a barrier for several hundred feet, turning Hansel Creek north and moving the point of confluence downstream.

Human Alterations

The re-alignment of Highway 97 in the late 1950's resulted in a straight channel and disconnection of nearly all the historical floodplain areas in this reach. The channel is confined by Highway 97 on river-right for its entire length. On the river-left side, levees and spoils piles create barriers to channel/floodplain connection for the majority of the reach. By straightening the reach, its length was reduced and its gradient was increased. A steeper gradient increases sediment transport capacity for a given flow and sediment size, which has likely lead to channel incision and further reduction of channel/floodplain connection. The highway also exacerbates erosion of the glacial terrace at several locations on river-left in the reach (Figure 86). There is a sand and gravel facility in the historical floodplain on the east side of the valley, which consists of roads, extensive re-grading, and vegetation clearing. The floodplain on the west side of the channel has also been developed, though not as intensively. The surface is cleared and there are log stockpiles and several abandoned car bodies. See Figure 87 for a map of human features.

Figure 86. View downstream just downstream of the Ingalls Cr confluence. Hwy 97 directly abuts the channel and contributes to erosion of the high glacial terrace on the opposite bank (May 2010 Photo).

Figure 87. Human features in Reach 5b/6. Flow is from south to north.

3.8.2 Reach-Scale Restoration Strategy

The prioritized reach-scale restoration and preservation strategy for Reach 5b/6 is included below. The strategy focuses first on protecting existing conditions from further impairment. This objective is followed by reconnecting the fundamental bio-physical processes that will create and maintain habitat conditions over the long-term.

The success of process restoration and habitat reconnection in this reach is hampered by the presence of Highway 97 as a continuous lateral barrier along river-right. There are also levees and spoils piles on river-left that further affect geomorphic processes and aquatic habitat conditions. These are chronic issues requiring significant study and planning to determine feasible restoration options.

1. ***Protect and Maintain***
   - **Prevent Further Degradation**- Opportunities to prevent further degradation should be pursued including purchasing land in the river corridor and/or obtaining conservation easements.
   - **Legal Protection**- Existing enforced legal protection is considered an intrinsic component of all potential projects.

2. ***Reconnect Stream Channel Processes***
   - **Highway 97**- Highway 97 abuts the reach for its entire length and is a large-scale, persistent barrier to channel and floodplain processes. In addition, the severe bank erosion along river-left will be difficult to address without addressing the presence of the highway. Consideration should be given to developing multiple options for alleviating the detrimental effects of the roadway. Alternatives might include culverts or bridges under the road to provide hydrologic connection or full highway re-alignment. It will be necessary to work with appropriate stakeholders to develop long-term solutions to highway impacts.
   - **Levees/Spoils Piles**- In addition to Hwy 97, two levees/spoils piles (on the west bank) affect stream channel and floodplain processes in this reach. These levees restrict channel migration, floodplain inundation, and affect the establishment of a functioning riparian zone. Work to remove or modify (e.g. set back) levees to recover stream channel processes.

3. ***Reconnect Floodplain Processes***
   - **Highway 97 and Levees**- See discussions above with respect to Highway 97 and the west-bank levees.

4. ***Riparian Restoration***
   - **Restore Riparian Areas**- The strategy for riparian restoration in this reach includes expanding the riparian corridor wherever possible and revegetating cleared areas.

3.8.3 Sub-Unit and Project Opportunity Summary

Seven sub-units were identified in this reach including one inner zone sub-unit, two disconnected inner zone sub-units, and three disconnected outer zone sub-units (Table 35, Figure 88, Figure 89). A total of 6 specific projects have been identified in this reach (Table 36).

Table 35. Summary of sub-units and project opportunities in Reach 5b/6.

