Wild Salmon Policy - Strategy 2: Fish Habitat Status Report for the Leiner River Watershed

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LIST OF ACRONYMS / ABBREVIATIONS USED

AUC	**Area Under the Curve**
CU	**Conservation Unit**
DFO	**Fisheries and Oceans Canada**
DO	**Dissolved Oxygen**
EMNG	**Ministry of Energy, Mines, and Natural Gas**
FISS	**Fisheries Information Summary System**
FPC	**Forest Practices Code**
GIS	**Geographic Information Systems**
IT	**Impairment Temperature**
LRDW	**Land and Resources Data Warehouse**
LWD	**Large Woody Debris**
MAD	**Mean Annual Discharge**
MFLNRO	**Ministry of Forests, Lands, and Natural Resources Operations**
MOE	**Ministry of Environment**
NSWS	**Nootka Sound Watershed Society**
ppt	**Parts per Thousand**
PSCIS	**Provincial Stream Crossing Inventory System (PSCIS)**
PSF	**Pacific Salmon Foundation**
SIL	**Stream Inspection Log**
TFL	**Tree Farm Licence**
UOTR	**Upper Optimum Temperature Range**
WCA	**West Coast Aquatics**
WCVI	**West Coast Vancouver Island**
WFP	**Western Forest Products**
WSC	**Water Survey of Canada**
WSP	**Wild Salmon Policy**

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1.0 INTRODUCTION

Canada's Wild Salmon Policy (WSP) sets out a series of strategies which will serve to incorporate habitat and ecosystem considerations into salmon management, and to establish local processes for collaborative planning throughout British Columbia (Fisheries and Oceans Canada, 2005). Strategy 1 of the WSP involves the identification of salmon Conservation Units (CUs), which are defined in the WSP as "a group of wild salmon sufficiently isolated from other groups that, if extirpated, is very unlikely to recolonize naturally within an acceptable timeframe" (Holtby and Ciruna, 2007). Strategy 2 of the WSP involves the assessment of habitat status, firstly in a synoptic habitat pressure analysis to inform landscape scale pressure indicators such as total land cover alteration, road density, riparian disturbance, etc., and secondly in an analyses of species and life cycle dependent habitats in the watershed. This strategy outlines a process for the identification of factors that are limiting production, high value habitats that require protection, and data gaps that require further monitoring. The assessment of habitat status will continue with the application of a monitoring framework using a selection of indicators and benchmarks, to identify changes in habitat condition over time (Stalberg et al, 2009).

Implementation of the WSP has been initiated throughout several regions along the west coast of Vancouver Island. The selection of high priority watersheds (Tahsis River, Leiner and Perry Rivers, Sucwoa River, Canton Creek, Tsowwin River, and the Conuma River) requiring habitat status assessments by the Nootka Sound Watershed Society (NSWS) represents the initiation of Strategy 2 of the WSP within Nootka Sound. The outcomes of these assessments is intended to facilitate the planning and prioritization of prescriptive measures to improve salmon habitats and populations, as well as identify data gaps and subsequent monitoring priorities on a watershed by watershed basis.

The following report presents a Strategy 2 habitat status assessment for the Leiner River watershed.

1.1 Objectives

This report is intended to identify the state and quantity of habitat factors that are potentially limiting fish production in the Leiner River, as well as known habitats (by life history stage) that require protection. Specific objectives of this report include:

- The documentation of existing habitat characteristics;
- A comparison to historical habitat characteristics, where information exists;
- Selection of habitat indicators and a comparison of assessed values to known risk benchmarks;
- Identification of data gaps requiring further monitoring; and
- Recommended enhancement activities within the study watersheds which would have both a direct and indirect effect on salmon species within the Leiner River watershed.

In addition to the abovementioned objectives, this work is also intended to feed into a future WSP expert-based risk assessment workshop whereby identified limiting factors will be ranked in order of spatial and temporal risk to fish and fish habitat on a watershed by watershed basis. It should be noted that the assessment of additional high priority watersheds (i.e. Tahsis River, Sucwoa River, Canton Creek, Tsowwin River, and the Conuma River) has been completed using the same framework.

1.2 Leiner River Watershed

The Leiner River watershed is located approximately 100km west of Campbell River, B.C., and 1.5km to the east of the Village of Tahsis on the west coast of Vancouver Island. The watershed is comprised of the Leiner River and Perry River drainages, which converge roughly 2km upstream of tidal water (Figure 1). For simplicity, these two rivers are considered as one watershed; however, they represent two distinct drainages, and are often referred to independently throughout this section. Both rivers drain from the Tlupana Range of Vancouver Island. The Leiner River flows southwesterly and the Perry River flows northwesterly. The rivers converge and flow westerly as the Leiner River into the east side of the Tahsis Inlet. The Leiner River watershed encompasses a drainage area of approximately $78km^2$ (each of the Leiner and Perry drainages each encompass an area of roughly $39km^2$).

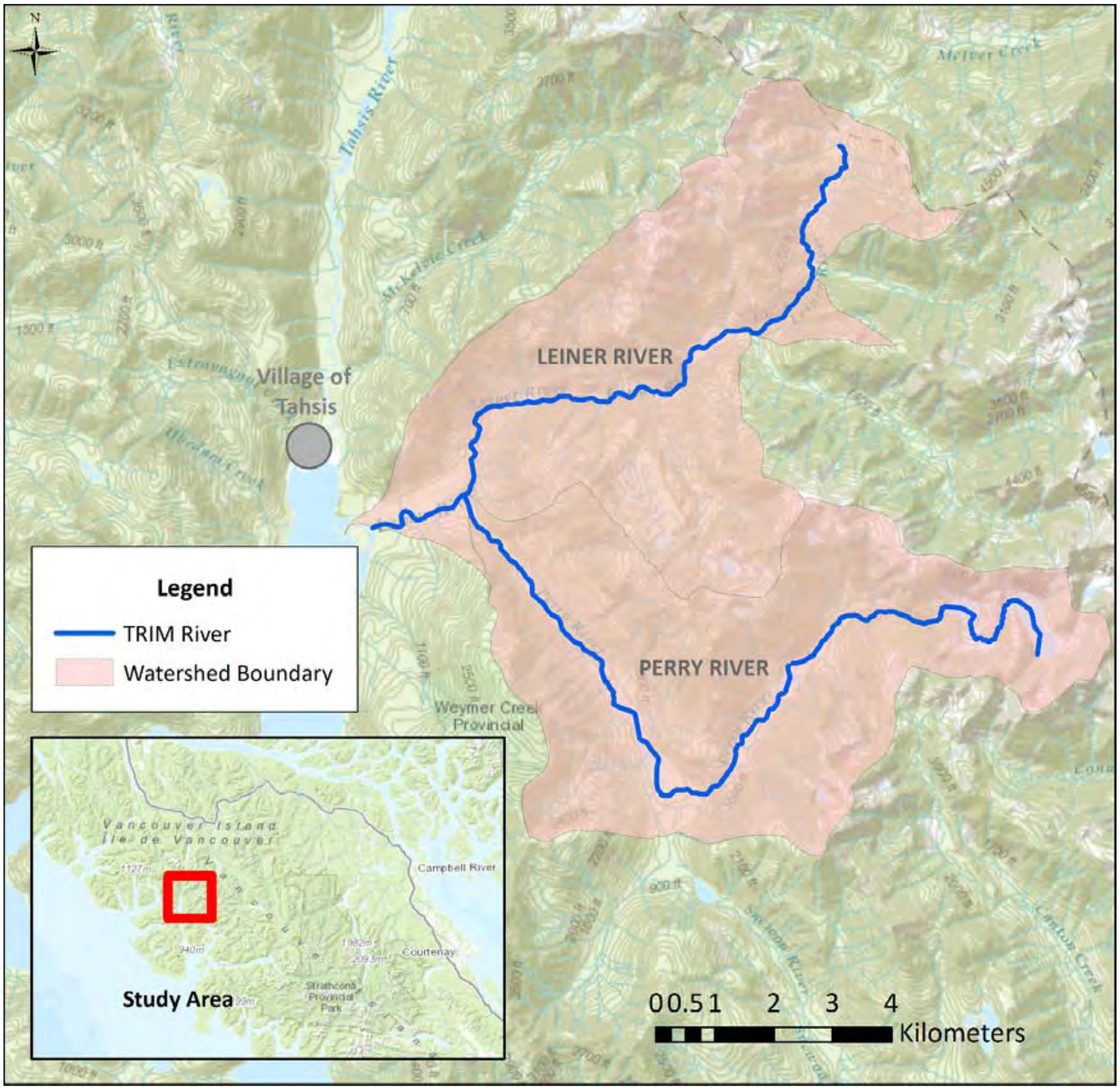

Figure 1. General location of the Leiner River watershed.

1.2.1 Climate, Topography, and Hydrology

The Leiner and Perry Rivers watershed is situated primarily within the coastal western hemlock submontane (very wet maritime) biogeoclimatic zone, with small components situated in the mountain hemlock (moist maritime) and coastal mountain-heather alpine zones. This area has a mild oceanic climate with high humidity. The majority of annual precipitation is received as rain in the lower elevations and as snow in the higher elevations. Mean annual rainfall for the Leiner watershed is 3,252mm (Fisheries and Oceans Canada, 2012). Between the months of October and April, high water events are observed frequently and Head Bay Road, which connects Tahsis to neighbouring Gold River, floods frequently where it parallels the Leiner River (Fisheries and Oceans Canada, 2012).

The Leiner River has a dendritic drainage pattern, with extensive steep slopes rising to narrow rounded ridgetops. Above the floodplain, the valley is typically V-shaped to narrow U-shaped, and the mainstem is a confined to entrenched semi-alluvial channel with a few alluvial and non-alluvial reaches. Steep non-alluvial tributary creeks are characteristic of the upper watershed, with numerous small upland lakes and ponds present. The headwaters of the Leiner River consist of two headwater basins, both of which extend into high elevation alpine zones. Numerous natural avalanche and rockslide tracks are present in both of these basins (Horel, 2008).

The main valley of the Perry River trends northwest to southeast, and branches into two headwater sub-basins at the south end. The lower 1.6km of the valley has steep-sided V-shaped valley walls with an entrenched semi-alluvial and non-alluvial mainstem. Above 1.6km the valley broadens with an irregular valley floor and a confined semi-alluvial mainstem. The upper valley includes a narrow shallow lake (Perry Lake), and is characterized by an alluvial mainstem with a broad floodplain (Horel, 2008).

1.2.2 Watershed Description

Assessments made of the Leiner River have indicated that it is stable and consistent with natural processes, with a broad floodplain and an unconfined alluvial mainstem that is subject to some natural channel migration in its lower reaches. Previous assessments conducted by Horel in 2008 described this watershed as moderately sensitive and least disturbed, with an important resident fishery or moderate anadromous capacity (Horel, 2008).

The Perry River is considered to be improving its stability; however, there are some sections of the river that are over-widened and aggraded as a result of historical land use practices. This watershed has been described as moderately sensitive and moderately disturbed, with high to very high fish capacity and large or potentially large anadromous runs (Horel, 2008).

1.2.3 Watershed History

The Leiner and Perry Rivers reside within the traditional territory of the Mowachaht / Muchalaht First Nation, who have resided in this area for thousands of years. The area was first visited by British and Spanish explorers in the 1770s and 1780s, with homesteaders and handloggers settling on Tahsis Inlet as early as 1882 (Sellars, 1992).

Resource Extraction

Logging has been the main form of resource extraction in the Leiner and Perry Rivers watershed. The forest land base is owned by the Crown, and the entire watershed falls within Tree Farm Licence (TFL) 19, which is currently held by Western Forest Products and administered by the Campbell River Forest District (Fisheries and Oceans Canada, 2012). Logging first occurred in the Leiner River valley in the early 1940s; however, due to difficulty of access, wood harvesting operations were primarily restricted to the lower 2km of the Leiner River (Fisheries and Oceans Canada, 2012). On the Perry River, forestry development began in the 1950s and 60s and continued into the 1990s (Heatherington, 1997). Due to the prohibitively difficult access in the Leiner River as compared to the Perry, only 3% of the available forest was harvested from the Leiner River between 1940 and 2006, whereas 58% of the total harvestable forest was logged from the Perry River over the same period (Horel, 2008). Photo 1 presents an example of the results of the logging practices on the Perry River in 1953.

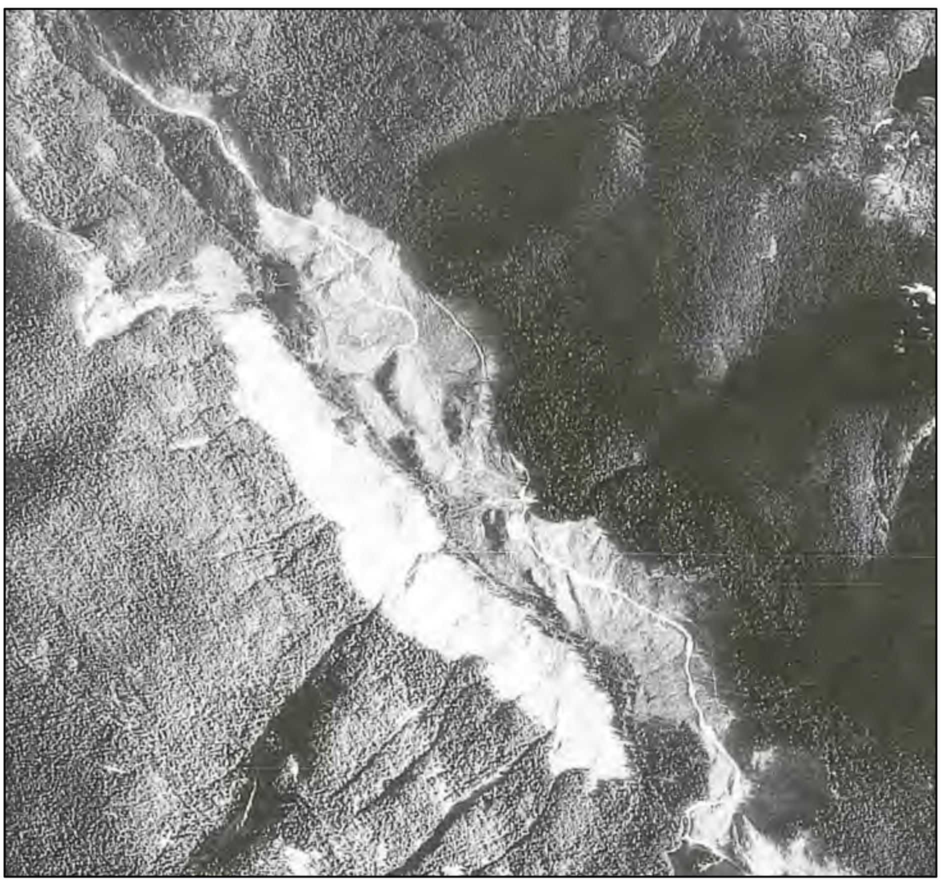

Photo 1. Logging activity in the Perry River watershed in 1953. Note the nearly complete removal of vegetation along the valley bottom.

Due to the confinement of resource development to the lower reaches of the Leiner River, little disturbance has been observed and the system is considered to be stable. In fact, no development-related slides have been reported on the Leiner (Horel , 2008). However, due to the productive capacity of the lower Leiner River and the importance of its estuary to juvenile salmonids and other wildlife, these areas should be considered sensitive and efforts should be made to prevent and reduce impacts to these areas.

The extensive logging activities that have taken place in the Perry River have resulted in a much higher degree of impact as compared to the Leiner River. To date there have been numerous development-related landslides including 6 from pre-code roads and 12 from pre-code cut blocks (Horel, 2008). The risk rating for the riparian forest along the banks of the Perry River has been previously assessed as high due to the fact that 31% of the entire stream length was logged to right to the stream banks, however, much of the riparian forest is regenerating now and is protected as a riparian buffer (Heatherington, 1997). Development in the upper watershed has resulted in some channel widening and aggradation; however, Perry Lake and the pond/wetland downstream of the lake act as sediment sinks, which interrupt the transport of sediment to the lower reaches.

Other Development

Several other small land developments have occurred in the lower reaches of the Leiner River (Figure 2). A municipally owned campsite is located on the right bank of the river roughly 3km from the village of Tahsis. This site contains 8 campsites within a regenerated forest. Another development is a small homestead known locally as Pete’s Farm. Pete’s Farm is a 2ha parcel of land located on the right bank of the river just upstream of tide water. This location is now a Community Heritage Site in recognition of the First Nations use of this site and to commemorate the only farm ever to be developed in the Tahsis area (Fisheries and Oceans Canada, 2012).

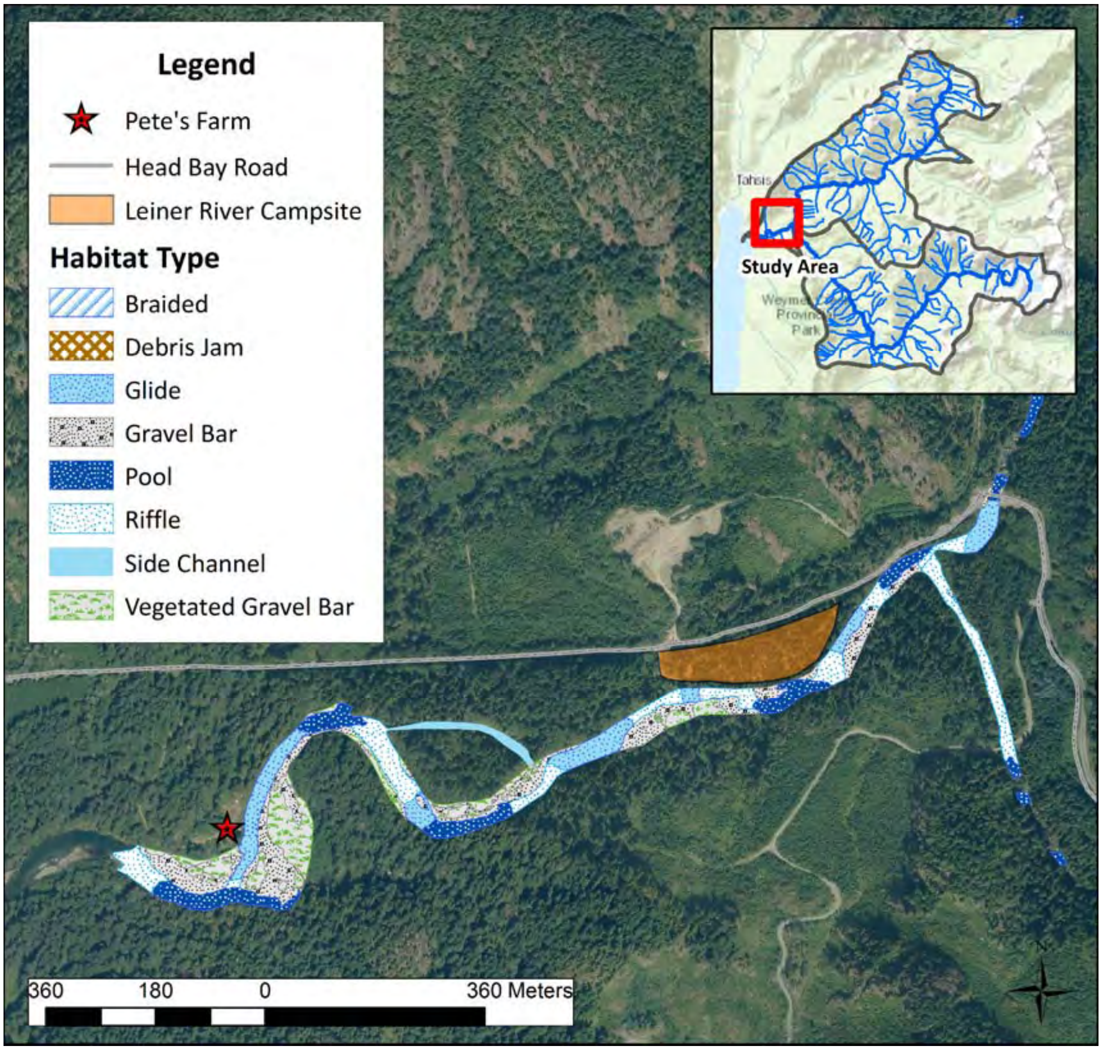

Figure 2. Other developments on the Leiner River.

With the development of a mill in the village of Tahsis in 1945, the Leiner River estuary became the site of log storage. When the mill was operational, the entire periphery of the estuary was used as a booming ground. See Photo 2 for an example of the booming conducted in the Leiner River estuary in 1977. Removal of log booms from the estuary has reportedly led to an increase in sedge habitat over the last 14 years (Tahsis Enhancement Society, 2014).

Photo 2. Historical photograph of the Leiner River estuary (on the right) showing log booming grounds in 1977. Also pictured is the Tahsis estuary and mill on the upper left.

2.0 METHODS

Strategy 2 habitat status assessments require the analysis of habitats using the pressure-state indicator model identified in Stalberg et. al. (2009). Within this model, pressure indicators are considered descriptors of landscape-level (and generally man-made) stressors, which can often be evaluated through the spatial analysis of remotely sensed data. State indicators are descriptors of specific habitat conditions, and are typically representative of 'on-the-ground' data collected during field operations. The following table describes the original stream, lake, and estuary pressure and state indicators considered under WSP Strategy 2:

Table 1. Pressure and state indicators identified in Stalberg et. al. (2009).

Habitat Type	Indicator Type	Indicator
Stream	Pressure	Total land cover alterations
Stream	Pressure	Watershed road development
Stream	Pressure	Water extraction
Stream	Pressure	Riparian disturbance
Stream	Pressure	Permitted waste management discharges
Stream	State	Suspended sediment
Stream	State	Water quality
Stream	State	Water temperature: juvenile rearing – stream resident species
Stream	State	Water temperature: migration and spawning – all species
Stream	State	Stream discharge
Stream	Quantity	Accessible stream length, based on barriers
Stream	Quantity	Key spawning areas (length)
Lake	Pressure	Total land cover alteration
Lake	Pressure	Watershed road development
Lake	Pressure	Riparian disturbance
Lake	Pressure	Permitted waste management discharges
Lake	State for sockeye lakes	Coldwater refuge zones
Lake	State for sockeye lakes	Lake productive capacity
Lake	Quantity	Lake shore spawning area (length)
Estuary	Pressure	Marine vessel traffic
Estuary	Pressure	Estuary habitat disturbance
Estuary	Pressure	Permitted waste management discharges
Estuary	State	Estuary chemistry and contaminants
Estuary	State	Estuary dissolved oxygen
Estuary	Quantity	Estuarine habitat area (riparian, sedge, eelgrass, and mudflat)

The selection of applicable indicators for the Leiner River watershed occurred following a comprehensive literature review and spatial data gathering and analyses. In addition to the indicators describe in Table 1, supplemental indicators were evaluated during the data gathering process based on data availability and their perceived importance.

2.1 Literature Review

Literature reviewed as part of the information gathering process included habitat assessments, monitoring initiatives, water use plans, watershed and estuary management plans, and various other technical documents. This information was obtained from the following sources:

- Web sources – FISS, WAVES online library, EcoCAT, J.T. Fyles Ministry of Forests online library, Google search;
- Technical reports received from local experts and stakeholders (i.e. DFO, private consultants, Western Forest Products [WFP], and others);
- Technical reports housed internally by MCW; and
- Interviews with key knowledgeable persons (i.e. the Tahsis Enhancement Society and the Nootka Sound Watershed Society)

Information from all sources was compiled and entered into a spreadsheet, and was separated by information theme (i.e. fish, habitat, impacts, water quality, etc.). Each document was comprehensively reviewed with important information extracted and synthesized on the spreadsheet. This method allowed for cross-comparison of document results, which was used to identify redundancy across sources and generate consensus on which habitat indicators apply in the system.

2.2 Spatial Data Gathering and Processing

Geographic Information Systems (GIS) data relevant to this project was obtained through the following resources:

- Land and Resources Data Warehouse (LRDW);
- West Coast Aquatics (WCA);
- Western Forest Products Ltd. (WFP);
- GeoBC;
- Ministry of Forests, Lands, and Natural Resource Operations (MFLNRO) Fish Passage Investment Program;
- University of British Columbia's Geographic Information Centre;
- Mapster;
- Shapefiles and orthophotographs courtesy of WFP; and
- Existing spatial data previously collected by MCW.