Sub-Unit	River Mile	Acreage
IZ-1	8.38-9.3	N/A
DIZ-1	8.4 – 9.25	N/A
DOZ-1	8.7 – 9.11	19
DIZ-2	8.9 – 8.99	N/A
DOZ-2	8.8 – 8.95	7
DOZ-3	8.25 – 8.81	20
DOZ-4	8.6 – 8.8	2

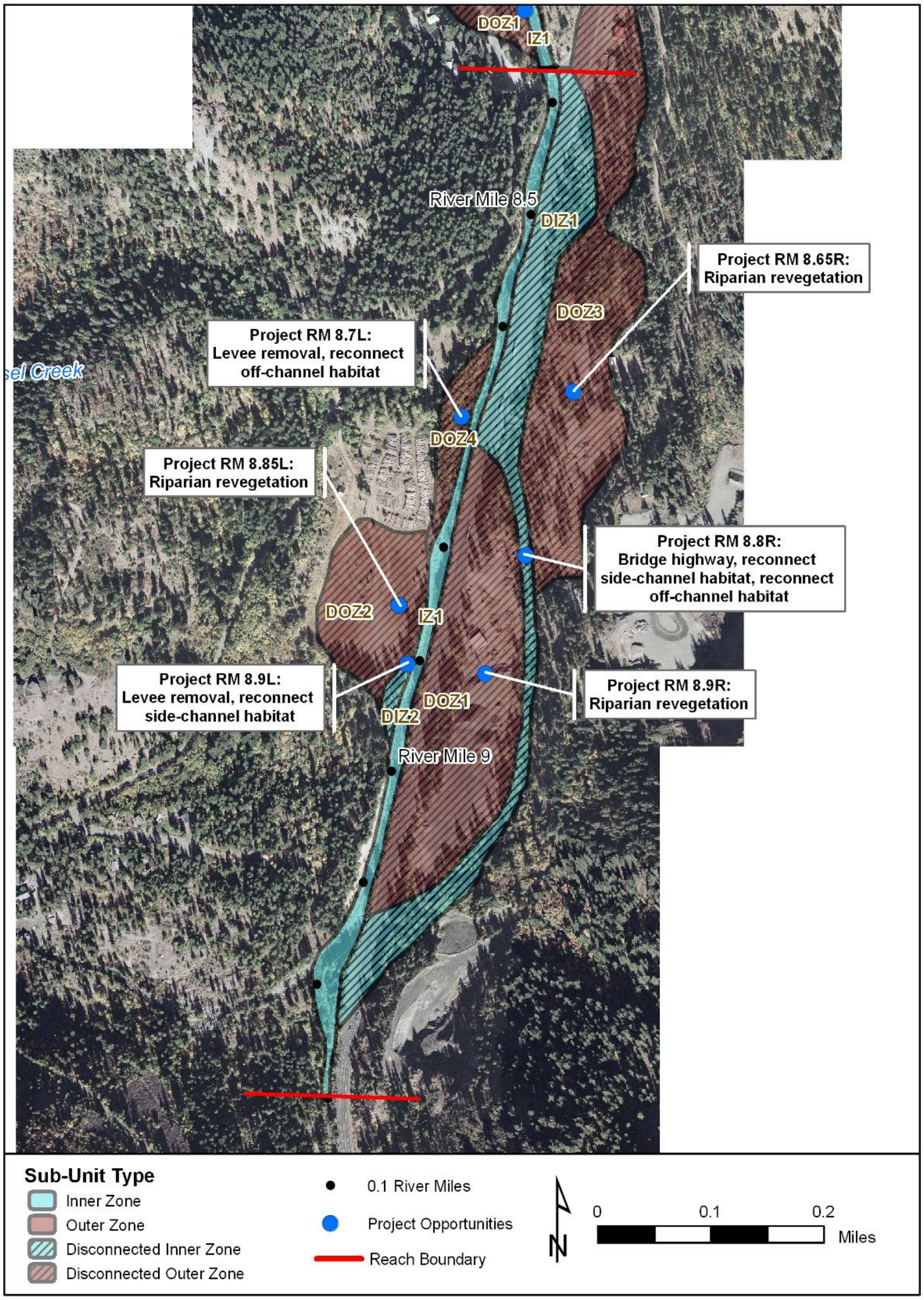

Figure 88. Sub-units and project opportunities in Reach 5b/6. Flow is from south to north.

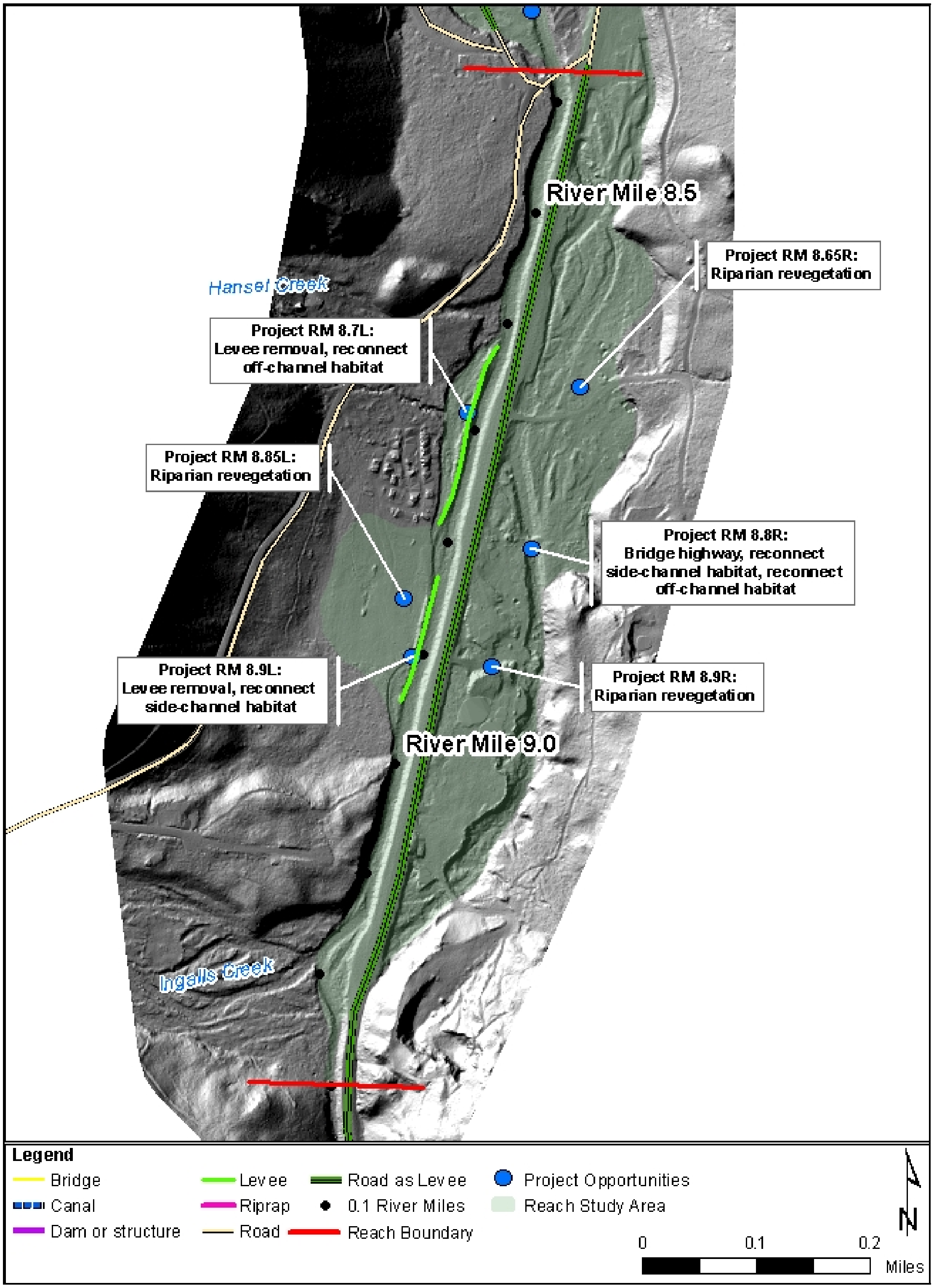

Figure 89. LiDAR hillshade of Reach 5b/6 illustrating topography in relation to human features and project locations in the reach. Flow is from south to north.