All GIS data processing and mapping was accomplished using ArcGIS Desktop 10.3 with the Spatial and 3D Analyst extensions. Once acquired, data was processed by clipping features to the BC Watershed Atlas 1:50,000 scale watershed boundaries.

2.3 Interviews

In addition to the information compiled during the literature review and spatial data gathering, interviews with the Nootka Sound Watershed Society and other experts in the area were conducted to incorporate local knowledge of the system. These interviews were conducted during the Nootka Sound Risk Assessment Workshop in Gold River on May 5 – 7, 2015.

2.4 Selected Stream Habitat Indicators

Upon review of the literature and spatial data gathered, stream habitat indicators were selected based on data availability and indicator suitability. The following sections describe methods used to analyze selected stream habitat indicators against known metrics and benchmarks.

2.4.1 Total Land Cover Alterations

Indicator Type: Pressure

Total land cover alteration captures potential changes in cumulative watershed processes such as peak hydrologic flows and sediment generation that can affect downstream spawning and rearing habitats (Poff et al., 2006 as cited in Stalberg et al., 2009). Alterations can be categorized by agriculture, urbanization, forestry, fire disturbance, mining activity, and road development.

Total land cover alterations in the Leiner River watershed were calculated by analyzing WFP's forest age layer for each watershed. This layer categorized all forested areas within a watershed using the following classification scheme: younger than 40 years, 41 to 120 years, and older than 120 years. Forested areas classified as older than 120 years were considered un-altered. Non-forested areas were described as non-productive. For polygons classified as non-productive by WFP, data was overlaid on high resolution 2012 – 2013 orthophotographs to differentiate the type of non-productive land present. These lands were further classified as follows: non-productive (alpine), non-productive (avalanche chute), non-productive (barren surface), non-productive (fresh water), and non-productive (urban). Classification into these non-productive categories was used to determine the area of natural (i.e. unaltered) non-productive land cover versus the area of altered non-productive land cover.

Land cover compositions and distributions were summarized for the entire watershed and analyzed to determine the total land cover alteration risk.

2.4.2 Watershed Road Development

Indicator Type: Pressure

The construction of roads in a watershed has the potential to increase fine sediment deposition into adjacent streams, reduce the aquatic invertebrate diversity, and affect aquatic connectivity, channel bed disturbance, and channel morphology (Tschaplinski, 2010). In addition, road densities are correlated with the extent of land-use within a watershed, and can be an indicator of overall watershed development (Stalberg et al, 2009).

Watershed road development was evaluated by calculating the lineal length of road per square kilometre of watershed. In order to obtain the most accurate representation of the existing road network, GIS layers obtained from the LRDW, WCA, and WFP were compared with 2013 high resolution orthophotographs. Discrepancies between layers were resolved and layers were merged to create one comprehensive road network.

Road development densities were determined by dividing the total length of roads in each watershed by the watershed area. Results were then compared with the following suggested benchmark identified in Stalberg et. al (2009):

<0.4km / km^2 = lower risk
>0.4km / km^2 = higher risk

2.4.3 Water Extraction

Indicator Type: Pressure

The consumptive use of water within a watershed has the potential to impact spawning and rearing habitats through the reduction of instream flows (ESSA Technologies Ltd., 2013). While watershed benchmarks are difficult to define in the absence of detailed climatic and hydrological data, relative risks can be assessed by comparing the total volume of licenced water extraction by watershed.

Water licence information was obtained through the LRDW. Spatial features were clipped within watershed boundaries, and permitted volumes (and licence type) were determined from the water licence attributes.

Watersheds with no licenced water extraction (for consumptive uses) were assigned low risk, while watersheds with any amount of extraction were assigned a moderate risk.

2.4.4 Riparian Disturbance

Indicator Type: Pressure

Riparian disturbance is a commonly used pressure indicator for both streams and lakes (Stalberg et al, 2009). Streamside vegetation provides many critical functions to aquatic habitats, including (but not limited to): temperature regulation, cover, large woody debris (LWD) deposition, nutrient input, and channel stability. While logging practices today are required to manage riparian vegetation adjacent to fish-bearing streams, impacts from historical logging to the stream banks have persisted. In many cases the return of riparian habitats to a proper functioning condition will require intervention through conifer release and bank stabilization practices.

Riparian disturbance in the Leiner River was determined by classifying vegetation within 100m of the high water mark. While a 30m delineation is the commonly referenced width for managing the riparian zone during development within B.C. (e.g., *The Land Development Guidelines for the Protection of Aquatic Habitat* (Fisheries and Oceans Canada & Ministry of Environment, 1992) discussions with the NWSW identified that an understanding of vegetation beyond this 30m width was necessary in order to fully understand impacts to the riparian zone (R. Dunlop, pers. comm.).

Vegetation was classified using 2013 high resolution orthophotographs. All vegetation within a 100m buffer of the high water line was classified using the following categories:

- Mature conifer (i.e. >90% mature coniferous stand);
- Mature mixed (i.e. mixture of mature coniferous and deciduous vegetation);
- Deciduous or regenerating (i.e. >90% deciduous stand and / or a regenerating coniferous stand);
- Early regenerating; and
- Non-productive (i.e. roads and bedrock surfaces).

Once classified, the riparian composition was summarized by fish species distribution to determine the relative riparian disturbance pressure for each species.

2.4.5 Permitted Waste Management Discharges

Indicator Type: Pressure

Permitted waste management discharges provide insight into potential pressures on water quality in streams, lakes, and estuaries. Information for the Nootka Sound area was obtained through the BC Ministry of Environment (MOE) permitted waste discharge authorization database (BC MOE Waste Management Website, 2015). A search was conducted for authorizations within the Tahsis, Gold River, and Zeballos. Results were mapped in ArcGIS using the coordinates provided in the database, and all authorization information was retained as fields in the attributes table.

2.4.6 Water Quality

Indicator Type: State

Suggested water quality metrics are the concentrations of contaminants, nutrients, and dissolved oxygen (DO) in stream water. This level of data is typically only available for systems with localized monitoring or research projects (Stalberg et al, 2009). For the Leiner

River, the only water quality data available was through the Ministry of Energy and Mines regional geochemical stream survey data. Relevant parameters sampled were compared with the Canadian Water Quality Guidelines for the Protection of Aquatic Life (Canadian Council of Ministers of the Environment, 2014) to determine if they were potentially limiting fish production.

2.4.7 Water Temperature: Juvenile Rearing and Migration

Indicator Type: State

Water temperature during the incubation, rearing, and migration of salmonid species has a significant impact on the timing of certain life stages (i.e. emergence), and is an important parameter to understand potential exposure to other limiting factors based on timing. No temperature data was available for the Leiner River watershed during the juvenile rearing and migration period and has been identified as a data gap.

2.4.8 Water Temperature: Migration and Spawning

Indicator Type: State

High water temperatures during the summer and fall have the potential to delay or be stressful to migrating salmonids (Sauter et al, 2001). The Upper Optimum Temperature Range (UOTR) and Impairment Temperatures (IT) for all species of salmonids were defined in Stalberg et al (2009) as 15°C and 20°C, respectively.

Stream temperature data was obtained from 2006 to 2013 from DFO's Stream Inspection Logs (SILs). Temperatures during spawner migration in the Leiner River were evaluated for this indicator by determining the maximum temperatures observed by snorkel survey crews each season against the UOTR and IT. Temperatures that remained below these values were considered low risk, temperatures that were at the UOTR or between the UOTR were considered moderate risk, and temperatures at or above the IT were considered high risk.

While a risk assessment of this habitat indicator was possible through SIL temperature data, it should be noted that this data represents only select point samples in time. Continuous temperature loggers during the spawning period are recommended to increase the robustness of this habitat indicator assessment.

2.4.9 Stream Discharge

Indicator Type: State

The carrying capacity of streams and their seasonal suitability for use by different salmonid species and life-stages are directly related to aspects of the annual hydrograph and "mean annual discharge" (MAD). The suggested benchmark for discharge is when the 1 in 2 year

30-day duration summer minimum flow (i.e. July – September) is less than 20% of MAD (Stalberg et al, 2009).

Limited discharge information was available for the Leiner and Perry rivers. Data available included select discharge measurements collected by Fisheries and Oceans Canada and a 1992 floodwater mapping study completed by Sellars in 1992. While this data was compiled and summarized, limited information prevented an analysis of this metric against the recommended benchmarks. As such, discharge has been identified as a data gap for the Leiner River watershed.

2.4.10 Accessible Stream Length

Indicator Type: State

Determination of the accessible stream length (by species) provides an indicator on the relative productive capacity of a watershed, and allows for the analysis of how landscape pressures (i.e. disturbed riparian zones) affect different species and life stages differently. Accessible stream length was determined through the compilation of several sources of information, including the Fisheries Information Summary System (FISS), BC MOE fish passage modelling (MFLNRO Fish Passage Technical Working Group Web Page, 2013), spatial data received from WCA, various technical reports, and interviews with the Tahsis Enhancement Society and the Nootka Sound Watershed Society. Compiled data was digitized as a line feature in ArcGIS to determine the linear length of fish distribution.

2.4.11 Key Spawning Areas (Length)

Indicator Type: State

Quantification of the key spawning areas provides an indicator on the relative productive capacity of a watershed, as well as a baseline to compare future changes in spawning habitat over time. In addition, identification and documentation of these key habitats will provide guidance on known habitats to protect from future industrial initiatives.

Key spawning areas were identified from the following sources: FISS, various technical reports, interviews with the Tahsis Enhancement Society and the Nootka Sound Watershed Society, and data extracted from recent SILs.

2.5 Additional Stream Indicators

Based on the breadth of data collected during the information gathering process and other known useful stream indicators, the following sections describe the supplemental stream indicators selected for analysis during the habitat status assessment work in Nootka Sound.

2.5.1 Stream Crossing Density

Indicator Type: Pressure

Stream crossings at roads have the potential to impede fish passage through interfering with or blocking access to upstream spawning or rearing habitats (thereby reducing the total amount of habitat salmonid habitat in a watershed (Harper & Quigley, 2000). These crossings have also been known to increase sediment delivery to streams through the provision of direct pathways to aquatic habitats (Brown et al, 2013).

Stream crossing information was obtained from the Provincial Stream Crossing Inventory System (PSCIS). Crossing density was calculated for each watershed by dividing the total number of crossings present in each watershed by the watershed area, and the distribution values across all watersheds were compared to evaluate relative risk. In addition, the number of modelled fish-bearing crossings was determined for each watershed to evaluate the number of crossings potentially affecting fish and fish habitat.

Risks were determined on a comparative basis by ranking both crossing density and the total number of fish-bearing crossings per watershed.

2.5.2 Habitat Composition

Indicator Type: State

Guidelines state that for systems greater than 15m and with gradients <2% poor salmonid habitat condition for summer and winter rearing occurs with <40% pool habitat area by reach. Systems with gradients between 2% and 5% experience poor summer and winter rearing conditions with <30% pool habitat area by reach, and systems with gradients >5% experience poor summer and winter rearing conditions with <20% pool habitat area by reach (Johnston and Slaney, 1996).

Habitat compositions for the Leiner River were determined by digitizing macrohabitat units from 2013 orthophotographs, where visible in the imagery (note that in some cases, classification was not possible based on canopy cover and / or shadowing). In addition, historical habitat unit composition was determined through GPS data collected in the mid-1990s by M.C. Wright and Associates Ltd. (unpublished data) and digitization of geo-referenced air photos from 1995. All habitats within the bankful widths were classified based on the following categories:

- Riffle;
- Pool;
- Glide;
- Cascade;
- Braided;
- Debris jam;
- Gravel bar;
- Vegetated gravel bar;
- Side channel; and
- Secondary channel.

Habitat units by percent composition were determined by calculating and comparing the respective areas of each habitat unit type in ArcGIS. An assessment of change in habitat unit composition over time was also determined through a comparison of the 2013 and 1995 data.

2.5.3 Channel Stability

Indicator Type: State

Forest harvesting and road building in a watershed have the potential to increase peak flows, increase sediment delivery, alter riparian vegetation, and disturb channel integrity. These alterations can cause morphological changes to a channel, and may result in aggradation or degradation of the streambed. These changes will often affect the stability of stream banks and the conditions of LWD in the system and subsequently impact critical salmonid habitats (i.e. spawning and rearing zones) (Hogan and Ward, 1997).

Channel stability in the Leiner River watershed was evaluated through the comparison of historical air photos (1980 and 1995) and recent orthophotographs (2013). Bankful widths, the location of vegetated and non-vegetated gravel bars, and eroding banks were compared between each time period, and used as an indicator of increasing or decreasing channel stability.

2.5.4 Large Woody Debris

Indicator Type: State

Large woody debris (LWD) affects channel form through the formation and stabilization of pools and gravel bars, and provides valuable habitat in the form of cover for salmonids. In many cases, a reduction in LWD amount and piece size as a result of forest harvesting has been assumed to occur gradually; however, recent studies indicate these changes occur during or shortly after harvest (Bilby and Ward, 1991). Changes in riparian stand composition (i.e. a transition from mature conifers to deciduous) are known to reduce the quality and longevity of LWD in a system as deciduous trees (i.e. alder) break down in river systems faster than mature conifers.

LWD was classified from the 2013 orthophotography where the stream channel was visible in the imagery. In many cases, canopy cover and / or shadows in the upper reaches of the systems prevented classification, and were identified as a data gap. Species differentiation of LWD (i.e. deciduous or coniferous) was not possible from the orthophotographs; however, some assumptions can be made based on classification of the adjacent riparian stand.

Visible LWD was classified using the following categories:

- Functioning (i.e. LWD situated at an angle or perpendicular to the stream bank, with the potential to create scour pools and influence channel form);
- Partially-Functioning (i.e. LWD situated at an angle or perpendicular to the stream bank, but remained only partially wetted and requires higher flows to provide full functionality, or LWD situated parallel to the stream bank);
- Non-Functioning (i.e. LWD situated parallel to the stream bank or situated on gravel bars well above the wetted width); and
- Debris Jam (i.e. a large raft of LWD, typically consisting of 10 pieces of LWD or greater).

LWD habitat condition was determined, at the reach level, using the following diagnostics described in Johnston and Slaney (1996):

- Good = >2 pieces of functional LWD per bankful width;
- Fair = 1 – 2 pieces of functional LWD per bankful width; and
- Poor = <1 piece of functional LWD per bankful width.

2.5.5 Off-Channel Habitats

Off-channel habitats provide valuable rearing and over-wintering habitat for various species of pacific salmon. Chum and coho are most strongly associated with these types of habitats, with chum often observed spawning in groundwater-fed channels or seepage areas, and coho observed spawning in groundwater channels and small surface-fed tributaries (Slaney and Zaldokas, 1997). Coho juveniles utilize refuge areas such as side channels, small tributaries, ponds, and lakes for over-wintering habitat as they provide protection from winter flood events. The productivity of coho in many coastal systems depends on the availability of of good winter refuge (i.e. off-channel) habitat (Diewert, 2007). In addition, off-channel habitats in the lower reaches of the river provide important foraging opportunities for all out-migration salmonids.

Evaluation of off-channel habitat condition in the Leiner and Perry rivers watershed was restricted to interviews with local experts, as these habitat types were typically not visible from orthophotography due to canopy cover.

2.6 Selected Estuary Habitat Indicators

Upon review of the literature and spatial data gathered, estuary habitat indicators were selected based on data availability and indicator suitability. The following sections describe methods used to analyze selected estuary habitat indicators against known metrics and benchmarks.

2.6.1 Estuary Habitat Disturbance

Indicator Type: Pressure

Estuaries are extremely important habitats for adult salmon for staging and physiological transition, and are also important to juvenile salmon for rearing, physiological transition, and refugia. Anthropogenic impacts within an estuary and throughout a corresponding watershed can have negative effects on both adult and juvenile salmonids utilizing these habitats. These impacts are compounded considering the added physiological stresses fish experience during the transition from the freshwater to marine environments, and the importance of estuarine habitat for foraging and rearing. Common impacts within estuaries include: 1.) loss of intertidal rearing habitat due to structural development, dredging and filling, and gravel deposition from upstream sediments; 2.) decreases in dissolved oxygen due to input of sewage, agricultural practices, and dredging of anoxic sediments; 3.) creating a toxic condition due to toxic chemical spills and the discharge of chemical waste from industry and mining; and 4.) an increase in suspended solids due to logging activities upstream, agricultural practices, dredging, and input of sewage and industrial waste (Aitkin, 1998).

Relative habitat disturbances in the Leiner River estuary were evaluated through the extent of known historical activities, the presence / absence of existing initiatives in the estuary, and residual impacts identified through literature reviews and orthophoto analyses.

2.6.2 Permitted Waste Management Discharges

Indicator Type: Pressure

Permitted waste management discharges within the estuarine habitat have the potential to impact salmonid through the reduction of water quality (i.e. dissolved oxygen) and an increase in suspended solids (Aitkin, 1998). This indicator was evaluated based on the presence / absence of permitted waste management discharges within the Leiner River estuary, as documented in the Ministry of Environment's waste discharge authorization database.

2.6.3 Estuary Chemistry and Contaminants

Indicator Type: State

An analysis of estuarine chemistry and contaminants (i.e. N, P, N:P, Metals, PAHs and PCBs) can provide an indicator of water quality suitability for aquatic life. Available water quality data was compared with the Canadian Water Quality Guidelines for the Protection of Aquatic Life (Canadian Council of Ministers of the Environment, 1999) to determine if any parameters exceeded the thresholds of these guidelines and therefore potentially impacting salmonids utilizing the estuary.

Limited chemistry or contaminant data for the Leiner River estuary was available, and has therefore been identified as a data gap.

2.6.4 Estuary Dissolved Oxygen

Indicator Type: State

Dissolved oxygen levels and stratification in estuaries have been shown to be important in the freshwater-marine transitions of migrating juvenile and adult salmon (Stalberg et al, 2009). No data was available for the Leiner River estuary; as such, this habitat indicator has been identified as a data gap.

2.6.5 Estuarine Habitat Area

Indicator Type: State

The area of riparian, sedge, eelgrass, and mudflat habitats within an estuary is considered an indicator of the productive capacity of an estuary. An analysis of estuarine habitat changes over time also provides an indicator of habitat improvement or degradation, and may identify critical habitats requiring protection and / or restoration.

Estuarine habitat area for the Leiner River was calculated through the digitization of habitat types from the 2013 orthophotographs. While no historical habitat areas were available for comparison, this data provides a baseline of information from which future changes over time can be compared.

3.0 WILD PACIFIC SALMON OF THE LEINER RIVER WATERSHED

The lower reaches of both the Leiner and Perry rivers are accessible to anadromous fishes. Presently, chinook, coho, chum and sockeye salmon (*Oncorhynchus tshawytscha, O. kisutch, O. keta, and O. nerka*, respectively) are observed on a yearly basis in the Leiner River watershed. Pink salmon (*O. gorbuscha*) historically spawned in the Leiner River; however, numbers have declined significantly since the early 1980s, and there is debate over whether recently observed individuals are genetically linked to the Leiner River or if they are strays from neighbouring systems (Fisheries and Oceans Canada, 2012). Other salmonid species present in the system include resident rainbow trout and steelhead (*O. mykiss*). The main species of interest are described in the following sections.

3.1 Chinook Salmon

3.1.1 Biology, Distribution, and Known Habitats

Chinook salmon are regularly observed in the lower reach of the Leiner River (from counting station 0 to 4), and a historical observation exists of chinook salmon in the Perry River near its confluence with the Leiner River (Fisheries and Oceans Canada, 2012; FISS Report: Perry Creek, 2015). Movement of chinook upstream of the Leiner River bridge is likely prevented by the steep cascade in this section (Fisheries and Oceans Canada, 2012). Figure 3 presents the distribution of chinook salmon in the Leiner River watershed.

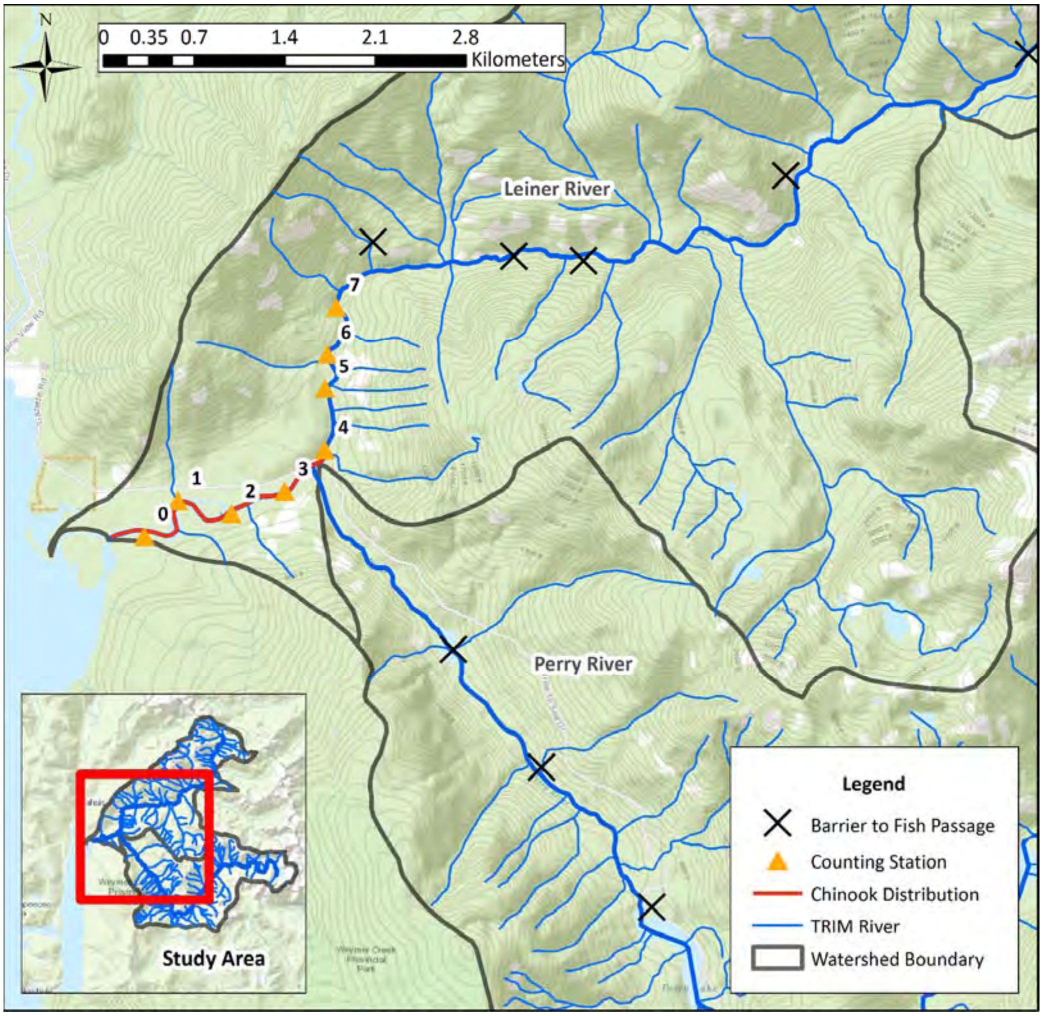

Figure 3. Chinook distribution in the Leiner River watershed.

Chinook salmon enter the Leiner River in mid-September, and spawning is known to peak in early October (Fisheries and Oceans Canada, 2012). Despite historical observations of chinook in the lower sections of the Perry River, recent surveys have not assessed this section and the status of Chinook in the Perry River should be viewed as a data gap (FISS Report: Perry Creek, 2015).

During upstream migration to the spawning grounds, adult chinook take advantage of several key holding pools between counting stations 0 and 4. Just above counting station 0, an important holding pool along the left bank exists, where broodstock collection for the Tahsis Enhancement Society typically occurs. Holding is also known to occur at pools between counting stations 1 and 2, at counting station 3, at the confluence with the Perry River, and directly upstream of the bridge (counting station 4) (Tahsis Enhancement Society, 2014). There is also a deep narrow pool along the left bank just upstream of counting station 2 that is a common holding area for chinook (Figure 4).

Chinook salmon eggs have the largest surface area to volume ratio when compared with other pacific salmon species. Consequently, their eggs are most sensitive to reduced oxygen levels. As such spawning grounds with adequate subgravel flows (and typically coarser gravels) are targeted during redd selection (Diewert, 2007). In the Leiner River, significant numbers of spawning adults have been observed regularly in the long riffles between counting stations 1 and 2 (Fisheries and Oceans Canada, 2012). Additionally, chinook are known to spawn in the pool tailout and riffle just downstream of the Leiner River bridge (Tahsis Enhancement Society, 2014) (Figure 4).