Table 36. Summary of Sub-Unit Descriptions, Restoration Strategies, Projects and Constraints for Reach 5a.

Sub-Unit	Description	Strategy *(Strategies are listed in priority order)*	Projects[1] *(specific identified projects are in **bold**)*	Potential Constraints
IZ-1	This sub-unit extends from river mile 8.38 to 9.3. Highway 97 forms the river-right bank for the entire length of the sub-unit. Sinuosity is low, and lateral migration is limited by Highway 97 and two sections of levee along river-left with a total length of 1,350 ft. Bed morphology is predominantly plane-bed with cobble/boulder substrate. The channel is constrained at the downstream end of the sub-unit by a bridge crossing at river mile 8.38.	Protect and Maintain		Highway 97 forms the channel margin for the entire distance of the sub-unit. Levees along river-left formed by riprap and excavation spoils.
DIZ-1	This sub-unit is the historical main channel prior to the realignment of Highway 97. The former channel of Peshastin Creek forms a large half-meander that extends from RM 8.4 to 9.25, as opposed to the straight modern channel. The highway disconnects all flow, habitat, and channel processes in this sub-unit. There is industrial development of the former floodplain that has resulted in fill of the channel as well. There are disconnected wetlands now occupying the downstream end of the sub-unit.	Protect and Maintain Reconnect Stream Channel Processes	***Project RM 8.8R –*** Bridge highway, reconnect main channel, reconnect side-channel habitat, reconnect off-channel habitat.	Highway 97 disconnects the sub-unit at the up and downstream ends. Industrial development with significant fill and grading of the adjacent floodplain and side-channels.

Table 36. Summary of Sub-Unit Descriptions, Restoration Strategies, Projects and Constraints for Reach 5a.

Sub-Unit	**Description**	**Strategy** *(Strategies are listed in priority order)*	**Projects**[1] *(specific identified projects are in **bold**)*	**Potential Constraints**
DOZ-1	This sub-unit occupies 19 acres on the inside of a long meander bend of the historical channel of Peshastin Creek. Re-alignment of Highway 97 disconnected this floodplain from channel processes and habitat. The surface has been almost entirely developed as an industrial location. The development includes extensive re-grading, clearing of vegetation, structures, and large stockpiles of rock. Project RM 8.8R in DIZ-1 would enhance connection of habitat and process in this sub-unit. Revegetation of the surface could be carried out independently of a stream channel reconnection project.	Protect and Maintain Reconnect Floodplain Processes Riparian Restoration	***Project RM 8.9R –*** Riparian restoration *Work to address floodplain disconnection (eg. road relocation, floodplain habitat restoration)*	Structures and roadways throughout the sub-unit Significant fill and grading of the floodplain
DIZ-2	This inner zone sub-unit is a small side-channel that extends along river-left from RM 8.9 to 8.99. A levee extends along the channel margin for the entire length of the sub-unit with short breaches at the up and downstream ends allowing some hydrologic connection at high flow. There is evidence of fairly recent sand deposition on this surface, but well-established trees suggest infrequent ground disturbing flows. The levee creates a barrier to channel processes such as lateral migration as well as to fish access at all but high flows	Protect and Maintain Reconnect Stream Channel Processes	***Project RM 8.9L*** – Levee removal, reconnect side-channel habitat.	• Highway 97 forms the opposite river bank • A levee creates a barrier along the channel margin for the entire length of the sub-unit

Table 36. Summary of Sub-Unit Descriptions, Restoration Strategies, Projects and Constraints for Reach 5a.