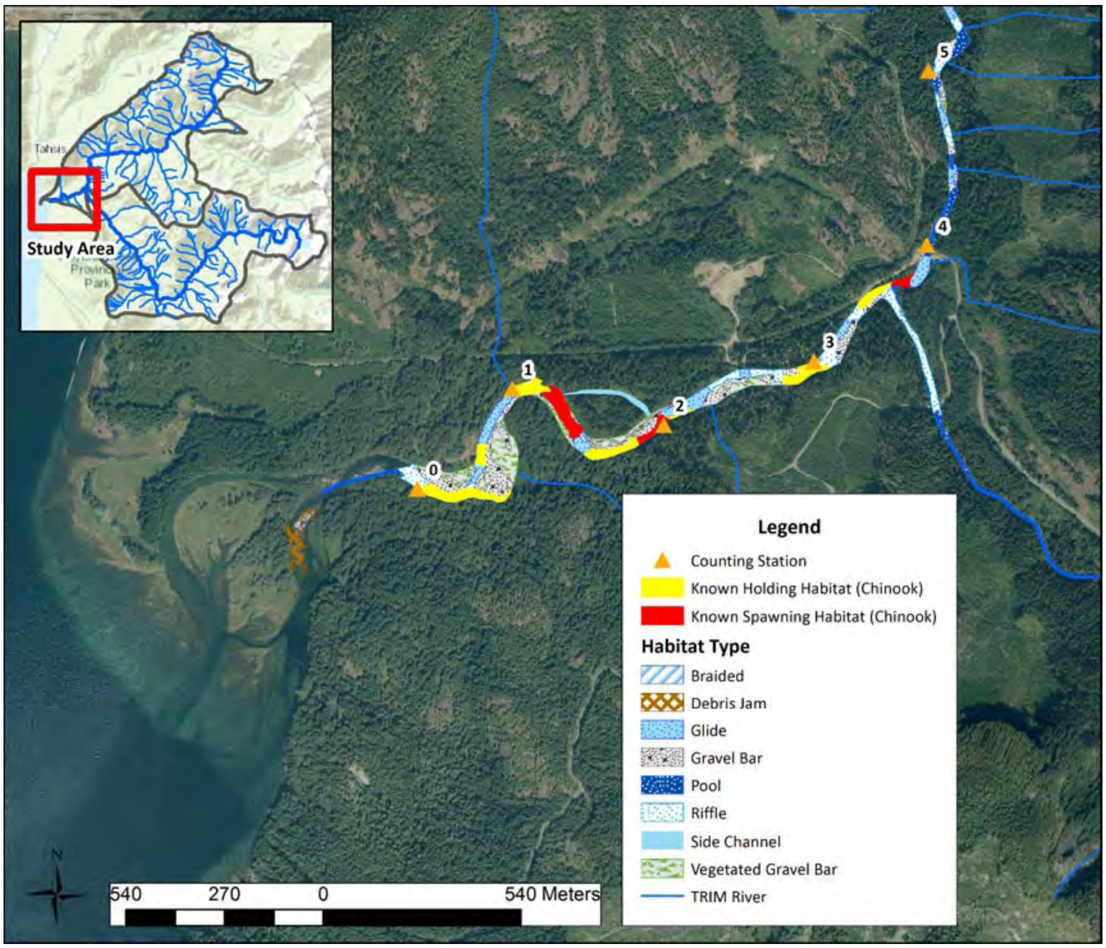

Figure 4. Known adult chinook holding and spawning habitat in the Leiner River.

Fry emergence is partially dependent on water temperature and can vary from year to year (i.e. the lower the water temperature, the longer the incubation period required). Following emergence, fry typically migrate downstream immediately. Chinook salmon can be separated into ocean-type and stream-type, with ocean-type migrating directly to sea after emergence, and stream-type remaining in the freshwater environment to rear for one or more years (Healey, 1991). The chinook of the Leiner River watershed are likely ocean-type as this is the dominant type of chinook in British Columbia (Diewert, 2007). Migration typically occurs between April and June for ocean-type chinook (note that the specific migration timing for this system is unknown). During downstream migration, fry typically target reduced flows at the river edges (Diewert, 2007). Given this requirement, the known migration habitat for chinook fry has been inferred for the Leiner River based on characteristics observed from the orthophotographs (See Figure 5).

Chinook are very dependent upon estuaries to complete their life cycle (Healey, 1991). Estuaries are an environmental transition zone that provides opportunities for feeding and growth, and refuge from predators. Upon reaching the estuary, juveniles rear in this zone for up to several months, where rapid growth (dependant on food resources available in the estuary) typically occurs (Diewert, 2007). Additionally, it is in the estuary where juvenile chinook seek cover and complete the physiological process of osmoregulation (Healey, 1991). For these reasons, the Leiner River estuary has been classified as known habitat for juvenile chinook salmon (See Figure 5).

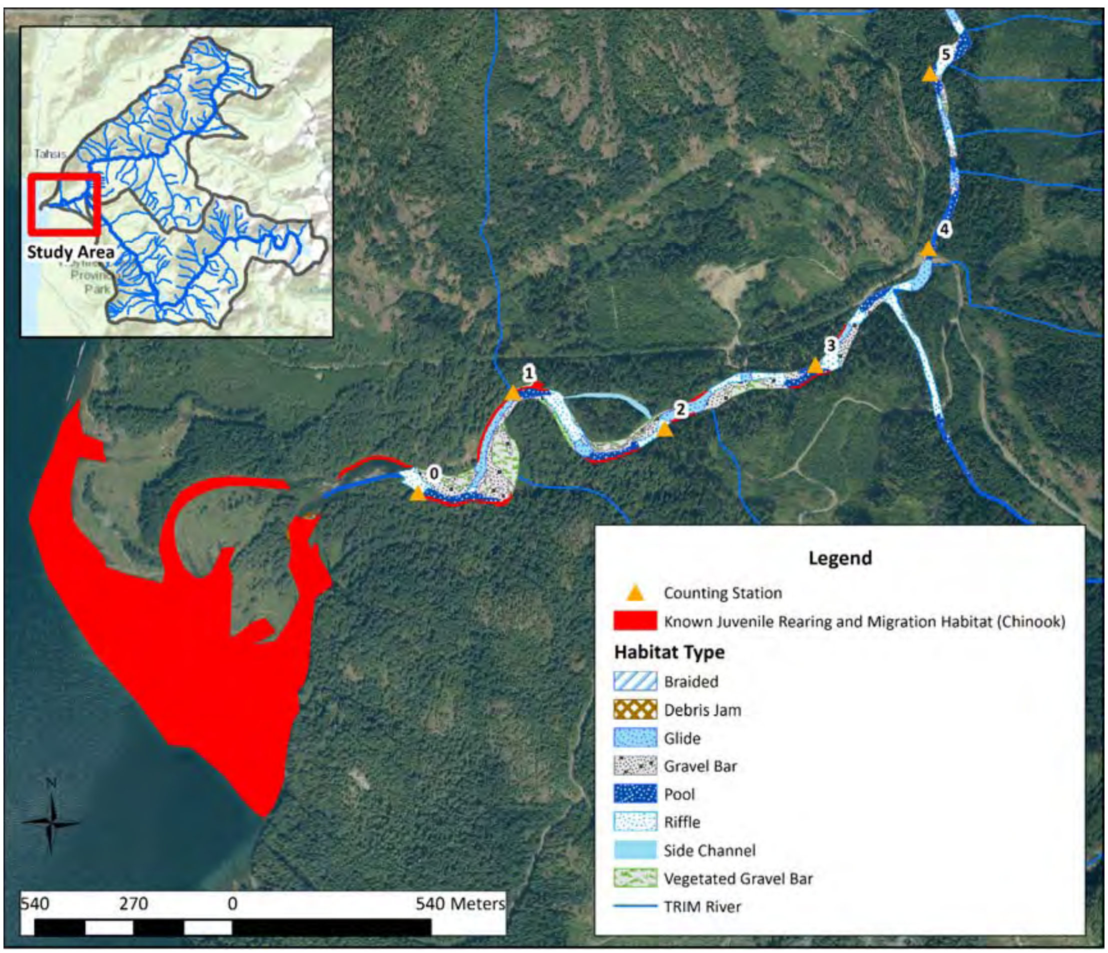

Figure 5. Known juvenile chinook migration and rearing habitat in the Leiner River.

3.1.2 Escapement

The spawning population of chinook in the Leiner River has remained relatively stable, with returns averaging around 350 fish (Fisheries and Oceans Canada, 2012). Brood stock from the Leiner River has been used in the past for enhancement in the Tahsis River, and enhancement activities by local volunteer groups are on-going in the Leiner River. Figure 6 presents the Chinook escapement since 1953 (based on data from DFO's NuSEDs database).

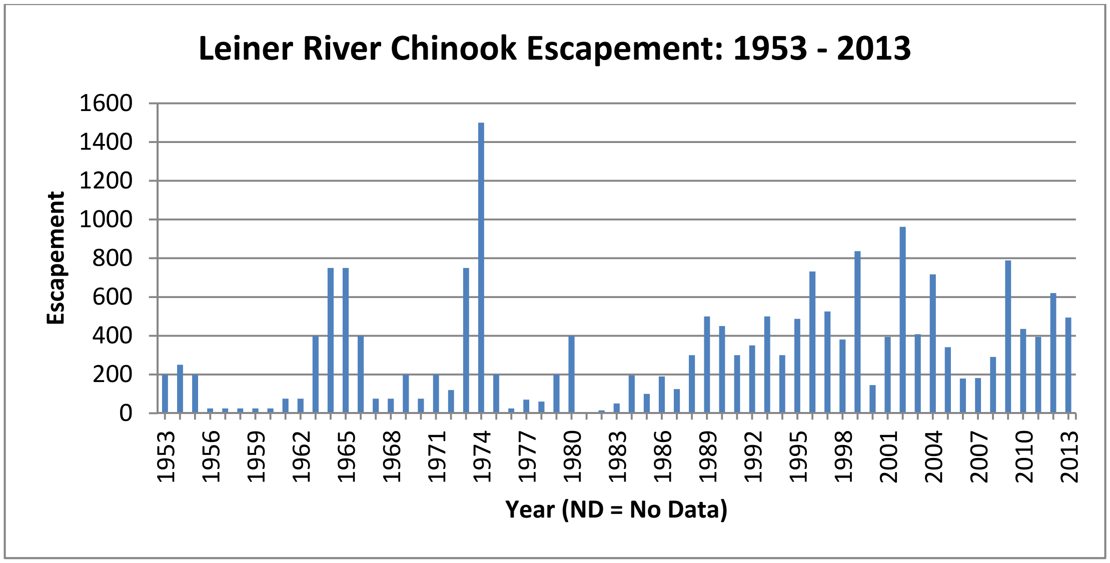

Figure 6. Chinook escapement in the Leiner River between 1953 and 2013[1] (compiled from DFO's NusEDS database).

3.2 Coho Salmon

3.2.1 Biology, Distribution, and Known Habitats

Coho are distributed broadly in both the Leiner and Perry Rivers (Figure 7). In the Leiner River, adults migrate as far as 5km upstream from tidal water, although migration beyond counting station 7 is often limited to high flow events (A. Eden, pers. comm.). In the Perry River coho are known to travel 3km upstream of the confluence with the Leiner (FISS Report: Perry Creek, 2015). Migration to higher sections of the watershed is prevented by barriers in both rivers. Coho are observed regularly by fisheries technicians performing escapement swims in the lower reaches of the Leiner River; however, few observations are

[1] Note that assessment methods prior to the mid-1990s were often generalized estimates of population numbers in the whole system, as opposed to the sectionalized species count methods that were implemented in the mid-1990s and later. As such, caution should be exercised when comparing counts prior to and following this change in assessment method.

made of coho in the Perry River as this system is not included in the escapement assessment methodology. Therefore, much of the information on coho habitat utilization and behaviour in this report is specific to Leiner coho. Perry River coho require further field investigation to fill in some of the data gaps regarding their distribution.

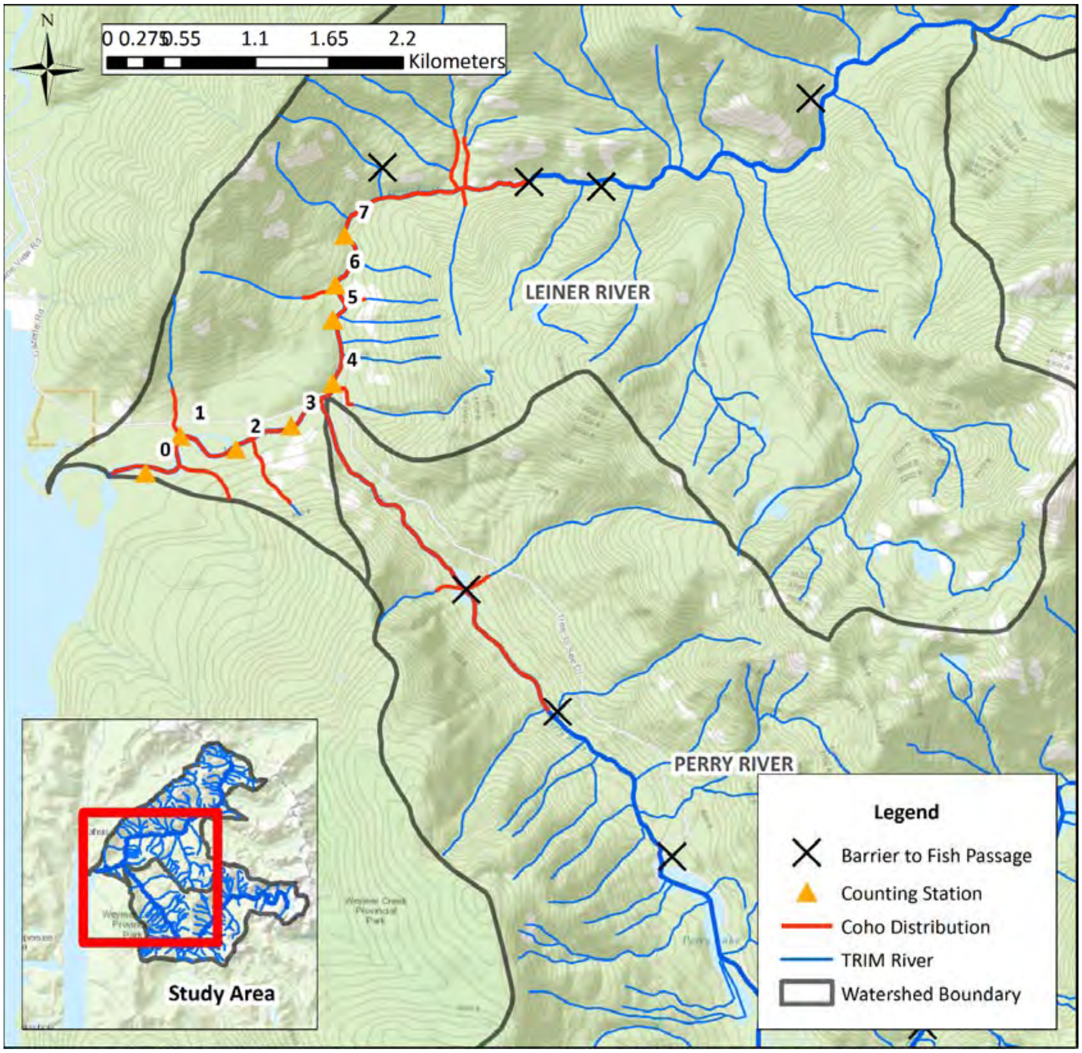

Figure 7. Coho distribution in the Leiner River watershed.

Coho salmon typically arrive in the Leiner River in early September and begin spawning in late October. Peak spawning typically occurs in mid-November, with the end of the run observed in late November (Fisheries and Oceans Canada, 2012).

During upstream migration to the spawning grounds, adult coho take advantage of several key holding pools between counting stations 0 and 7. Of particular interest is the section between counting stations 3 and 4. In this area, coho hold and wait for high water events in order to allow them access to the portion of the Leiner River above the bridge. Coho salmon also migrate into the Perry River from this section. Historic information from 1965 indicates that the Perry River receives the majority of the coho spawning population; however, this has not been verified (Brown, 1979). Upstream of the bridge in the Leiner River, coho are known to hold in pools between counting stations 4 to 7 (DFO SILs, Tahsis Enhancement Society, 2014). Distribution of spawning coho above counting station 7 is not well documented and is considered a data gap. Figure 8 presents the known holding habitat for coho salmon in the Leiner River.

Coho spawning habitat is very diverse, and can range from large river systems to small headwater streams and / or tributaries (Diewarts, 2007). Local knowledge indicates that coho spawning occurs in a riffle at the downstream end of the Leiner River Rec Site between counting stations 2 and 3 (see Figure 8) (Tahsis Enhancement Society, 2014). DFO stream cards show that in years when the Leiner is surveyed above counting station 4 that >70% of the coho adults hold and spawn above counting station 4. Several smaller tributaries and off-channel habitats in the lower Leiner River, near the estuary, have also been reported to support spawning populations of coho (Tahsis Enhancement Society, 2014). Future investigations should be undertaken to determine the location of coho spawning in the mainstem of both the Leiner River and Perry River systems. Additionally, side channel habitat should be investigated in each system during the peak of coho spawning, as these areas are frequently utilized by spawning coho. This information will be valuable for planning sustainable resource development in the future and could be a useful starting point for planning enhancement work in the area.

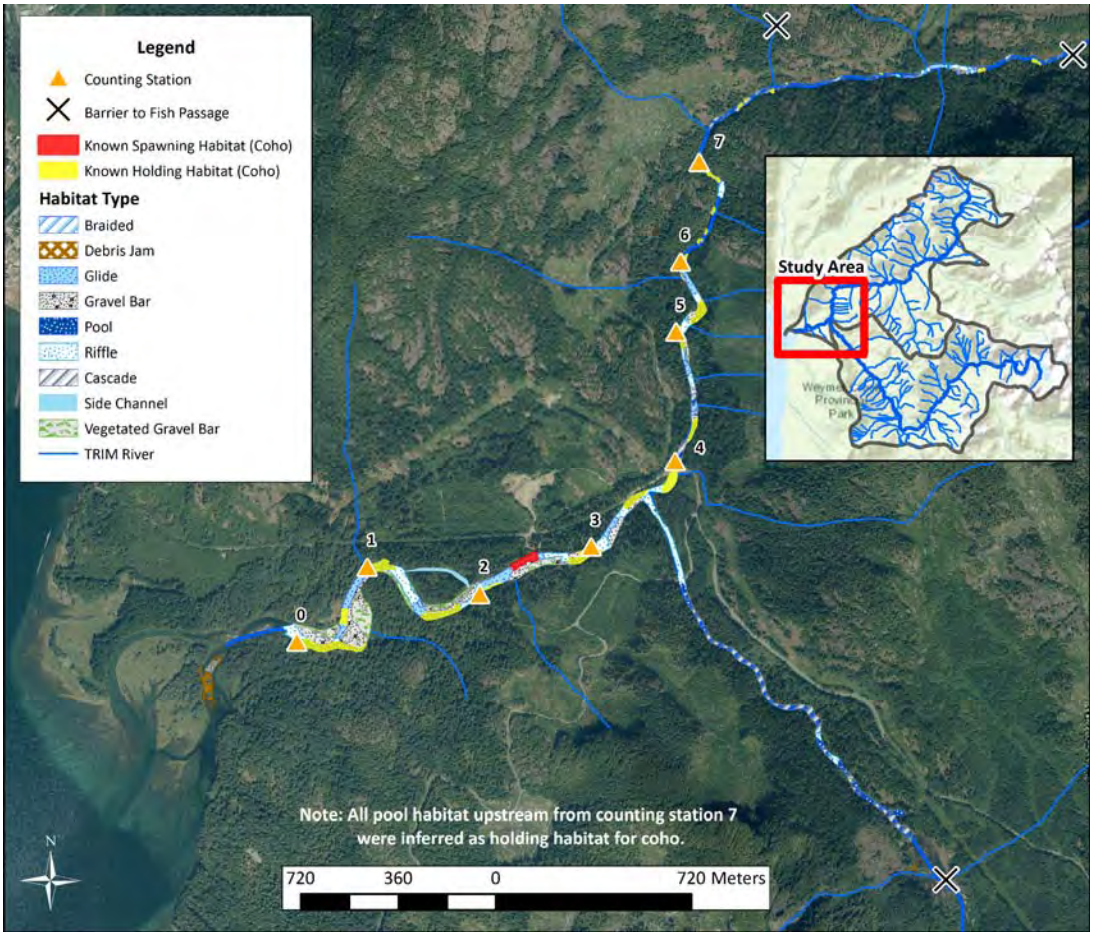

Figure 8. Known adult coho holding and spawning habitat in the Leiner River watershed.

Fry emergence is partially dependent on water temperature and can vary from year to year (i.e. the lower the water temperature, the longer the incubation period required), although it typically occurs between March and late June (Diewerts, 2007). Like chinook, coho salmon can be separated into stream-type or ocean-type, with ocean-type fish migrating directly to sea after emergence, and stream-type fish spending one or more years in fresh water before migrating into the marine environment (Aitkin, 1998). Sampling in the nearby Tahsis River estuary determined that, while some coho migrate directly to sea after emergence, the majority spent a year or more in fresh water, indicating a largely stream-type population (Western Canada Hydraulic Laboraties Ltd., 1981). Like the Tahsis, coho in the Leiner and Perry system are predominantly stream-type and may have a small population of ocean type coho. During early development in the river, pools, backwaters, side channels, and small tributaries are sought out as rearing habitat (Sandercock, 1991). By late fall to early winter, fry move into deep pools or off-channel habitats which provide shelter from winter storm events. The productivity of many coastal systems for coho largely depends on the availability of over-wintering habitat (i.e. off-channel refuge areas) (Diewert, 2007).

Little specific information is available on the distribution of coho fry in the Leiner and Perry Rivers, however, it has been noted that coho fry are commonly observed throughout the area (counting stations 0 to 7) during escapemet surveys. In particular, large numbers of fry are observed in the vacinity of large woody debris accumulations (Fisheries and Oceans Canada, 2012). Interviews with local experts indicated the presence of high value off-channel rearing habitat just north of counting station 0; however, access is restricted (R. Iles and L. Vansolkema, pers. comm.). Figure 9 presents the known rearing and migration areas for juvenile coho salmon based on observation and generalized habitat requirements. Future investigations should seek to determine the connectivity and juvenile coho utilization of off-channel habitat in the Leiner and Perry Rivers.

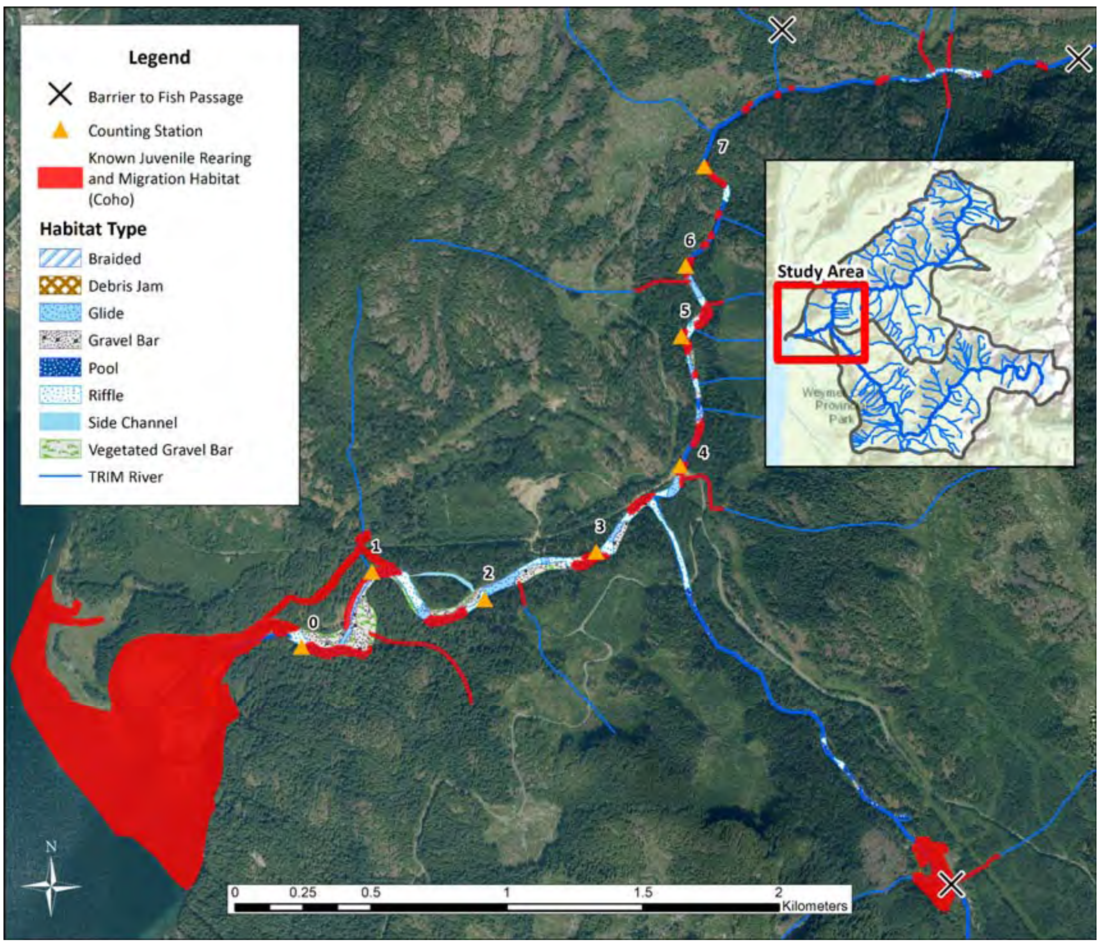

Figure 9. Known juvenile coho migration and rearing habitat in the Leiner River watershed.