Sub-Unit	Description	Strategy *(Strategies are listed in priority order)*	Projects[1] *(specific identified projects are in **bold**)*	Potential Constraints
DOZ-2	DOZ-2 is a 7 acre floodplain sub-unit that lies to the west of the channel between RM 8.8 and 8.95. The levee discussed in the summary of Project RM 8.9L also forms a barrier to channel/floodplain connection in this sub-unit as well. The removal of the levee would serve to re-connect the main channel and DOZ-2. Additional impacts to habitat include riparian clearing except for a narrow strip along the channel margin, and excavation near the center of the sub-unit.	Protect and Maintain Reconnect Floodplain Processes Riparian Restoration	***Project RM 8.85L*** – Riparian revegetation ***See Project 8.9L*** *Work to address floodplain disconnection (eg. road relocation, levee removal, floodplain habitat restoration)*	Highway 97 parallels the sub-unit on the opposite side of the active channel. There is some residential development, abandoned car bodies, and log stockpiling on the alluvial fun just uphill of the sub-unit.
DOZ-3	This is a historical floodplain area where habitat and process have been disconnected by the re-alignment of Highway 97. The sub-unit is 20 acres in area and extends along the east side of the valley between RM 8.25 an 8.81. In addition to the impact of Highway 97, this sub-unit has been developed for industrial and commercial uses. Associated with this development are substantial clearing, road building, re-grading, and several structures. LiDAR data shows side-channels and multiple high-flow channels that suggest this surface was once well connected to channel processes and habitat. The channel reconnection project summarized as Project RM 8.8R would help reconnect this surface as well.	Protect and Maintain Reconnect Floodplain Processes Riparian Restoration	***Project RM 8.65R*** – Riparian revegetation. ***See Project RM 8.8R*** *Work to address floodplain disconnection (eg. road relocation,culvert installation, floodplain habitat restoration)*	Highway 97 parallels the sub-unit for its entire length. Substantial development and associated re-grading, fill, and clearing.

Table 36. Summary of Sub-Unit Descriptions, Restoration Strategies, Projects and Constraints for Reach 5a.

Sub-Unit	Description	Strategy *(Strategies are listed in priority order)*	Projects[1] *(specific identified projects are in **bold**)*	Potential Constraints
DOZ-4	This is a small (2 acre) floodplain area on the west side of the channel between RM 8.6 and 8.8 that is disconnected from the inner zone by spoils piles. These spoils appear to be material dredged from the current channel when Highway 97 was re-aligned. The piles have been placed near the confluence of Hansel Creek and Peshastin Creek, turning Hansel Creek north for several hundred feet before it drains into Peshastin Creek. Because of the connection to Hansel Creek, the floodplain area in this sub-unit appears to provide good riparian habitat. However, connections to channel processes in Peshastin Creek are compromised. There is a small area where high water from Peshastin Creek can flow into the floodplain near RM 8.79, but the area is otherwise blocked by the spoils piles, which serve as levees. The outflow of Hansel Creek is located at RM 8.6. The outflow provides habitat connection at moderate to high flows.	Protect and Maintain Reconnect Floodplain Processes	***Project RM 8.7L*** – Levee removal, reconnect off-channel habitat	Highway 97 runs parallel to the sub-unit on the opposite side of the main channel. Spoils form a continuous barrier along the channel margin of the entire sub-unit.