3.2.2 Escapement

Coho populations in the Leiner River have remained stable for the past 15 years at roughly 700 fish, with some returns exceeding 1,000 (Fisheries and Oceans Canada, 2012). Coho numbers are likely underestimated due to timing of the run and that many of the adults migrate upstream beyond the index survey area and are missed in the stock assessment counts (Fisheries and Oceans Canada, 2012). Historical records show a peak return of 7,500 fish in 1973 to the Leiner River (Figure 10). Observations of coho in the Perry River indicate that more than 700 coho returned to this system in the early 1950s (Figure 11) (NuSEDS, 2015). During the early to mid-1990s, poor ocean survival resulted in a decrease in the abundance of coho on the WCVI, which was reflected in escapements to the Leiner River within this time frame (Fisheries and Oceans Canada, 2012). Additionally, very few observations specific to coho escapement have been made on the Perry River and the status of the coho population in this system is unknown and is therefore a data gap (Figure 11). Future investigations should seek to clarify the distribution, timing, and escapement of coho salmon in both the Leiner and Perry Rivers.

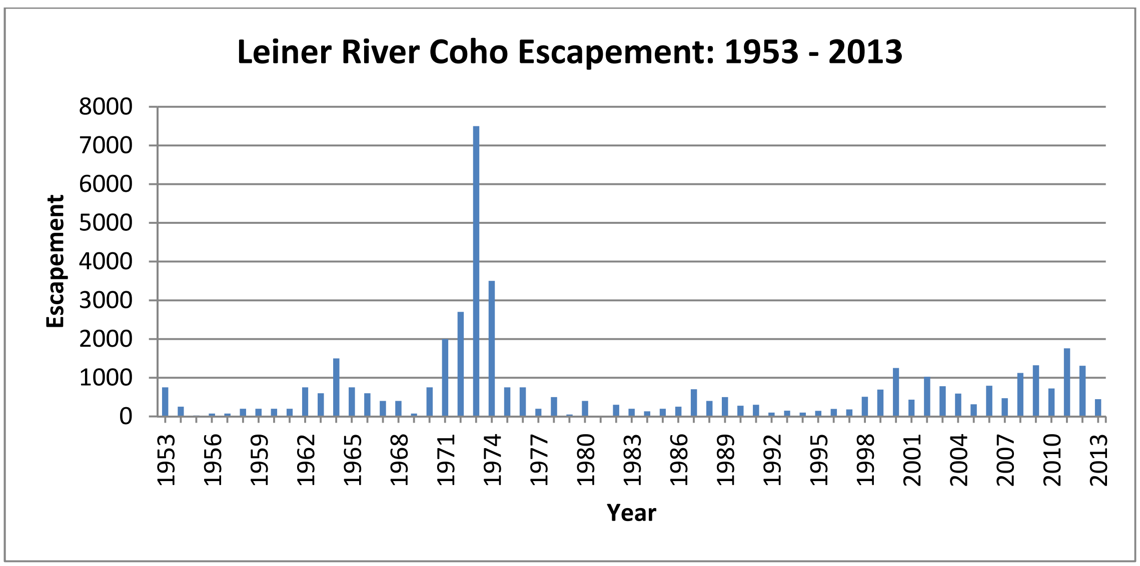

Figure 10. Coho escapement in the Leiner River between 1953 and 2013 (compiled from DFO's NuSEDs database).

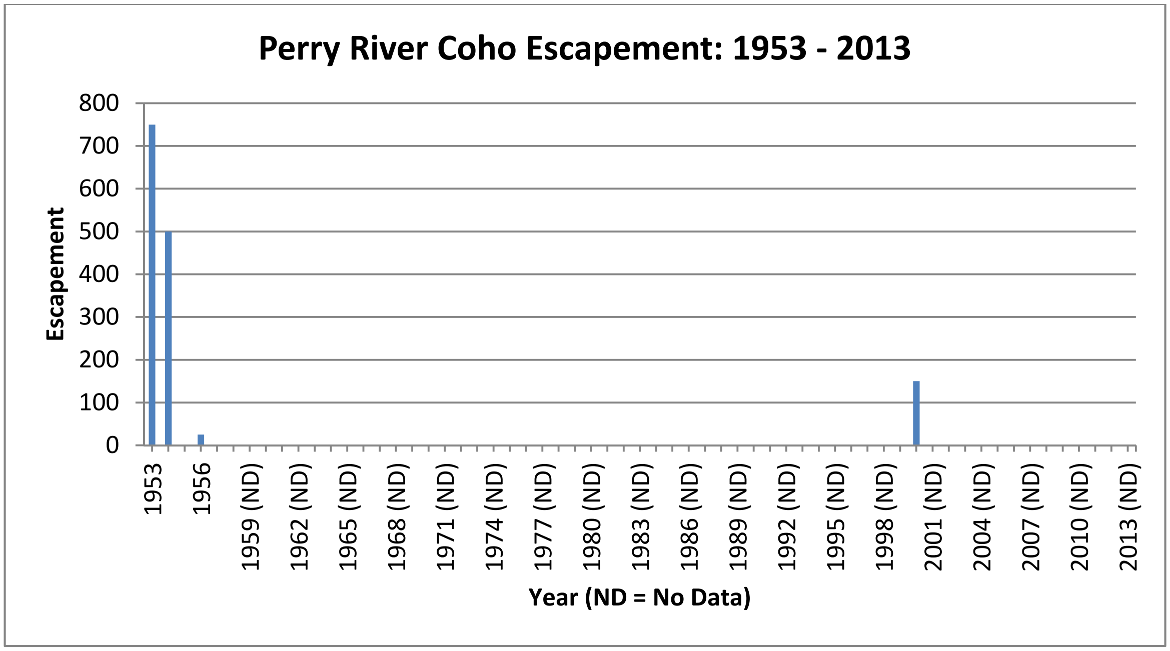

Figure 11. Coho escapement in the Perry River between 1953 and 2013 (compiled from DFO's NuSEDS database).

3.3 Sockeye Salmon

3.3.1 Biology, Distribution, and Known Habitats

Sockeye arrive in the Leiner River in early August and begin spawning in late October. Peak spawning is observed in mid- November, and spawning is typically over by early December (Fisheries and Oceans Canada, 2012). Sockeye salmon are commonly observed in the Leiner River during escapement surveys from the estuary up to counting station 4 (Leiner River Bridge). Sockeye are periodically observed upstream of this point but the numbers and incidence of observation are extremely low (Fisheries and Oceans Canada, 2012). In the Perry River, sockeye are known to be present up to the wetland 2.5km downstream of Perry Lake, however, field investigations should be conducted to confirm this distribution (Tahsis Enhancement Society, 2014). See Figure 12 for the distribution of sockeye in the Leiner and Perry River watershed.

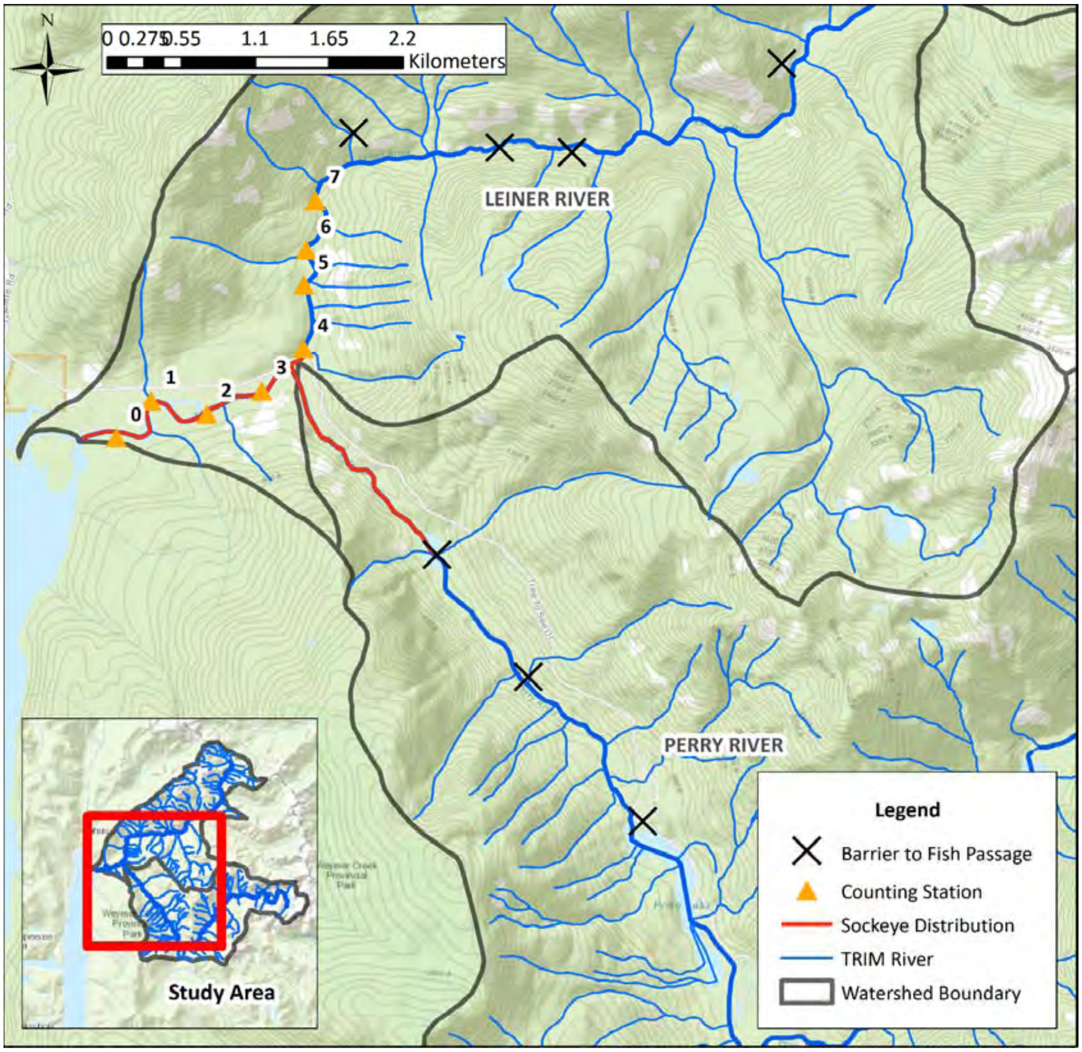

Figure 12. Sockeye distribution in the Leiner River watershed.

Upon returning to the Leiner River, adult sockeye move upstream and hold in the numerous pools located between counting stations 1 and 4. Of particular importance for sockeye holding is the deep pool located just downstream of counting station 2, opposite Pete's Farm. Additionally, sockeye are known to hold in the pool located at counting station 3 and in the pool and glide located just downstream of counting station 4 (Fisheries and Oceans Canada, 2012). See Figure 13 for the locations of key sockeye holding areas in the Leiner River.

During escapement assessment swims, heavy sockeye spawning has been observed in the long riffle just downstream of counting station 1. Of particular importance is the partially vegetated area on the left bank in this section (Fisheries and Oceans Canada, 2012). Occasional spawning is also observed just upstream of the confluence with the Perry River

(A. Eden, pers. comm.). See Figure 13 for the locations of known sockeye spawning areas in the Leiner River.

Little is known of the sockeye holding and spawning habitat in the Perry River; however, local knowledge suggests that sockeye make it as high up as the wetland, and future investigations should seek to identify known holding and spawning habitat in this system (Tahsis Enhancement Society, 2014).

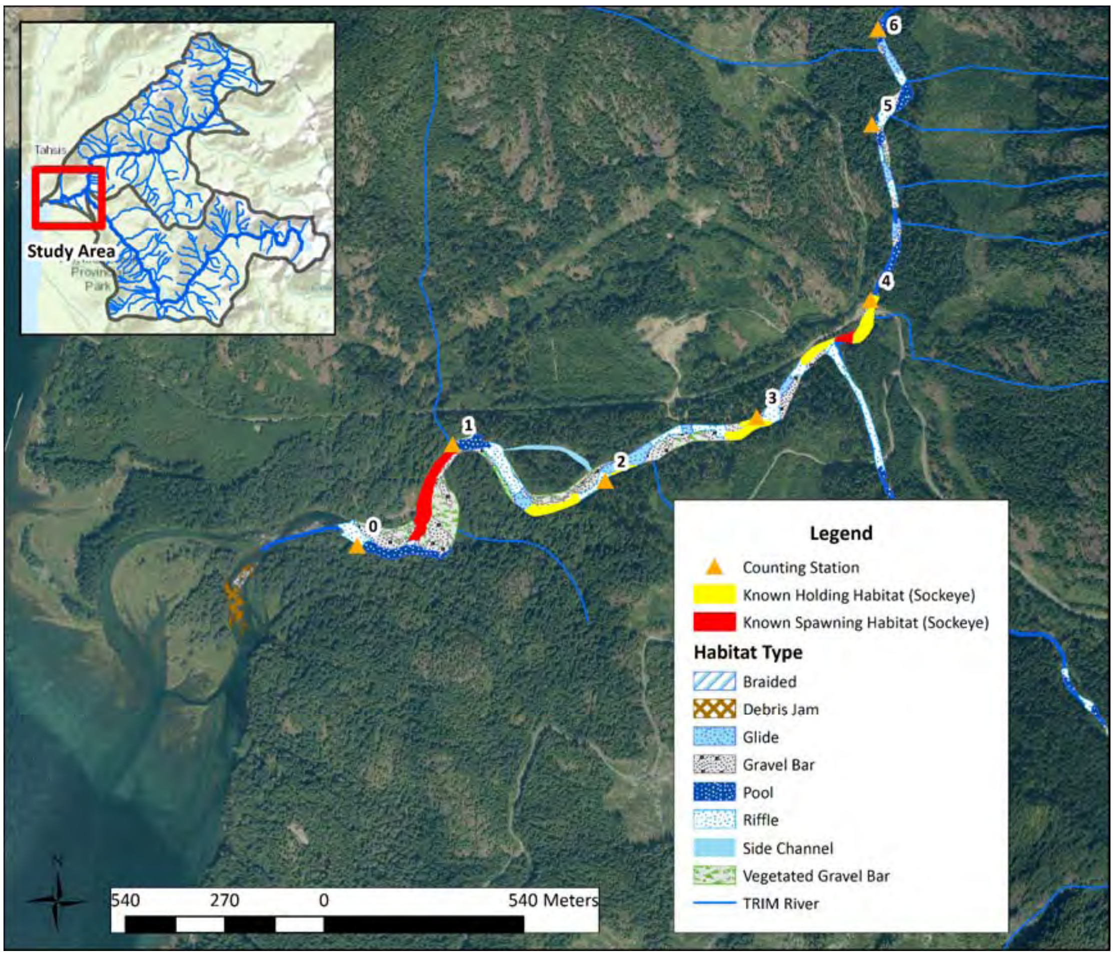

Figure 13. Known adult sockeye holding and spawning habitat in the Leiner River.

Sockeye in the Leiner and Perry Rivers, are likely sea-type, and migrate downstream following emergence and rear in the estuary prior to entering the marine environment (Diewerts, 2007). Little data exists on freshwater rearing habitats for the Leiner and Perry Rivers, and future investigations should seek to identify the location of key rearing habitat for this species. Key migration and rearing habitat is presented in Figure 14, and is based on general life history requirements (Diewerts, 2007).

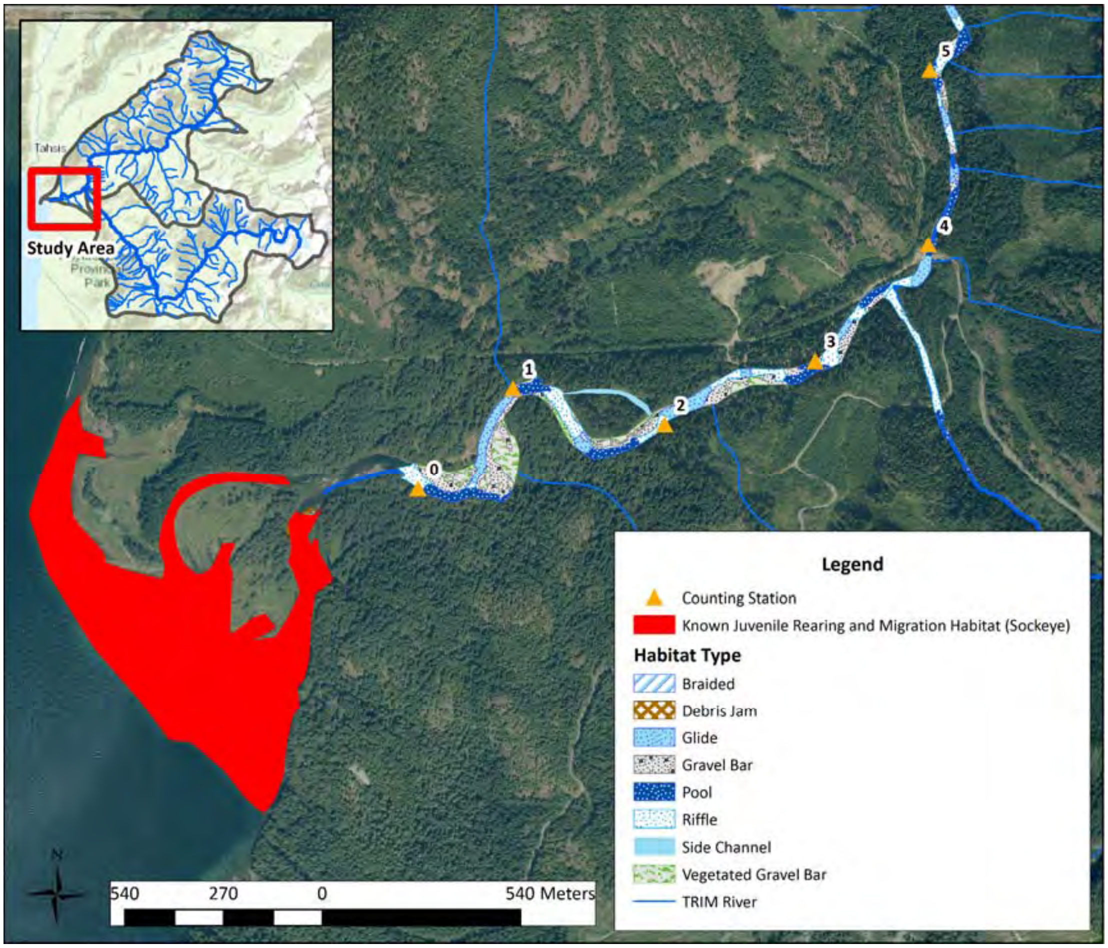

Figure 14. Known juvenile sockeye migration and rearing habitat in the Leiner River.

3.3.2 Escapement

The Leiner River has a stable population of sockeye, with recent escapements ranging from 700 – 1,500 fish, and a peak escapement of approximately 6,714 fish in 1997 (Figure 15). Sockeye escapements have displayed an interesting trend over the past three decades. Prior to 1980, sockeye were rarely observed in the Leiner River. However, through the 1980s and into the 1990s, the sockeye population increased dramatically. DNA examination indicated that the sockeye were genetically connected to the Leiner and were not based on a stray population (Fisheries and Oceans Canada, 2012). Little is known of the status of sockeye in the Perry River.

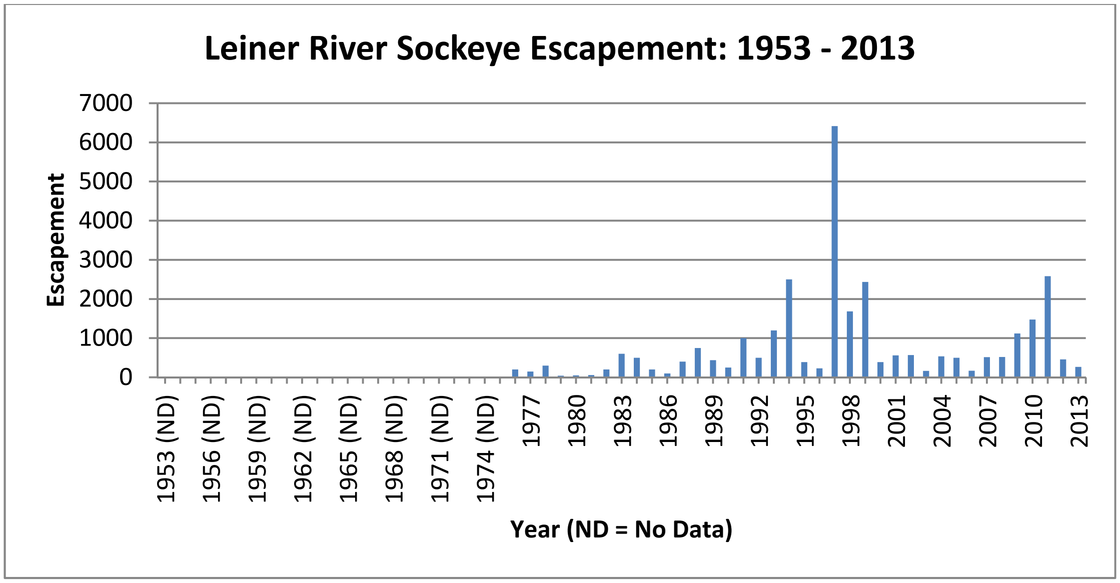

Figure 15. Sockeye escapement in the Leiner River between 1953 and 2013 (compiled from DFO's NuSEDS database).

3.4 Chum Salmon

3.4.1 Biology, Distribution, and Known Habitats

Chum salmon arrive in the Leiner River in late September and begin spawning in mid-October. Peak spawning is generally observed in late October and the run is finished by early November (Fisheries and Oceans Canada, 2012). Chum are distributed in the Leiner River up to the pool at counting station 4. Migration upstream of this point is likely impeded by the steep cascade upstream of the Leiner River bridge. Historical records indicate that chum make use of the Perry River for spawning, however, no recent observations exist (Heatherington, 1997; NuSEDS, 2015). Figure 16 presents the known distribution of chum salmon in the Leiner River watershed.