[1] *For additional information on specific identified project opportunities, see Peshastin Project Opportunities list in Appendix B.*

3.9 Summary of Project Opportunities

The spatial distribution and types of projects in the study area are dependent on the condition of biophysical processes, the level of human disturbance, and specific opportunities that are available for restoration (Figure 90, Table 37). Instream habitat enhancement is the majority opportunity type in the study area, comprising 28% of the project opportunities. Reconnecting stream channel processes is the second most frequent project type, comprising 24% of the projects. Riparian restoration projects make up 19% of the projects. Although "protect and maintain" is a broad objective for the entire study area, specific protection projects at discrete locations comprise 13% of the project opportunities. Off-channel projects and floodplain reconnection projects make up the remainder with 9% and 7% of the total projects respectively. It should be recognized that a majority of the "reconnect stream channel processes" projects also serve to reconnect floodplain processes.

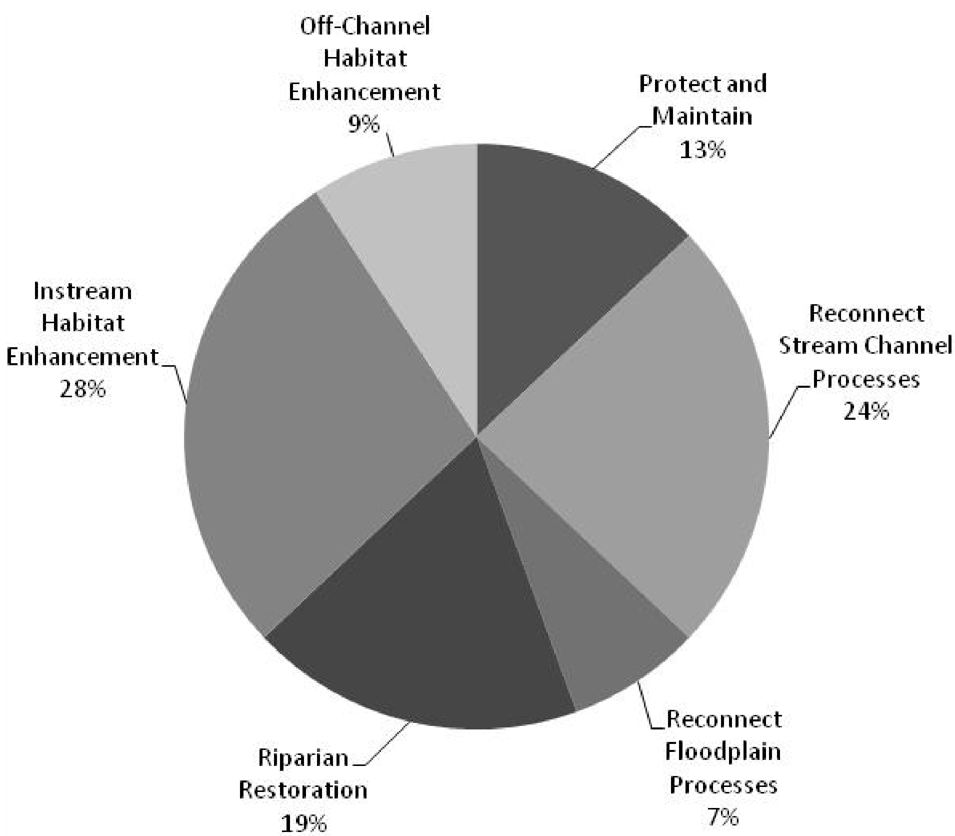

Figure 90. Comparison of the distribution of project types in the study area.

Table 37. Summary of projects identified for each reach in the study area.

Reach	Protect and Maintain	Reconnect Stream Channel Processes	Reconnect Floodplain Processes	Riparian Restoration	Instream Habitat Enhancement	Off-Channel Habitat Enhancement	Totals
1		6		3	1		10
2	4	3		1	9	5	22
3	2	1	3	1	2		9
4	1	1			2		4
5a				2	1		3
5b/6		2	1	3			6
Totals	**7**	**13**	**4**	**10**	**15**	**5**	**54**
%	**13%**	**24%**	**7%**	**19%**	**28%**	**9%**	

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