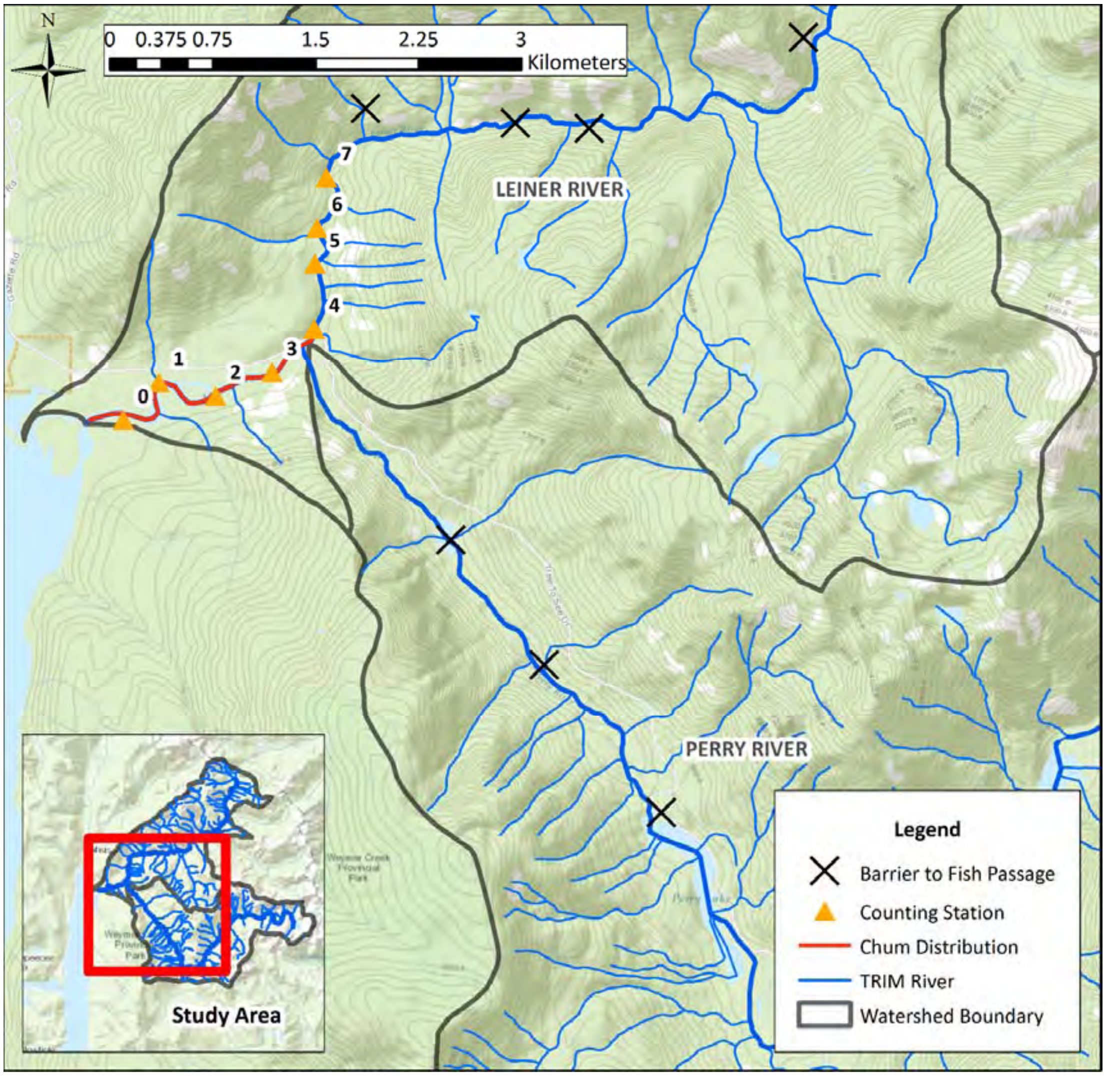

Figure 16. Chum distribution in the Leiner River watershed.

During upstream migration to the spawning grounds, chum salmon utilize several key holding pools between counting stations 0 and 4. Key holding habitat includes the large pool at counting station 0, the pool just upstream of counting station 1, the pool at the downstream end of the riffle just downstream of counting station 2, the pool at counting station 3, and the glide and pool just downstream of the Leiner River bridge and at the confluence of the Perry River (Fisheries and Oceans Canada, 2012). See Figure 17 for the locations of key chum holding areas in the Leiner River.

During escapement assessment swims, heavy chum spawning has been observed in the long riffle just downstream of counting station 1. Of particular importance is the partially vegetated area on the left bank in this section (Fisheries and Oceans Canada, 2012). Local knowledge indicates that chum also spawn in the tidal portion of some of the creeks and off-channel habitat located in the lower reaches of the watershed (Tahsis Enhancement Society, 2014). See Figure 17 for the locations of key chum spawning areas in the Leiner River.

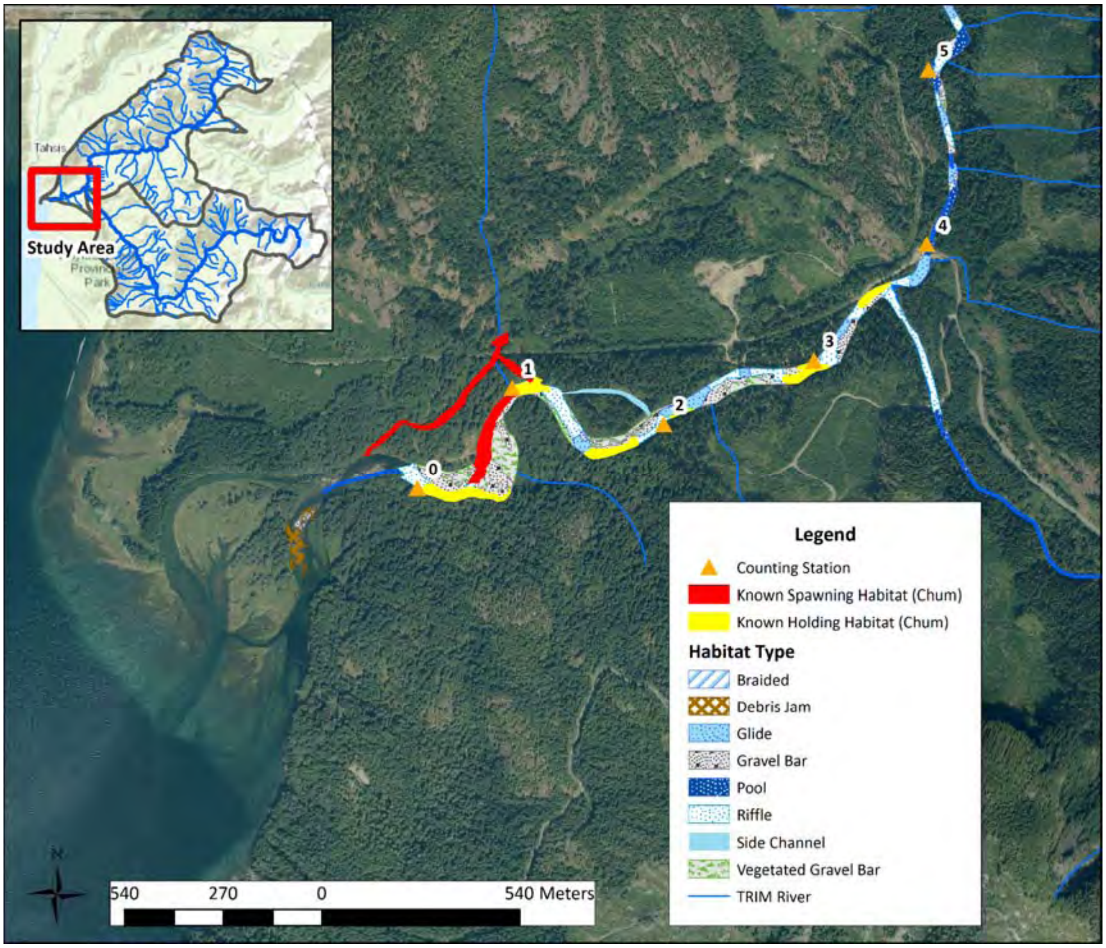

Figure 17. Known adult chum holding and spawning habitat in the Leiner River.

Like other species in the Leiner River watershed, the length of time required for egg incubation is partially dependant on water temperature. Upon emergence, chum fry immediately begin downstream migration to the estuary, typically between the months of March and May (Diewerts, 2007).

Chum salmon are highly dependent on estuaries for rearing and are known to spend more time in this zone than any of the other species. This period of residence in the estuarine environment appears to be the most critical phase of the life history of chum salmon, and plays a major role in determining the size of the adult return (Aitkin, 1998). Given this important life history requirement, the Leiner River estuary has been classified as known juvenile migration and rearing habitat (Figure 18).

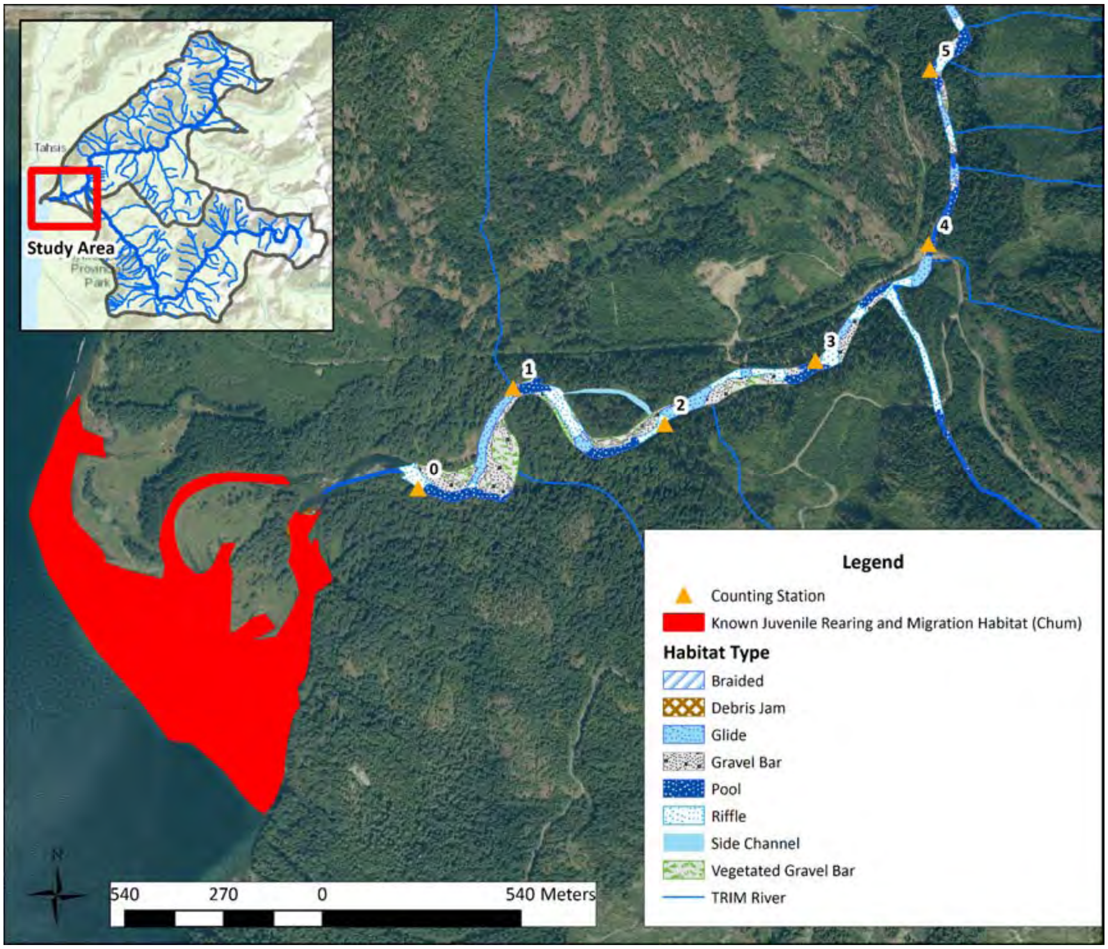

Figure 18. Known juvenile chum rearing and migration habitat in the Leiner River.

3.4.2 Escapement

Chum salmon have experienced falling returns in the Leiner River over the past 5 years, a trend that has been observed in chum populations coast-wide (Fisheries and Oceans Canada, 2012) (M. Wright, pers. comm.). The highest escapement over the last decade was roughly 5,000 fish, whereas the peak count in 2011 was roughly 700 fish (Figure 19). Escapement counts from the mid-1950s indicate that there may have been as many as 1,500 chum spawning in the Perry River at this time; however, there have been no recent counts to determine if chum still utilize the Perry River. Future investigations should seek to elucidate the status of chum salmon in the Perry River, as this system may support a significant number of this species.

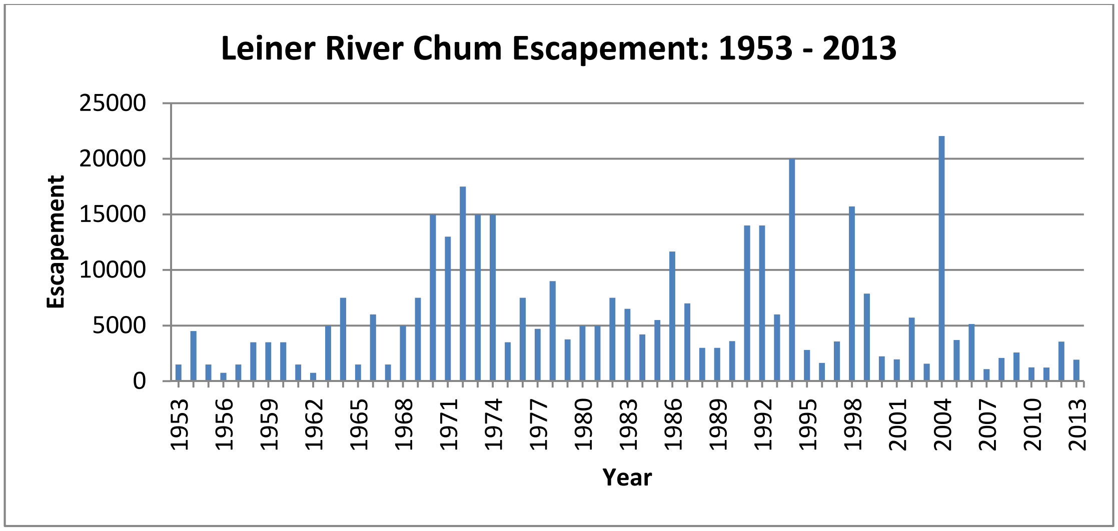

Figure 19. Chum escapement in the Leiner River between 1953 and 2013 (compiled from DFO's NuSEDS database).

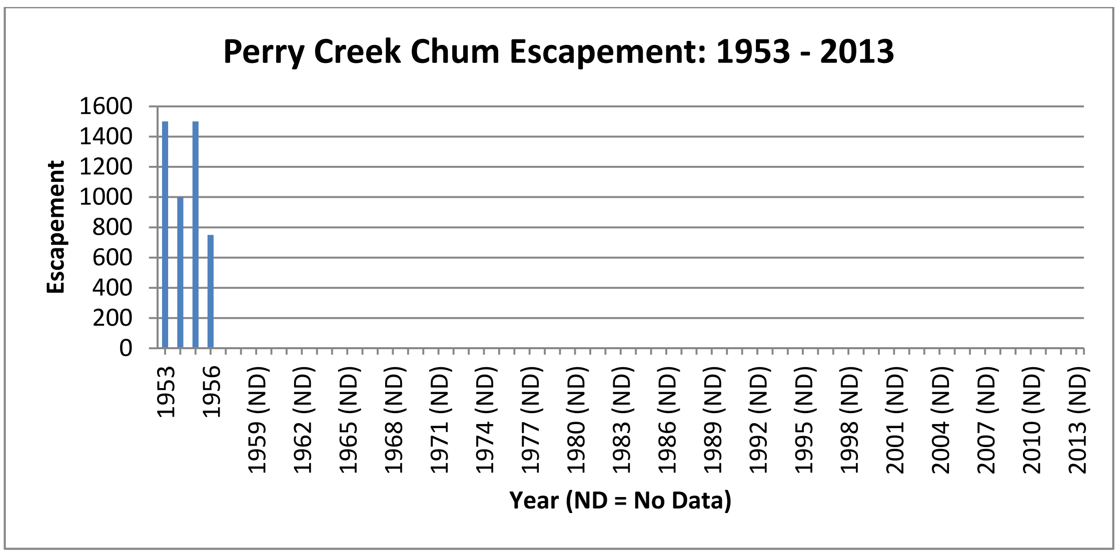

Figure 20. Chum escapement in the Perry River between 1953 and 2013 (compiled from DFO's NuSEDS database).

3.5 Pink Salmon

Historically, the Leiner River supported a relatively large run of pink salmon, with returns reaching as high as 15,000 individuals. Recent returns, however, have been very low and it is unclear whether the few individuals observed have been strays or if they are genetically related to the historical population of pinks in the Leiner and Perry River systems (Fisheries and Oceans Canada, 2012) (Figure 21). Historical observations indicate that pink salmon used to be distributed up to the bridge in the Leiner River and as far up as the wetland in the Perry River (Tahsis Enhancement Society, 2014). Future genetic analysis may be required to determine if the returning pinks are related to the historical stocks and if they should be a focus of enhancement efforts. Due to the low number of pinks in the Leiner and Perry Rivers, this species is not considered in further discussions of habitat indicators and limiting factors.

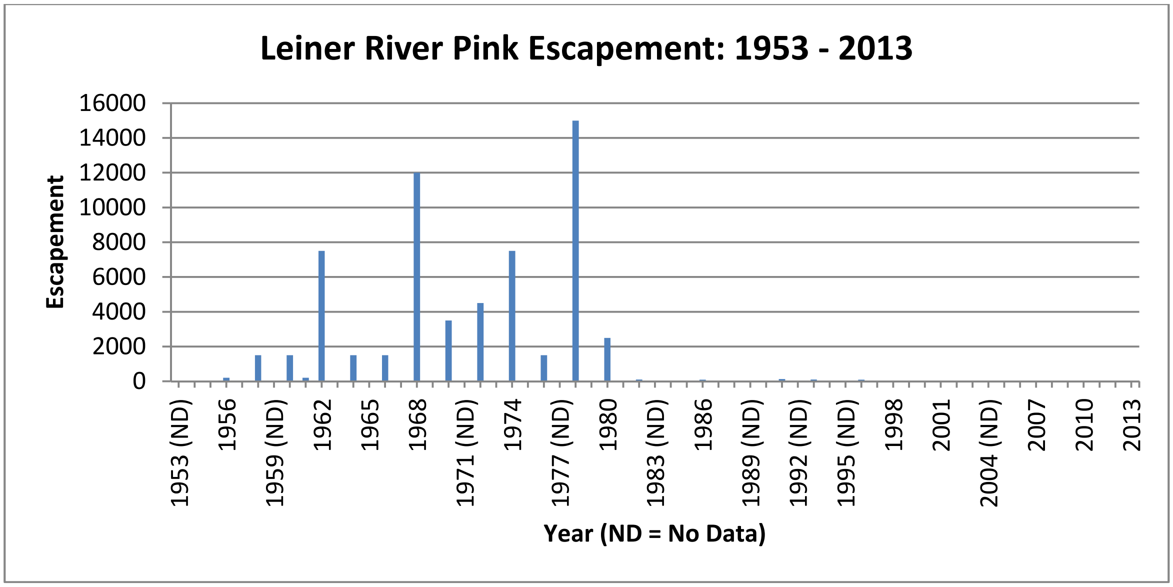

Figure 21. Pink salmon escapement in the Leiner River between 1953 and 2013 (compiled from DFO's NuSEDS database).

4.0 HABITAT INDICATOR ASSESSMENT RESULTS

The following sections present the results of the assessed habitat status indicators in the Leiner River watershed.

4.1 Stream Pressure Indicator: Total Land Cover Alterations

Total land cover alterations for the Leiner River watershed (including both the Leiner River and Perry River watersheds) are summarized in Figure 22 and Figure 23:

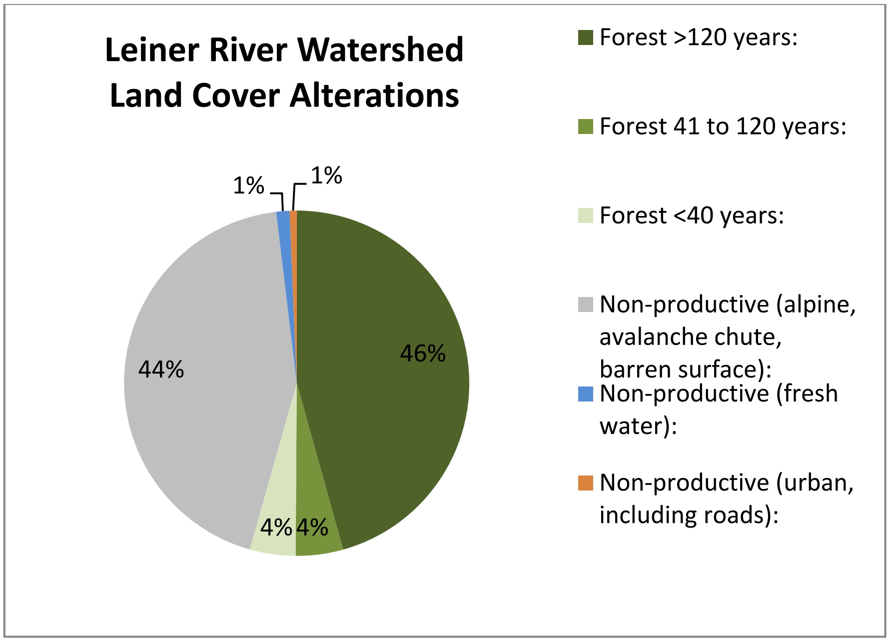

Figure 22. Total land cover alterations for the Leiner River watershed.

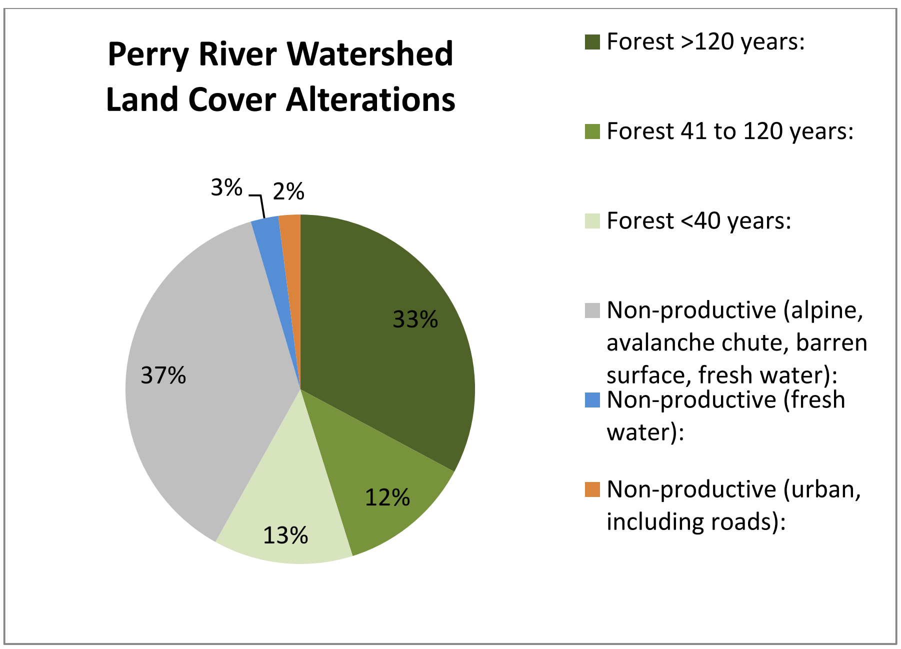

Figure 23. Total land cover alterations for the Perry River watershed.

In the Leiner River, approximately 91% of the watershed land remains unaltered, with mature (>120 year old) forest (46%) and naturally non-productive (44%) (i.e., alpine, avalanche chute, and barren surfaces) areas comprising the majority of the land in roughly equal proportions. Approximately 1% of the watershed has been altered as roads, and approximately 8% of the watershed remains as altered forests (i.e. <120 years old). Note that this analysis does not include data for the campsite in the lower Leiner River.

In the Perry River watershed, 73% of the land remains unaltered with mature forest (33%) and non-productive areas (40%) comprising the majority of this portion. Roughly 2% of the watershed has been altered as roads and power transmission line right-of-ways, and 25% of the watershed remains as altered forest.

An analysis of the distribution of altered land cover area in the Leiner River indicates that any recent alterations have generally not been located in close proximity to the critical salmonid habitat sections of the river, except for some sections in the lower reaches. Data for the lower reaches of the system should not be considered complete as a block of parkland between counting stations 2 and 0 was not included in the provided land cover data. The Leiner River is considered to be quite stable in its lower reaches with the only bank erosion evident is along the right bank below counting station 1 at Pete's Farm and as a result the watershed has been classified as low risk for total land cover alterations. See Figure 24 for the distribution of total land cover alterations in the Leiner River.

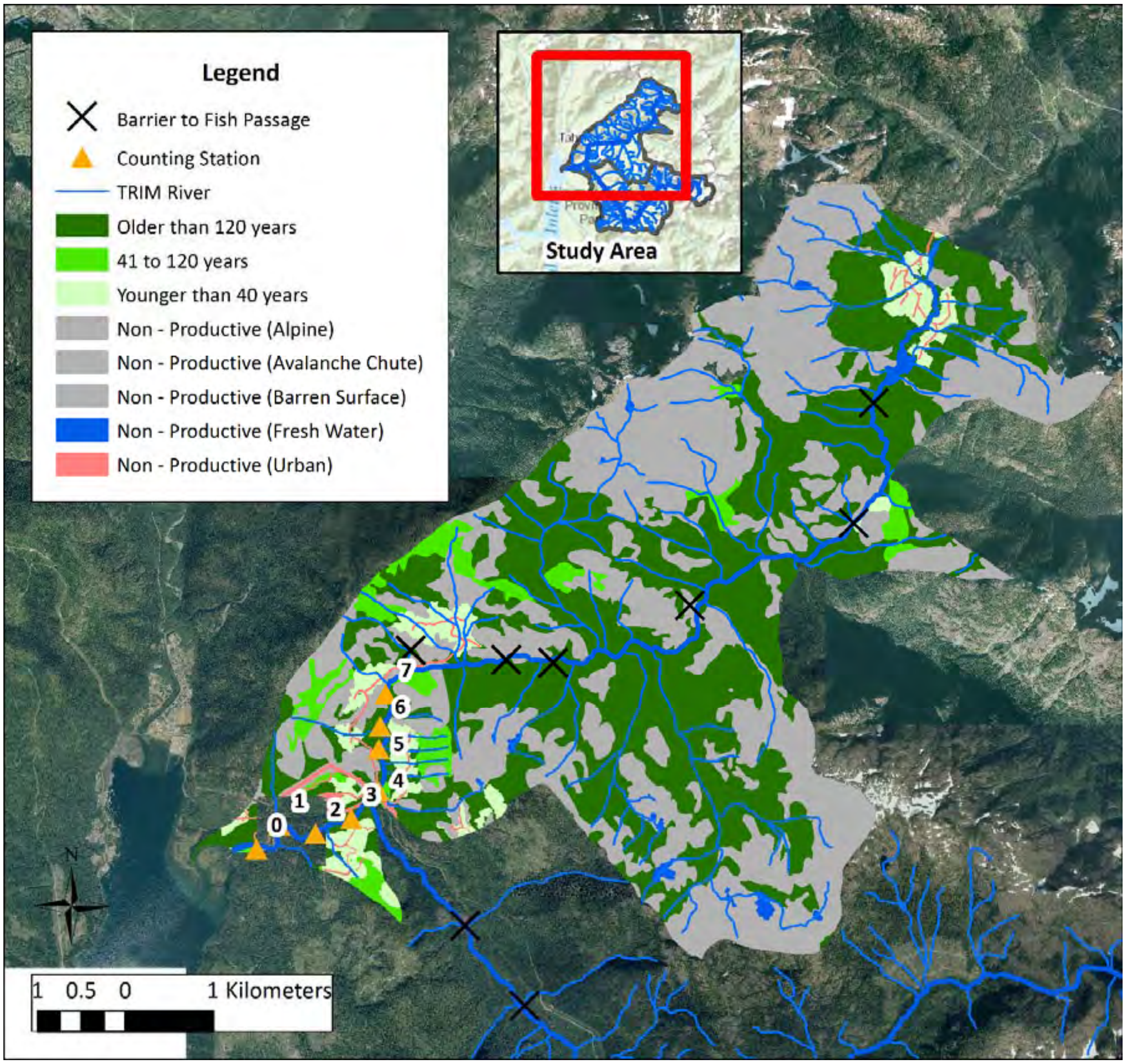

Figure 24. Distribution of total land cover alterations in the Leiner River drainage.

Analysis of the distribution of altered cover in the Perry River indicates that this system has had much higher loss of cover in potentially productive areas. It can be seen in Figure 25 that long sections of forest adjacent to the river have been logged within the last 60 years. Much of this forest was logged right to the river banks in the 1960s and 70s (Heatherington, 1997). Impacts such as channel aggradation and over widening have been observed as a result of this land alteration; however, the system appears to be in a trend of recovery (Heatherington, 1997 and Horel, 2008). Perry Lake and the wetland likely act as sediment sinks, which serve to protect the downstream section of the creek from the impacts of land cover alteration. For these reasons, the Perry River is considered to be moderate risk for land cover alterations.

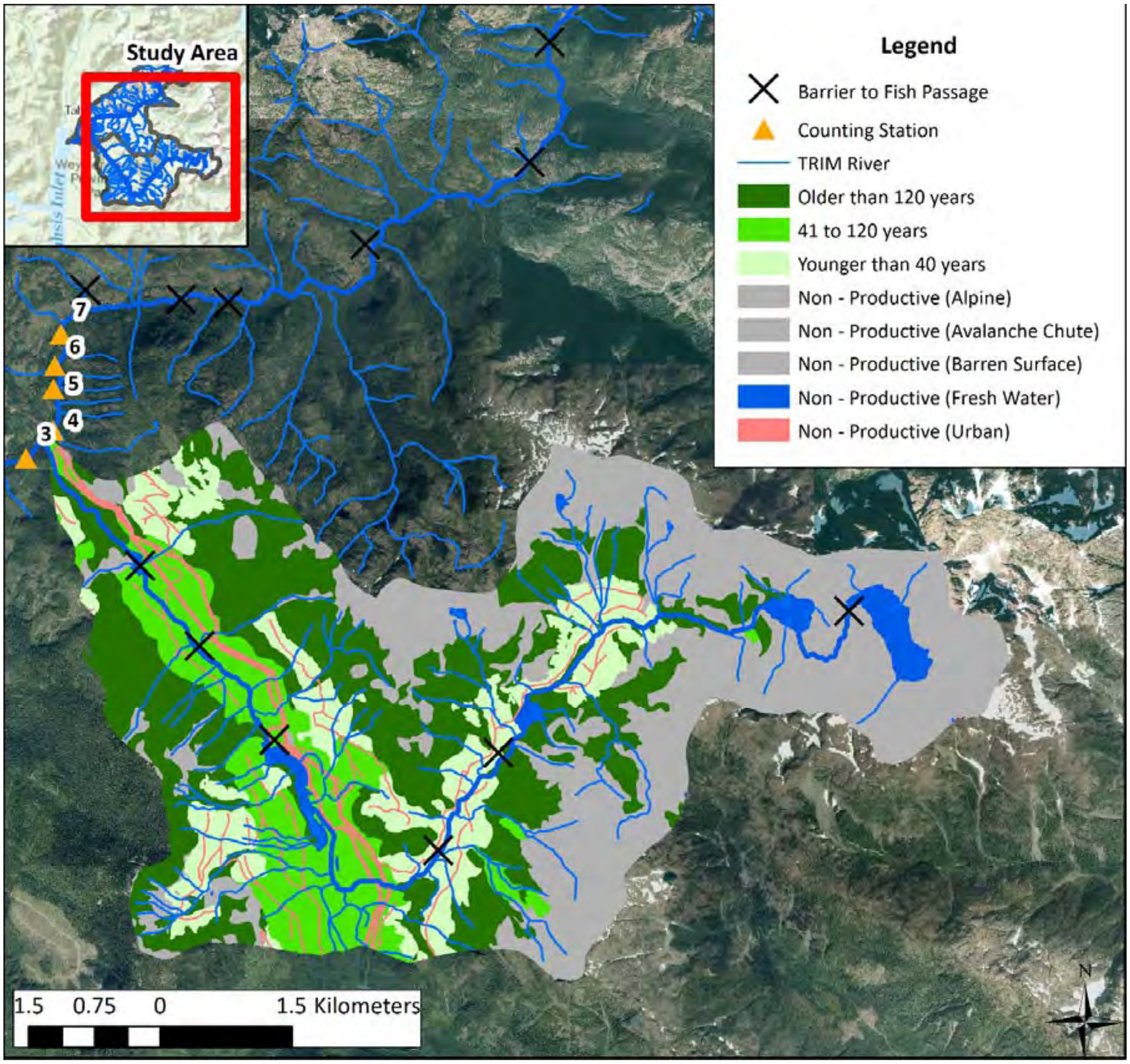

Figure 25. Distribution of total land cover alterations in the Perry River watershed.

4.2 Stream Pressure Indicator: Watershed Road Development

Watershed road development density was calculated to be 0.410km/km^2 for the Leiner River watershed, and 1.114km/km^2 for the Perry River watershed. Road density in the Leiner River watershed was roughly equal to the suggested benchmark of 0.4km/km^2 (Stalberg et al, 2009), whereas the Perry River watershed exceeded this benchmark. See Figure 26 for the locations of road development in each watershed. Given the fact that the road density in the Leiner River watershed is roughly equal to the suggested benchmark, this system is considered to be at moderate risk from watershed road development density. Conversely, the Perry River watershed is considered to be high risk as the road development density was significantly higher than the suggested benchmark.

Despite the high road density calculation in the Perry River watershed, it should be noted that simple road density (i.e. total length of road per area of watershed) does not distinguish between roads that are overgrown relative to those that are in active use, roads that have been deactivated or remediated from roads that have not, or roads built before the Forest Practices Code (FPC) from those built under FPC standards (Horel, 2008).

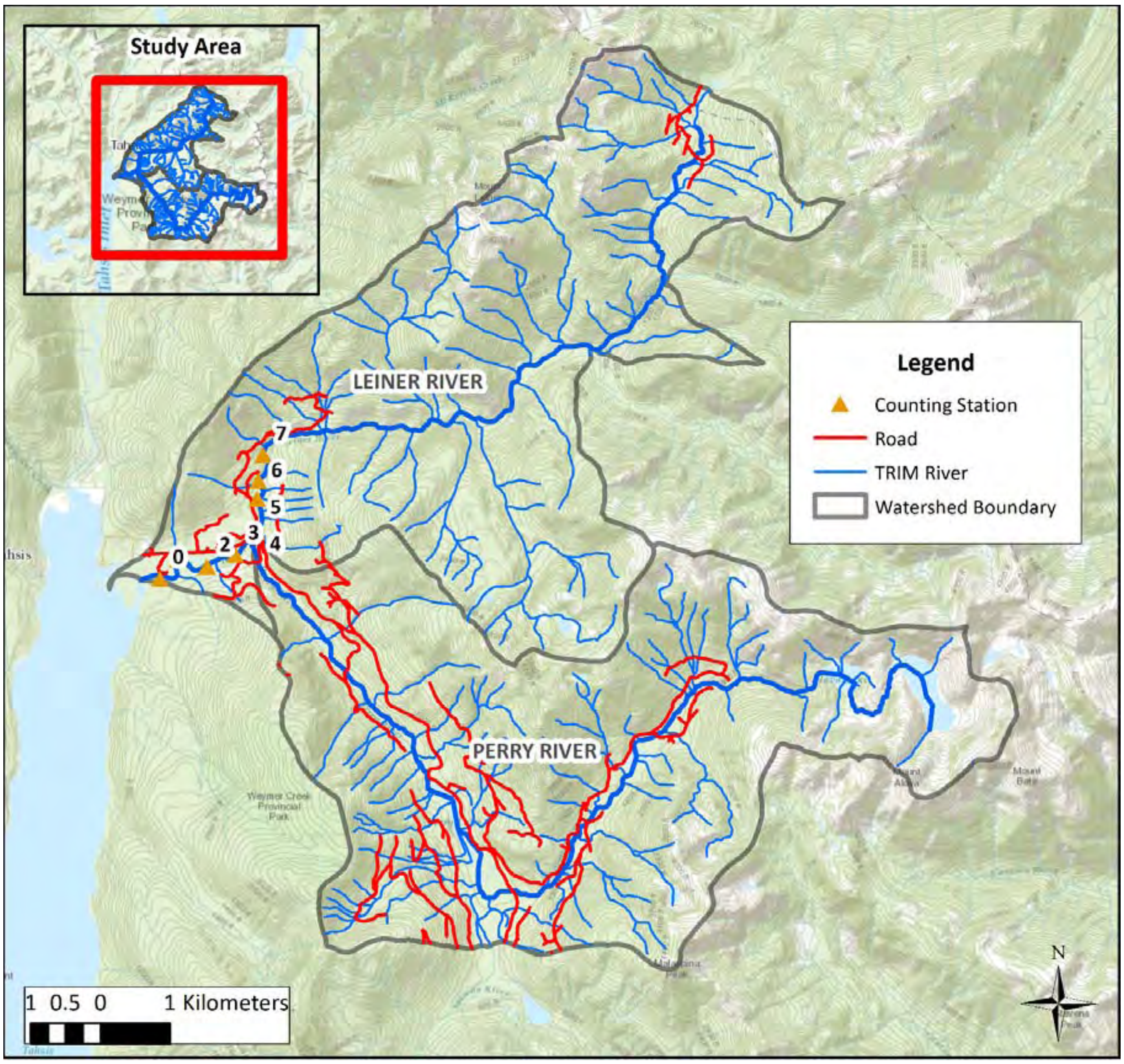

Figure 26. Watershed road density in the Leiner River and Perry River watersheds.

4.3 Stream Pressure Indicator: Water Extraction

There is presently one active water extraction licence application on the Leiner River to divert water just upstream of counting station 7 for the purposes of power generation. On the Perry River there are presently two active licence applications – one to divert water from Perry Lake for power production, and one to utilize Perry Lake for water storage for use in the power project (Figure 27). Two previous applications to divert and store water at Perry Lake were rejected. Additionally, an application to divert water from the upper reaches of the Perry River was rejected. Considering the non-consumptive nature of these water licence applications, and the fact that there is no active water extraction occurring on either river, the Leiner and Perry River watersheds are considered low risk for water extraction.

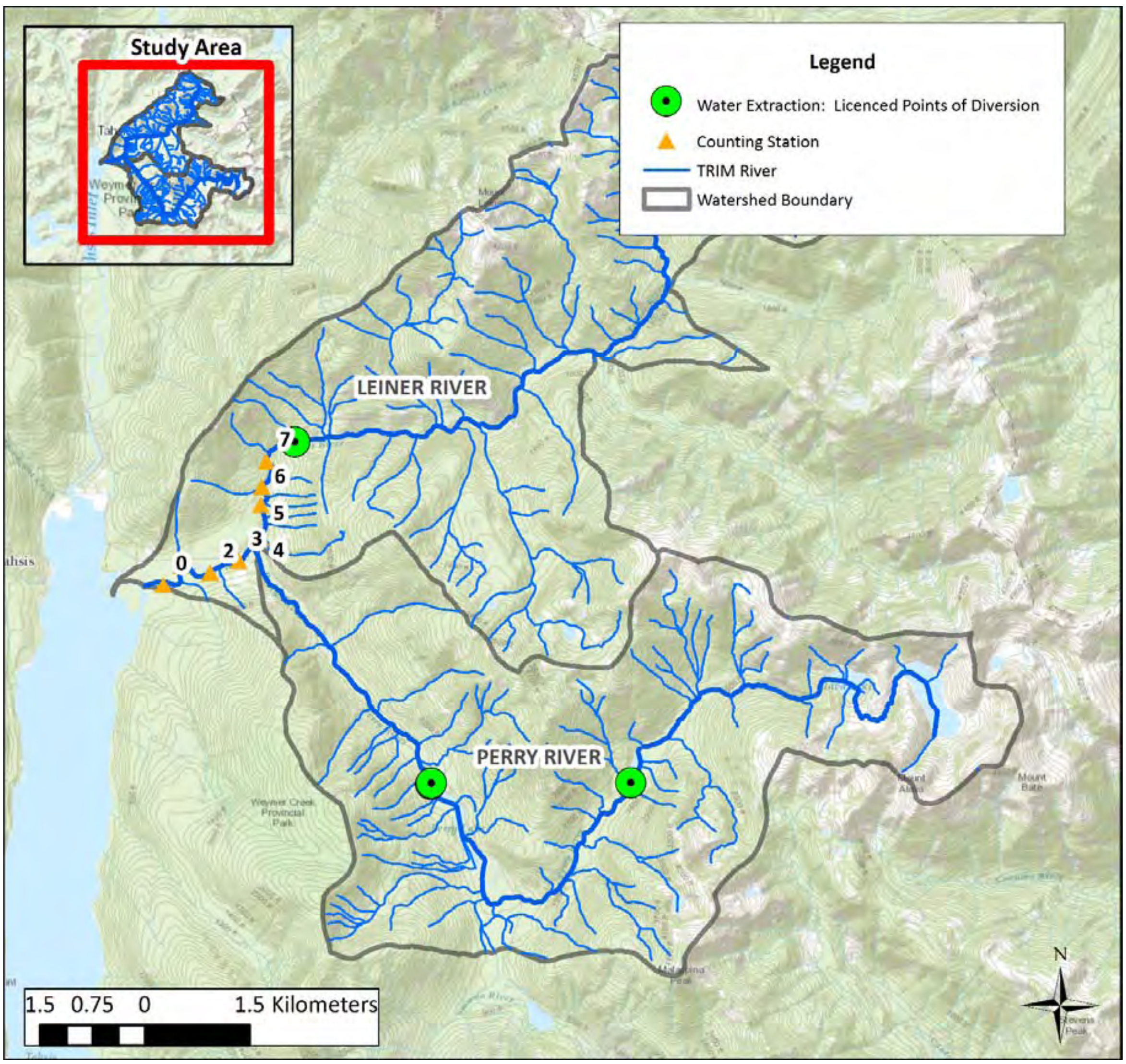

Figure 27. Licenced water points of diversion for the Leiner River and Perry Rivers watershed.

4.4 Stream Pressure Indicator: Riparian Disturbance

The riparian forests bordering the Leiner River and Perry Rivers are in an advanced state of recovery with a large component (64% and 69% respectively) classified as mature (>41 years). (Figures 28, 29 and 30). There are some areas in the Leiner/Perry Rivers where some of the fish habitats bordered by riparian forests comprised of deciduous regenerating, early regenerating and non-productive (i.e. Pete's Farm). These are areas that will continue to experience some channel instability. An assessment of the deciduous stands should be made to develop a prescription to accelerate the recovery of these deciduous stands to a predominantly coniferous stand.

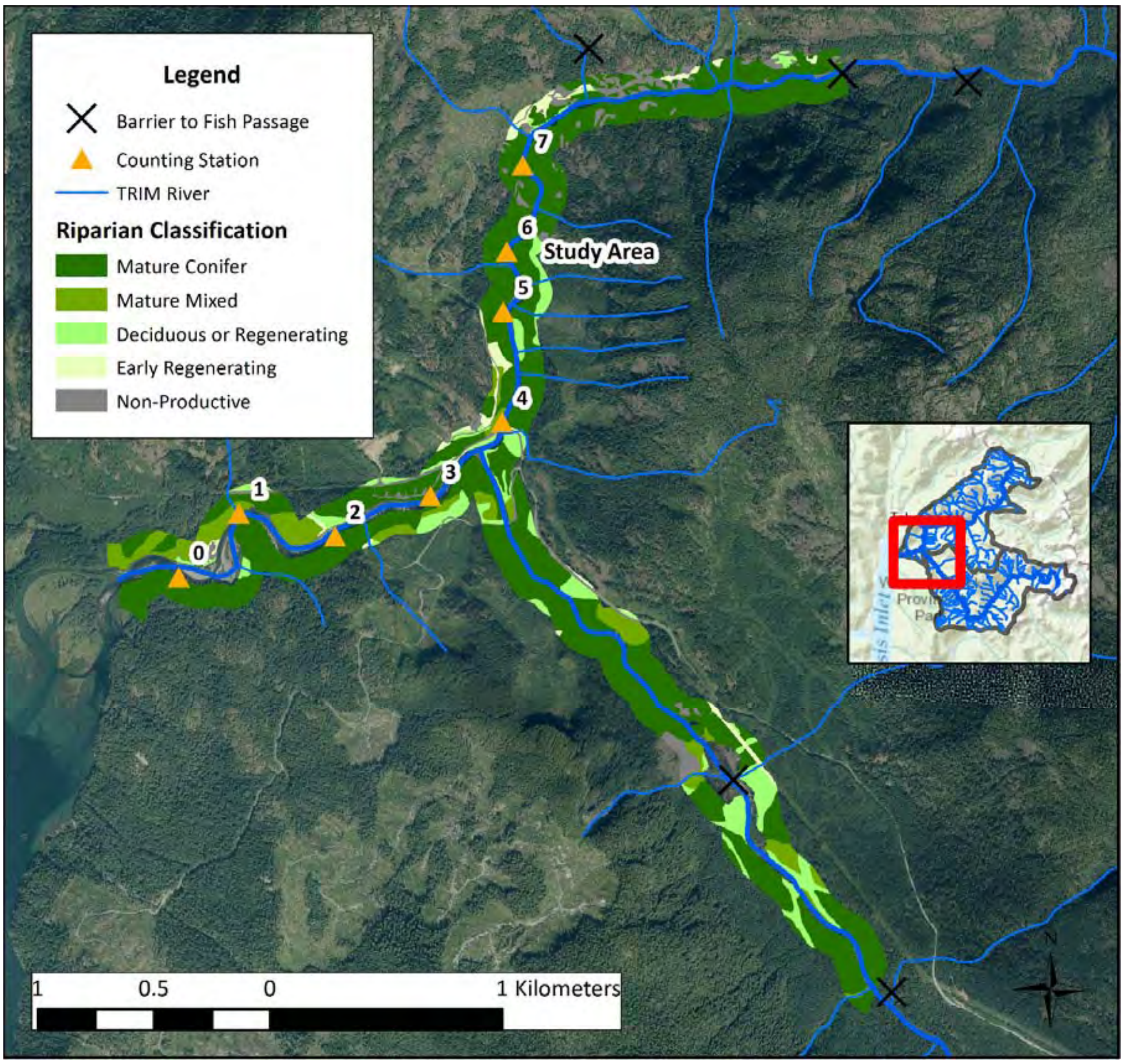

Figure 28. Riparian disturbance in the Leiner River and Perry Rivers watershed.

The riparian forests are likely providing protection for spawning and rearing habitats for all species of salmon and are stabilizing because of increased channel bank stability (this should be confirmed). In its present state the Leiner and Perry Rivers riparian forests are likely stable enough to provide critical functions to the aquatic environment, including: temperature regulation, sufficient root structure to hold soils together, which will control sediment input, eventually will provide a source of LWD to increase channel structure and stability, energy through leaf litter inputs and nutrients.

The suggested benchmark for riparian disturbance is 5% (Stalberg et al, 2009); however, due to the apparent stability of the Leiner River, and the steady regeneration of vegetation alongside the Perry River, this system is considered low risk for riparian disturbance.

An analysis of riparian condition for tributaries to the Leiner and Perry rivers was not possible based on the uncertainty of the location of these streams. As such, this has been identified as a data gap for coho, considering this species is the heaviest utilizer of these types of habitats. The riparian zone should also be evaluated to determine the age and size of trees in the riparian forest.

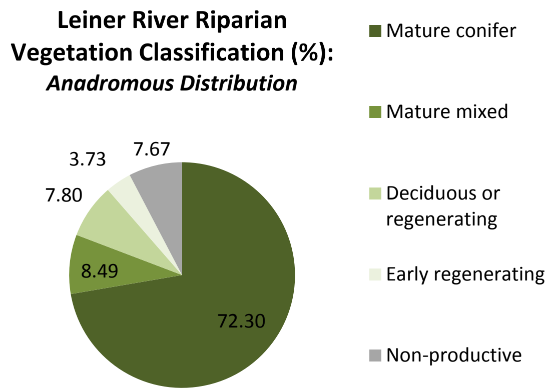

Figure 29. Riparian vegetation composition for the anadromous reach of the Leiner River watershed.

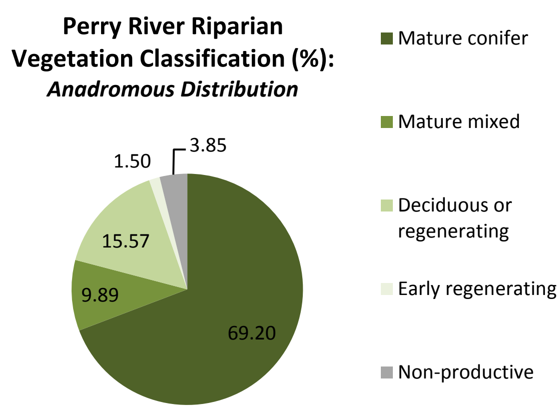

Figure 30. Riparian vegetation composition for coho and sockeye in the Perry River.

4.5 Stream Pressure Indicator: Permitted Waste Management Discharges

There are presently no waste or waste water disposal permits in the Leiner River or Perry River watersheds. As such, this watershed is given a low risk rating for permitted waste management discharges.

4.6 Stream State Indicator: Water Quality

Interviews with the NSWS and local experts indicated the likelihood of water quality in this system to be impacting productivity levels was low (with the exception of intergravel flow DO levels) (NSWS, 2015). Limited water quality data was available for the Leiner River and Perry River watersheds through EMNG regional geochemical stream survey monitoring sites. A total of nine geochemical monitoring sites have been established in the watershed, with four on the Leiner River and five on the Perry River (see Figure 31). All sites were sampled once in 2007.

Data collected in 2007 at these nine showed that, of the metals detected in the samples (copper, lead, mercury, molybdenum, and zinc), all remained below the Canadian Water Quality Guidelines for the Protection of Aquatic Life (Canadian Council of Ministers of the Environment, 2014). At one site on the Perry River, the sampled value for molybdenum was approaching the recommended maximum; however, all other sites sampled showed values well below the maximum suggested limit for molybdenum. Subsequent sampling could be conducted to determine if this was an aberrant value. Reported pH values at these sites were between 6.0 and 6.4 (BC Ministry of Energy and Mines, 2015).

Note that no water quality data with respect to in-stream and intergravel DO was available for Leiner and Perry Rivers watershed. While the data available indicated that (of the sampled parameters) no issues were identified, the spatial and temporal distribution of this data was not robust enough to determine its influence on fish production in the watershed. As such, the water quality habitat indicator has been identified as a data gap.

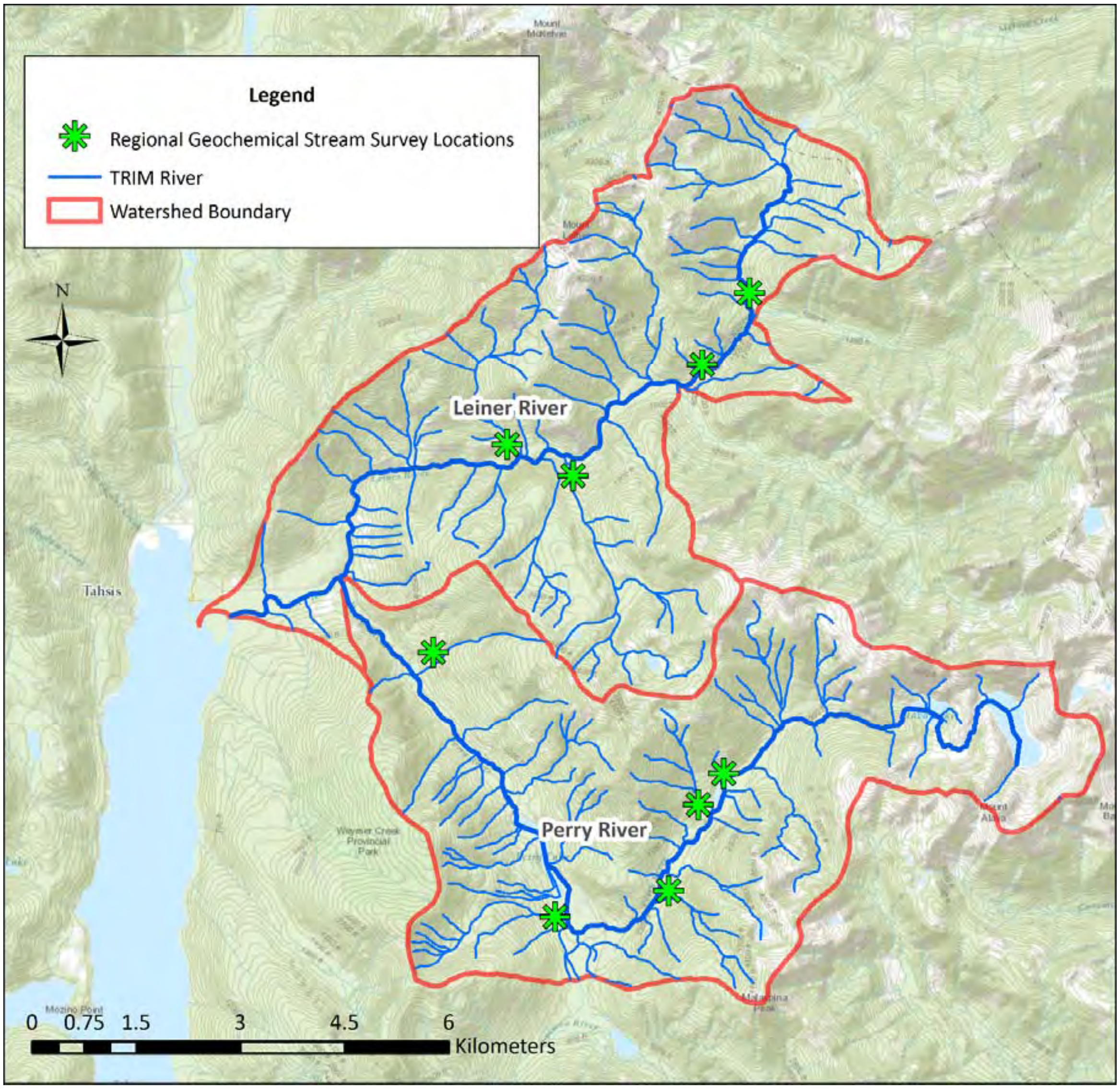

Figure 31. Regional geochemical stream survey locations in the Leiner River and Perry River watersheds.

4.7 Stream State Indicator: Water Temperature (Migration and Spawning)

Interviews with local experts indicated water temperatures in the Leiner and Perry rivers to not likely be impacting productivity levels (NSWS, 2015). Compilation of SIL data during the spawning period on the Leiner River demonstrated water temperatures to have remained below the UOTR (between 15°C and 20°C) for all species between 2006 and 2013. The limit was approached on September 17, 2013, but has never been exceeded. As such, this habitat indicator was ranked as low risk.

Note that this indicator was identified as a partial data gap given the limited temporal distribution of these point samples.

Table 2. Water temperature data from 2006 to 2013 for the Tahsis River during adult migration and spawning.

LEINER RIVER						
Year	***Date***	***Temperature (°C)***	***Species Present***			
			SK	***CO***	***CH***	***CM***
2006	Sept. 20	11	X	X	X	X
	Sept. 26	10	X	X	X	X
	Oct. 6	8.5	X	X	X	X
	Oct. 11	8	X	X	X	X
	Oct. 30	6	X	X	X	X
	Nov. 13	5	X	X	X	X
	Nov. 24	3.5		X		X
	Nov. 26	3	X	X		X
	Dec. 22	3		X		
2007	Aug. 31	11	X	X	X	X
2008	Sept. 6	9	X	X	X	
	Sept. 23	9	X	X	X	X
	Oct. 1	10	X	X	X	X
2010	Sept. 8	10	X	X	X	X
	Sept. 29	8	X	X	X	X
	Oct. 3	10	X	X	X	X
	Oct. 4	10	X	X	X	X
	Oct. 5	9	X	X		X
	Oct. 15	8	X	X	X	X
	Oct. 16	8	X	X	X	X
	Oct. 28	9	X	X	X	X
	Nov. 14	7	X	X		X
2011	Sept. 9	12	X	X	X	X
	Sept. 16	9.5	X	X	X	X
	Sept. 18	9	X	X	X	X
	Sept. 29	10	X	X	X	X
	Oct. 2	9	X	X	X	X
	Oct. 7	10	X	X	X	X
	Oct. 14	7	X	X	X	X
	Oct. 25	6	X	X	X	X
	Nov. 15	5	X	X	X	X
	Dec. 2	5	X	X		
2012	Sept. 4	12	X	X	X	X
	Sept. 14	10	X	X	X	X
	Sept. 16	10	X	X	X	X
	Sept. 23	10	X	X	X	X
	Sept. 26	8	X	X	X	X
	Oct. 4	8	X	X	X	X
	Oct. 7	6	X	X	X	X
	Oct. 24	6	X	X	X	X
	Oct. 26	6	X	X	X	X
	Nov. 8	6	X	X		X
	Nov. 12	6	X	X		X
2013	Sept. 4	13	X	X	X	X
	Sept. 17	14	X	X	X	X
	Oct. 9	8	X	X	X	X
	Oct. 15	8	X	X	X	X
	Oct. 28	7	X	X	X	X
	Nov. 10	7	X	X	X	X

4.8 Stream State Indicator: Discharge

Discharge data for the Leiner and Perry Rivers watershed was limited. At present, there is no WSC flow gauge or DFO hydromet station on either river; however, DFO personnel have collected several discharge measurements from the Leiner River, and plans are in place to collect sufficient stage-discharge data to develop a rating curve for this system. Discharge measurements were collected at the Leiner River bridge using a Sontek Hydroboard and the River Surveyor Live software. See Table 3 for the discharge measurements collected at the Leiner River to date.

Table 3: Discharge measured at the Leiner River bridge during 2014 by DFO technicians.

Sample Date	Discharge (m^3/s)	Standard Deviation (m^3/s)
August 8, 2014	0.88	0.18
October 20, 2014	26.04	0.38
November 25, 2014	13.31	0.99

A 1992 flood water mapping study on the Leiner River estimated the 20-year daily return of discharge at 463m^3/s and an instantaneous peak discharge of 792m^3/s (Sellars, 1992). This data was not available for the Perry River. Interviews with local experts indicated that recent forest harvesting in the Perry River watershed may be increasing peak flows; however, this is being actively managed through rates of cut (NSWS, 2015).

An assessment of discharge in the Leiner and Perry Rivers against the suggested benchmark of 1 in 2 year 3-day duration minimum flow of less than 20% MAD was not possible based on the absence of continuous discharge data. As such, this indicator has been identified as a data gap. Continuation of DFO's river surveyor program will facilitate the future establishment of a stage-discharge relationship for the Leiner River.

4.9 Stream State Indicator: Accessible Stream Length

Information on accessible stream length for the Leiner and Perry Rivers watershed was compiled from the Leiner River stream narrative (Fisheries and Oceans Canada, 2012), FISS, and interviews with the local Tahsis Enhancement Society. Based on the GIS distribution data presented in Figure 3, Figure 7, Figure 12, and Figure 16, Table 4 summarizes accessible stream length by species.

Table 4. Accessible stream length, by species, for the Leiner and Perry Rivers watershed. All values in km. Values with an asterisk (*) are considered to be data gaps.

	Chinook	Coho	Sockeye	Chum
Leiner Mainstem	2.19	8.19	2.19	2.19
Leiner Tributary	0.00	3.17	0.00	0.00
Perry Mainstem	0.00*	3.50	1.87	0.00*
Perry Tributary	0.00	0.45	0.00	0.00
Total	2.19	15.31	4.06	2.19

The upstream distributional extent of chinook, sockeye, and chum in the Leiner River is the bridge at counting station 4. Coho are able to migrate much further upstream and also make use of tributaries for spawning habitat and as such, the accessible length for coho is much higher than it is for any other species. The accessible length for chinook and chum in the Perry River is identified as a data gap since historical observations place these species in the Perry River, but none have been observed in recent years. Future escapement surveys should seek to determine the status of Chinook and chum in the Perry River in order to fill this data gap.

Continual monitoring will be required to determine if accessible stream length is a limiting factor to fish production (i.e. if this length is reduced over time, it may be identified as limiting).

4.10 Stream State Indicator: Key Spawning Areas (Length)

Key spawning area lengths, by species, were calculated based on the locations presented in Figure 4, Figure 8, Figure 13, and Figure 17. For detailed descriptions of spawning locations for each species, please refer to Section 3.0. Table 5 presents the total length of the key spawning areas on the Leiner River. Information on key spawning areas was not available for the Perry River.

Table 5. Key spawning area lengths, by species, for the Leiner River.

Chinook	Coho	Sockeye	Chum
0.298km	Data Gap	0.269km	0.269km

Data for coho, however, should not be considered complete as there was little information available in regard to preferred spawning grounds on the Leiner River for this species. Due to the fact that their distribution extends beyond the index area surveyed by DFO, it is likely that there are other key spawning areas for coho in the Leiner River. Future surveys should be conducted over the entire length of the coho distribution in the Leiner River in order to identify all of the key spawning areas for this species.

Additionally, there is no data for the key spawning locations of any species in the Perry River. This system should be surveyed as part of the fall spawner escapement assessments in order to determine the key spawning areas for all species that utilize the Perry River.

4.11 Stream State Indicator: Stream Crossing Density

Table 6 summarizes the available stream crossing data for the Leiner River and Perry River watersheds.

Table 6. Stream crossing density (and fish-bearing status) in the Leiner and Perry Rivers watershed, as modelled in the PSCIS database.

LEINER RIVER		PERRY RIVER	
# of Crossings:	30	# of Crossings:	85
# of Fish-Bearing:	11	# of Fish-Bearing:	36
# of Non-Fish Bearing:	19	# of Non-Fish Bearing:	49
Crossing Density:	0.78/km2	Crossing Density:	2.16/km2

The results based on the PSCIS database indicate that the Perry River has a much higher stream crossing density than the Leiner River, and both rivers have a higher density than the neighbouring Tahsis River (deVisser and Wright, 2015). The suggested benchmark for this indicator is a relative comparison of crossing density and number of modeled fish-bearing crossings (Stalberg et al, 2009). In the Leiner River, 37% of the crossings are fish bearing, whereas 42% of the crossings are fish-bearing in the Perry River. Due to the higher crossing density and the (marginally) higher proportion of fish-bearing crossings in the Perry River as compared to the Leiner, the Perry River could be considered as higher risk than the Leiner; however, no data exists on the status of the stream crossings in either system. Therefore, the risk associated with stream crossing density should be considered a partial data gap until further field assessments have been performed on the crossings in the area. Based on the present assessment, the Leiner River is ranked as low risk and the Perry River is ranked as moderate risk from this pressure indicator.

4.12 Stream State Indicator: Habitat Composition

An analysis of habitat in the Leiner River from counting station 6 down to tidal water indicates that there is a generally even distribution of riffle, pool, and glide habitat, with the most dominant feature type being glide habitat. There are also a high proportion of gravel bars, especially in the lower sections of the Leiner River from the bridge down. Figure 32 presents the habitat mapping of the Leiner River. Mapping upstream of counting station 6 was not possible as a closed canopy and / or steep-walled canyon sections obscured the stream features.

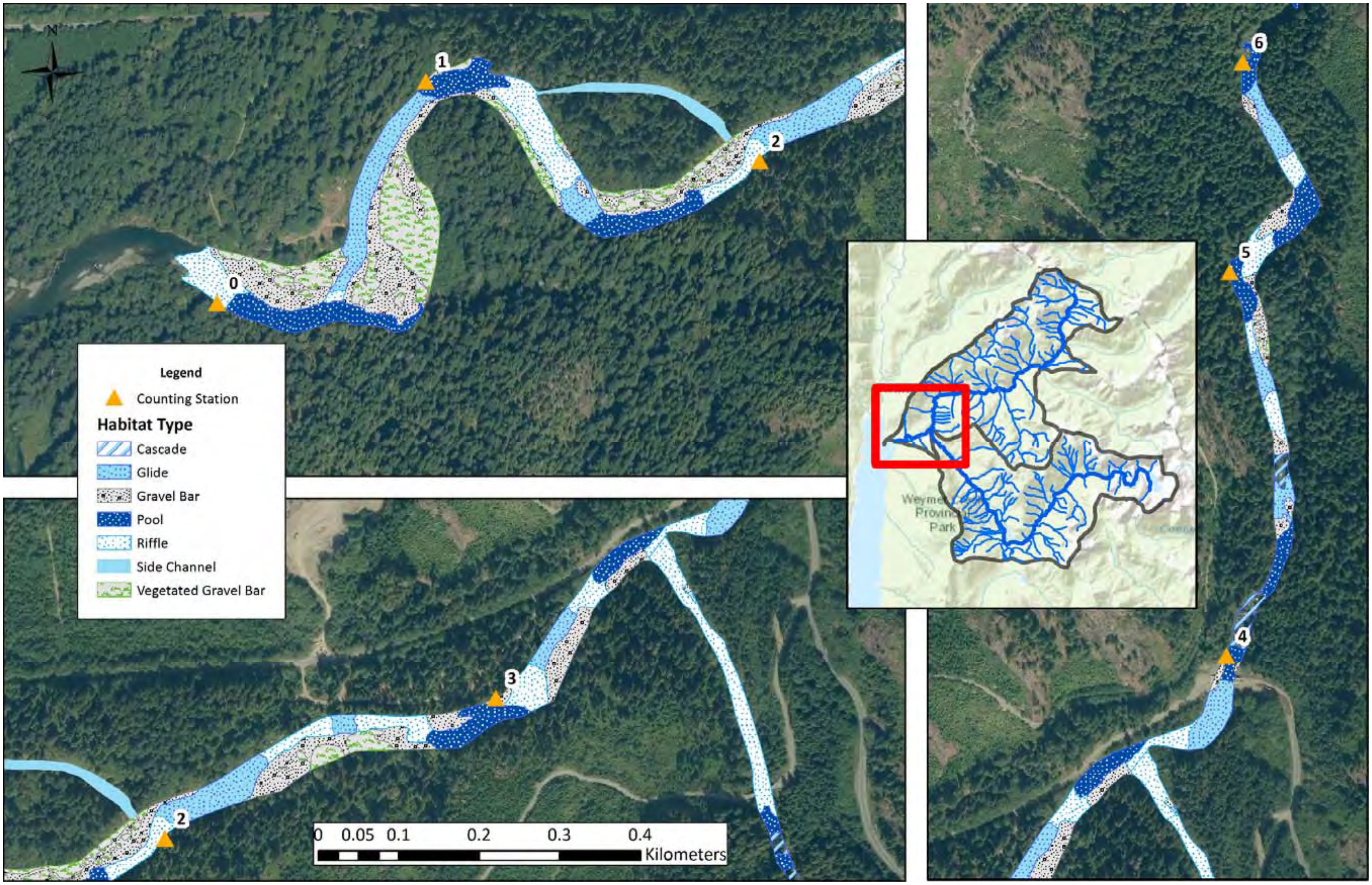

Figure 32. Habitat unit classification (2013) of the Leiner River.

The Perry River was mapped from the wetland down to the confluence with the Leiner River (Figure 33). Mapping upstream of this point was not possible as a closed canopy obscured the stream features. The majority (approximately 57%) of the mapped habitat in the Perry River was determined to be cascade, followed by a smaller proportion of riffle and pool habitat. The majority of the riffle habitat is located close to the confluence with the Leiner River. Above the riffle section, the river narrows into a canyon where much of the cascade habitat is located.

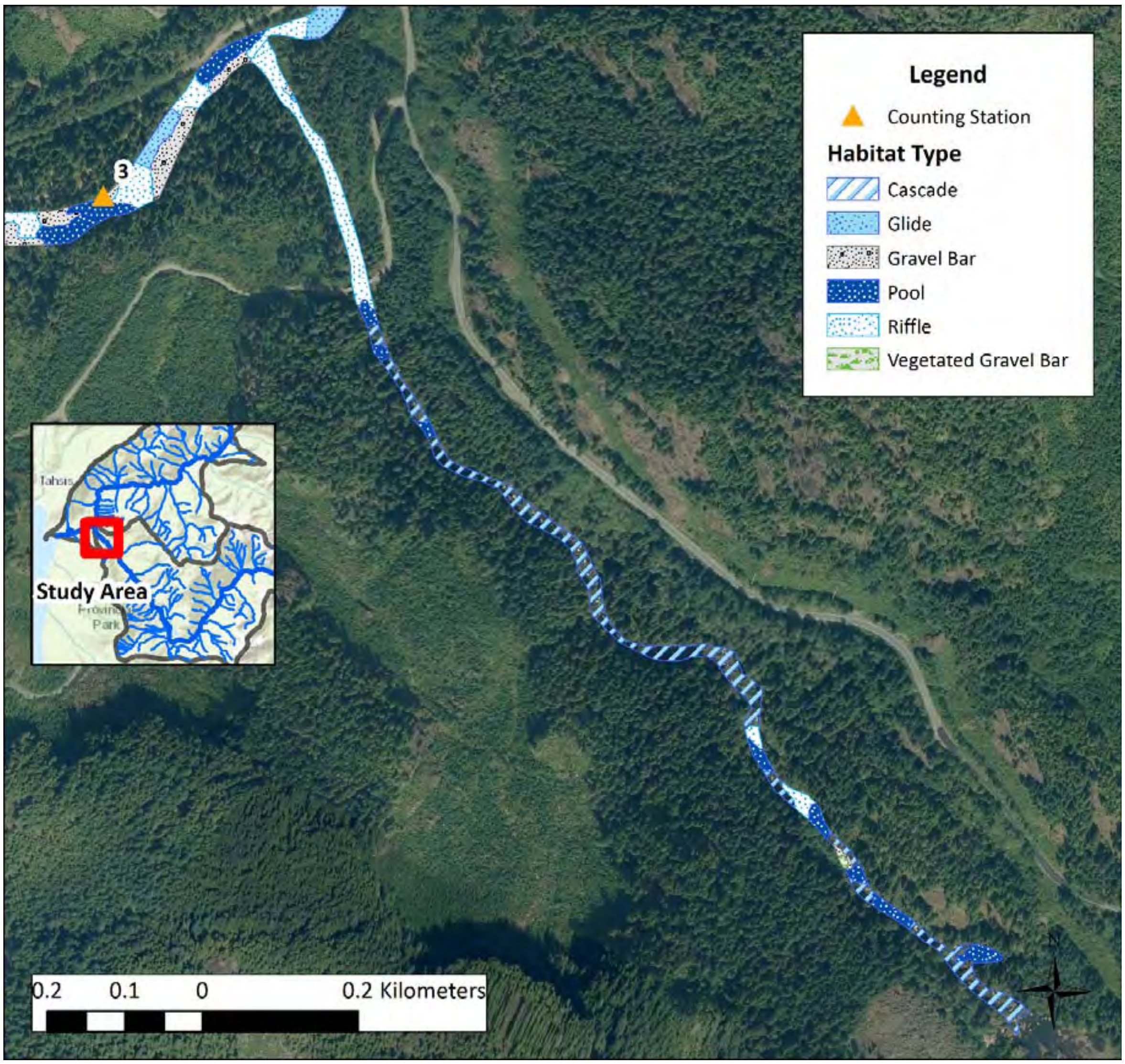

Figure 33. Habitat unit classification (2013) of the Perry River.

In terms of habitat composition within the visible mapping range of the Leiner River (i.e. between counting stations 0 and 6), pools comprise approximately 22% of the available habitat, while riffles, glides, and gravel bars comprise approximately 21%, 27%, and 31% of the remaining habitat composition (Figure 34).

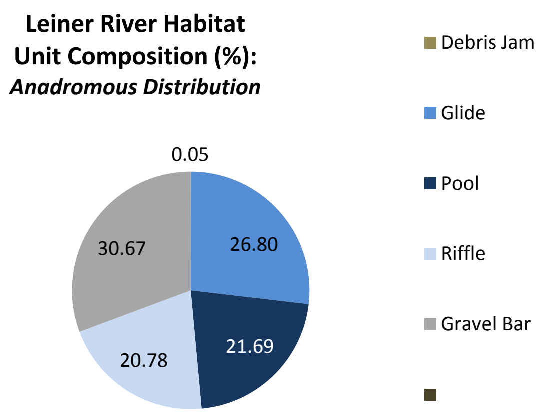

Figure 34. Habitat unit composition in 2013 of the anadromous reach of the Leiner River.

Habitat composition in the Perry River showed a significant component of cascade habitat (26%), which is typical of higher-gradient systems such as the lower Perry River. Riffles comprised approximately 26% of the available habitat, with pools and gravel bars comprising 15% and 2%, respectively (Figure 35).

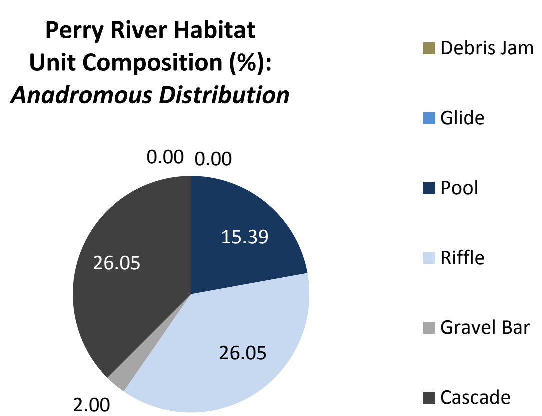

Figure 35. Habitat unit composition in 2013 of the anadromous reach of the Perry River.

A comparison of habitat unit composition in the Leiner River between 1995 and 2013 (where data overlapped between counting stations 0 and 4) has demonstrated some moderate changes. The most obvious change is an increase in pool and glide habitat. The increase in pool habitat between 1995 and 2013 is a good indication that the system is in a trend of recovery and is quite stable in its lower reaches. There was also an increase in gravel bar area, which may indicate aggradation, but may also be the result of the water levels at which the orthophotographs were taken. Interviews with local experts indicated habitat within the Leiner River to be relatively stable (NSWS, 2015). Figure 36 presents the relative proportions of each habitat unit type between 1995 and 2013 in the Leiner River, and Figure 37 presents the habitat mapping of the Leiner River between 1995 and 2013.

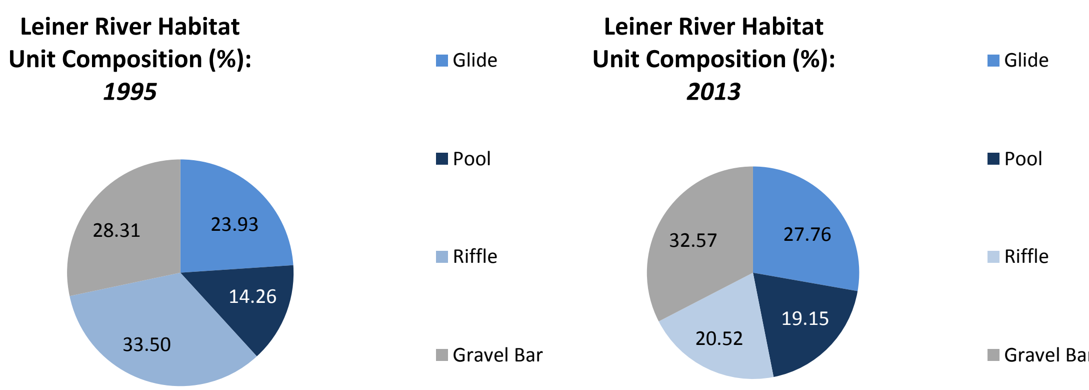

Figure 36. Change in habitat unit composition between 1995 and 2013 in the Leiner River, between counting stations 0 and 4.

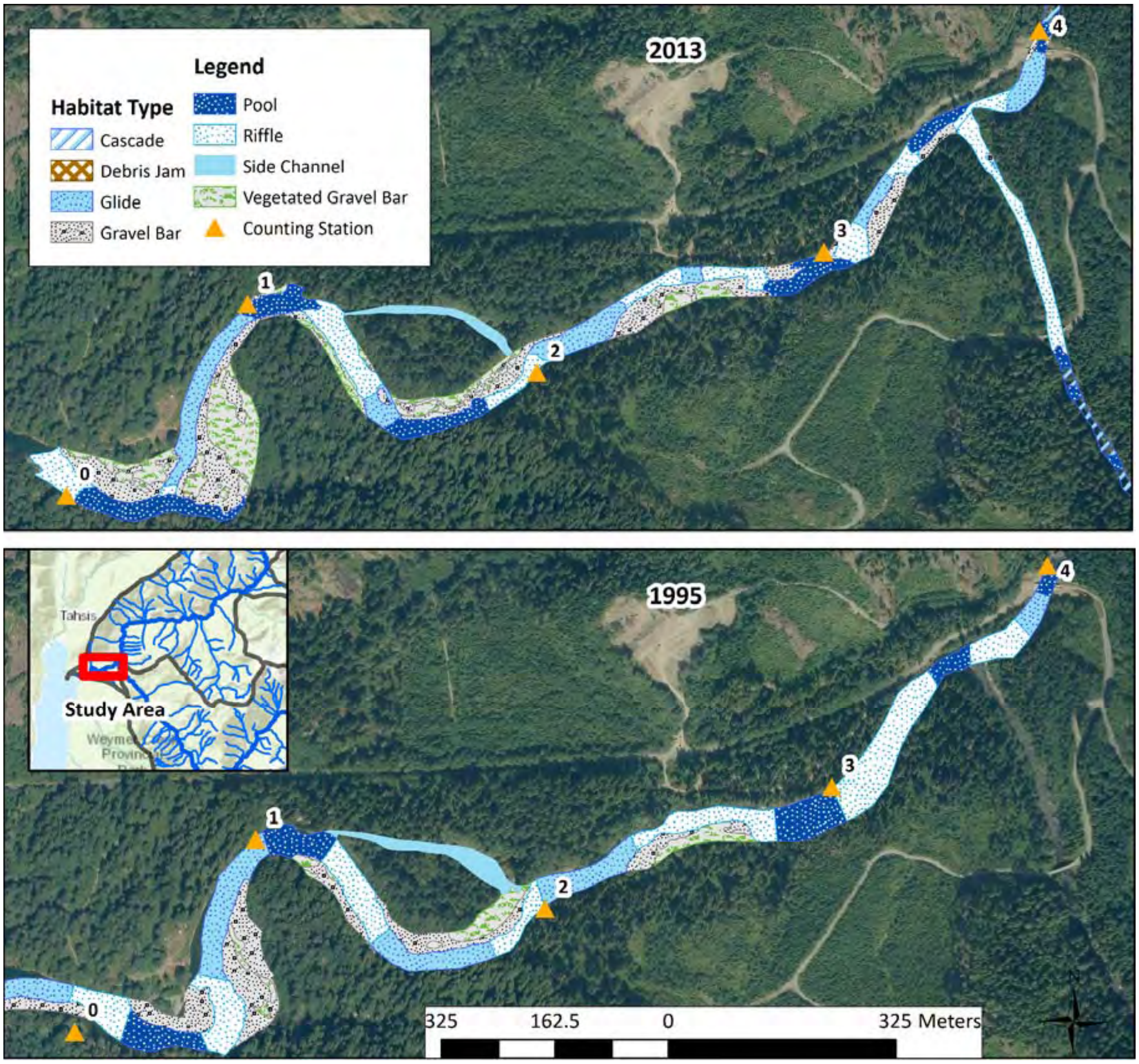

Figure 37. Habitat unit composition between 1995 and 2013 in the Leiner River from counting stations 0 to 4.

The benchmarks described in Johnston and Slaney (1996) indicate that for systems less than 15m bankful width and with gradients of <2%, poor salmonid habitat condition for summer and winter rearing occurs with <40% pool habitat area by reach. Similar conditions are experienced in systems with gradients between 2% and 5% where <20% pool habitat area is observed. The Leiner and Perry Rivers likely fit into this steeper category. While both rivers are greater than 15m wide in average width, this metric still provides a useful comparison of pool habitat composition. Considering this benchmark, the habitat composition indicator for the Leiner River has been classified as low risk. This is due to the observed trend of increasing pool frequency between 1995 and 2013, and the fact that currently, the pool frequency meets the suggested benchmark.

The Perry River is classified as high risk due to the fact that pool frequency is below the benchmark for high gradient systems. However, the status of fish in this system should be verified and the entire system should be accurately mapped before making an assessment on the effect of habitat. As such, this indicator is a partial data gap for the Perry River.

4.13 Stream State Indicator: Channel Stability

A comparison of 1980, 1995, and 2013 imagery between tidal water and counting station 6 in the Leiner River demonstrated some changes over time (see Figure 38). The section between counting stations 0 and 1 has shown a trend of increasing meander and some widening. A side channel on the right bank between counting stations 1 and 2 has been showing a trend of revegetation since 1980. This side-channel may have occurred in the past due to a debris jam that directed flow from the left bank of the river to form a channel on the right bank. Upstream of counting station 2 the Leiner River has shown some variation in its bankfull width, but only minimal changes have occurred and no significant channel widening is apparent. Prior assessments have concluded that the channel migration observed between the bridge and tidal water is occurring at a natural rate (Horel, 2008). Upstream of the bridge the channel is constricted and largely non-alluvial, which is likely why there is very little channel migration or widening in this area. Interviews with local experts indicated the Leiner River to generally be a stable, well-defined channel (NSWS, 2015).

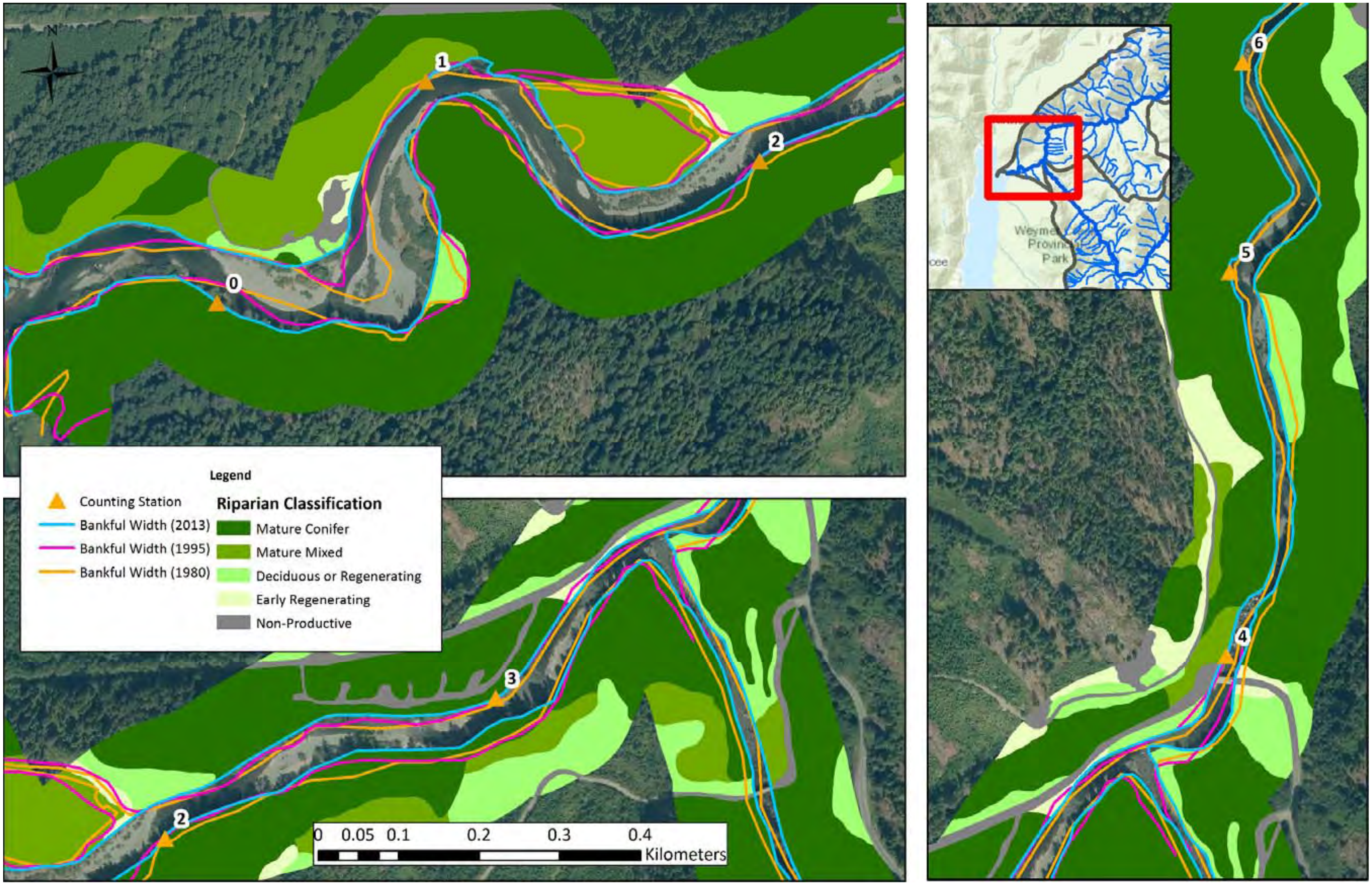

Figure 38. Bankful widths between 1980, 1995, and 2013 in the Leiner River between tidal water and counting station 6.

The Perry River has shown little variation in its bankful width in the section below the wetland (Figure 39). It does appear, however, that the channel became slightly narrower between 1980 and 2013. Little change would be expected in this section as it is primarily entrenched and non-alluvial (Horel, 2008). Upstream of Perry Lake there has been some channel over widening as a result of instability in this area. Assessments have indicated, however, that there is a trend of improvement in this area (Horel , 2008).

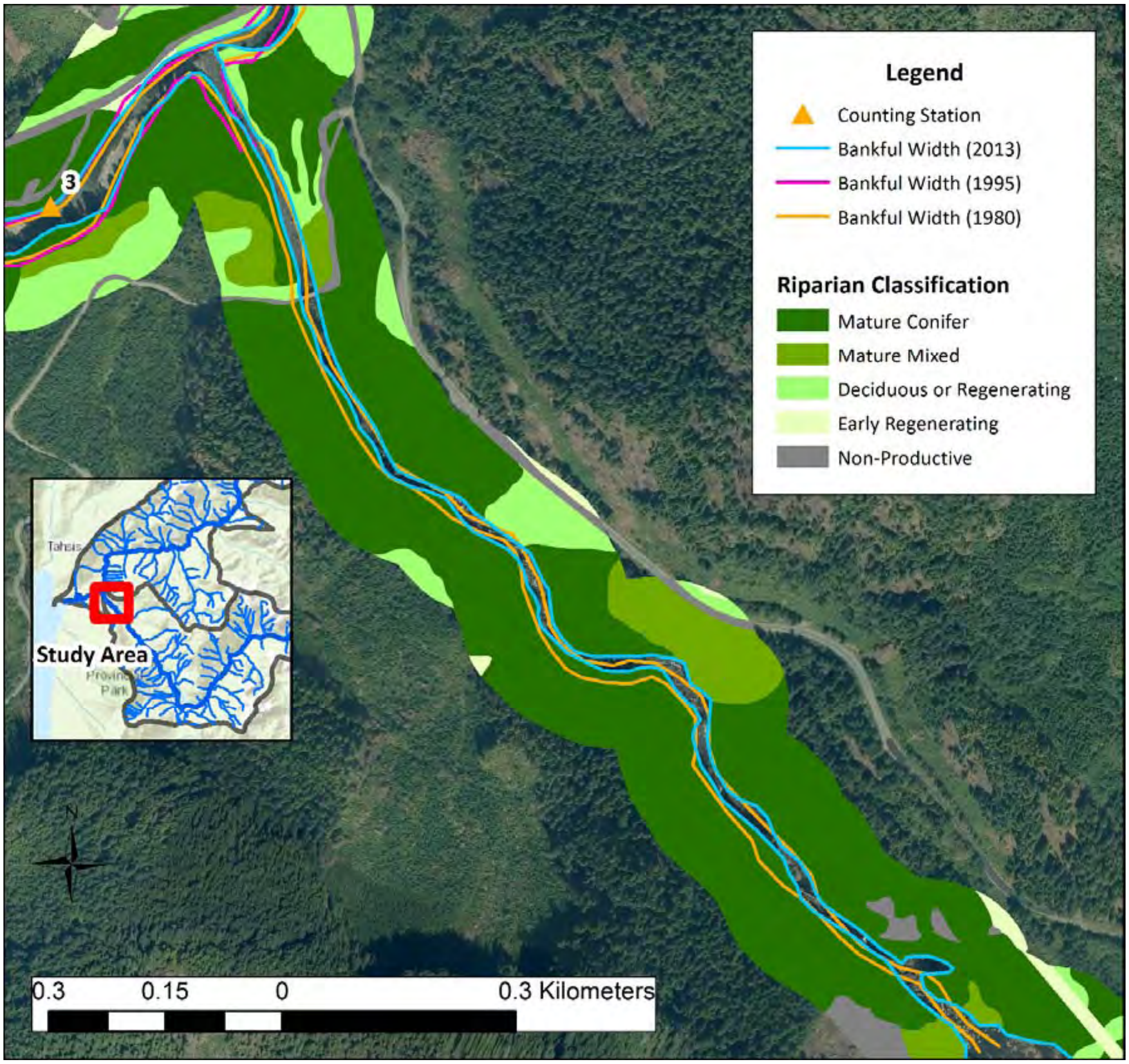

Figure 39. Bankful widths of the Perry River in 1980, 1995, and 2013, between the wetland and the confluence with the Leiner River.

Given the natural channel migration and apparent stability of the Leiner River, it was given a low risk rating for channel stability. The Perry River is showing a trend of recovery from past impacts, but the channel is still over-widened above Perry Lake. For these reasons, the Perry River was given a moderate risk rating for channel stability.

4.14 Stream State Indicator: Large Woody Debris

LWD was evaluated in the Leiner River to the upstream extent of the coho distribution (see Figure 7). Classification upstream of this point was not possible due to canopy cover and / or shadowing obscuring the river in the orthophotographs. In the Perry River, LWD was also classified to the upstream extent of the coho distribution. The Leiner River was separated into two reaches – Reach 1 was from the bridge down to tidal water, and Reach 2 was from the bridge up to the upstream extent of the coho distribution. In the Perry River, the entire coho distribution was considered as one reach (Reach 1). Table 7 presents the amount and classification of LWD in the Leiner and Perry rivers, based on analysis of 2013 orthophotographs.

Table 7. LWD classification in the Leiner and Perry Rivers.

River	Reach	Pieces of Functioning LWD per Bankful Width	Pieces of Non-Functioning LWD per Bankful Width	Pieces of Partially-Functioning LWD per Bankful Width	Number of Debris Jams	LWD Classification
Leiner	1	0.06	0.02	0.07	1	Poor
Leiner	2	0.10	0.35	0.10	0	Poor
Perry	1	0.02	0.25	1.43	1	Poor

Based on the results presented above, there is a lack of functional LWD in the Leiner and Perry rivers. In the Leiner River, the debris jam and much of the LWD is concentrated in the lower reaches (i.e., below counting station 0) and in the estuary (see Figure 40). Upstream of counting station 0 LWD is only sparsely distributed. Interviews with local experts confirmed this lack of debris, and indicated there is very little refuge area during high flows (NSWS, 2015). The Perry River shows the same general trend with minimal functional LWD over much of the assessed length. There is a higher amount of partially functional LWD (i.e., partially submerged and / or parallel to the current) in the Perry River, much of which is located in the wetland area (see Figure 41). As such, this section could provide valuable rearing habitat for juvenile salmonids, which further exemplifies the need for an assessment to determine the status of salmonids in the Perry River.

As a result of the mature coniferous forest that dominates the riparian zone throughout much of the fish-bearing length of both the Leiner and the Perry Rivers, there is a relatively high potential for recruitment of quality LWD. This type of riparian forest would likely provide quality LWD due to the fact that larger coniferous LWD is considered more stable, longer lasting, and more influential over stream flow (Poulin et al, 2000). However, it seems that much of the wood that recruited in the Leiner or Perry quickly gets flushed out of the upper reaches of the system and washed out into the estuary.

Due to the minimal amount of functional LWD and debris jams in both the Leiner and Perry Rivers, both systems are rated as high risk for this habitat indicator.

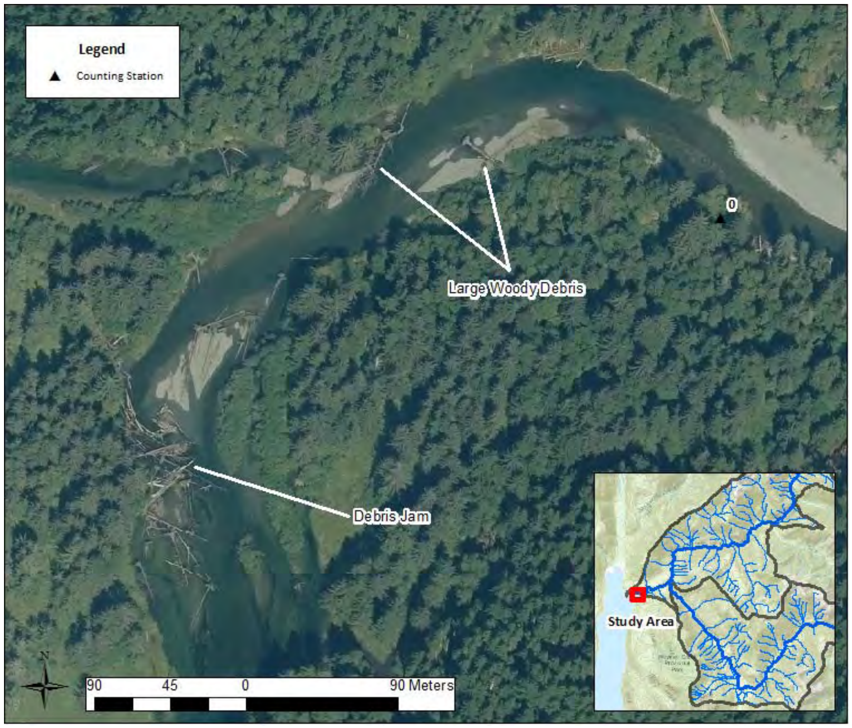

Figure 40: Debris jam and large woody debris in the lower Leiner River.

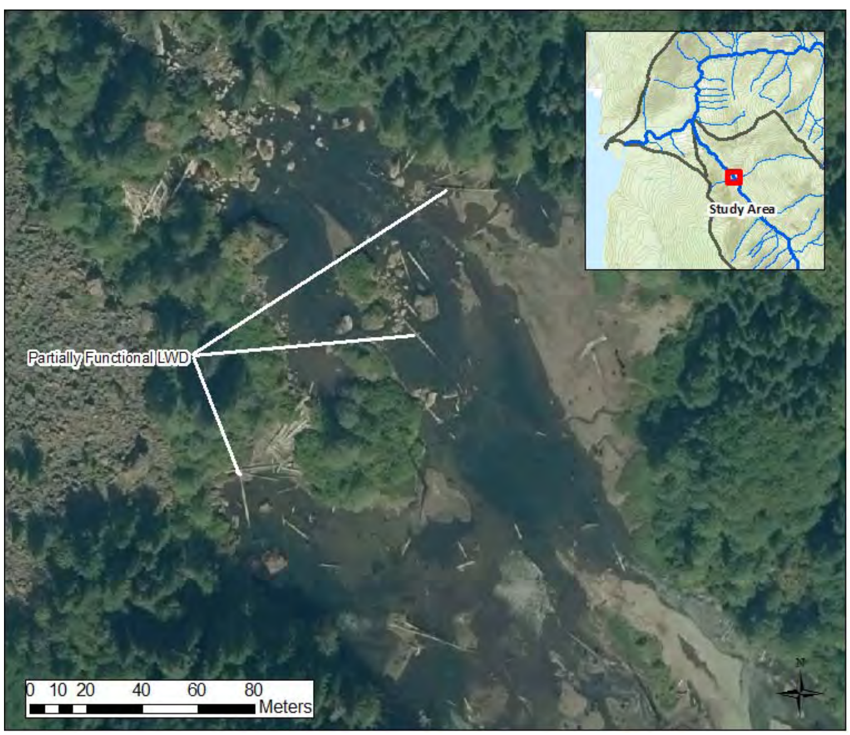

Figure 41: Example of partially-functional LWD at the wetland in the Perry River.

4.15 Stream State Indicator: Off-Channel Habitats

Very little off-channel habitat is known in the Leiner and Perry rivers watershed. Some habitat may exist in the lower reach of the Leiner River; however, observations have indicated connectivity with the mainstem may be an issue (particularly during low flows). Disconnected off-channel habitat has been observed just north of counting station 0 (in between the mainstem and the road) (NSWS, 2015). Based on the lack of field data, this habitat indicator has been classified as a data gap.

4.16 Estuary State Indicator: Estuary Disturbances

The Leiner River estuary has remained relatively free from disturbance in comparison to the neighbouring Tahsis River estuary (deVisser and Wright, 2015). Historically, the main source of disturbance to the estuary has come from log storage for the Tahsis sawmill. However, the estuary has not been used for booming since the early 2000's, and an increase in sedge habitat has been observed as a result (Tahsis Enhancement Society, 2014). Despite the removal of booms from the Leiner River estuary, there is still an active log handling / storage lease situated in close proximity to the estuary (Figure 42). Efforts should be made to ensure that no future log handling occurs within 100 m of the estuary.

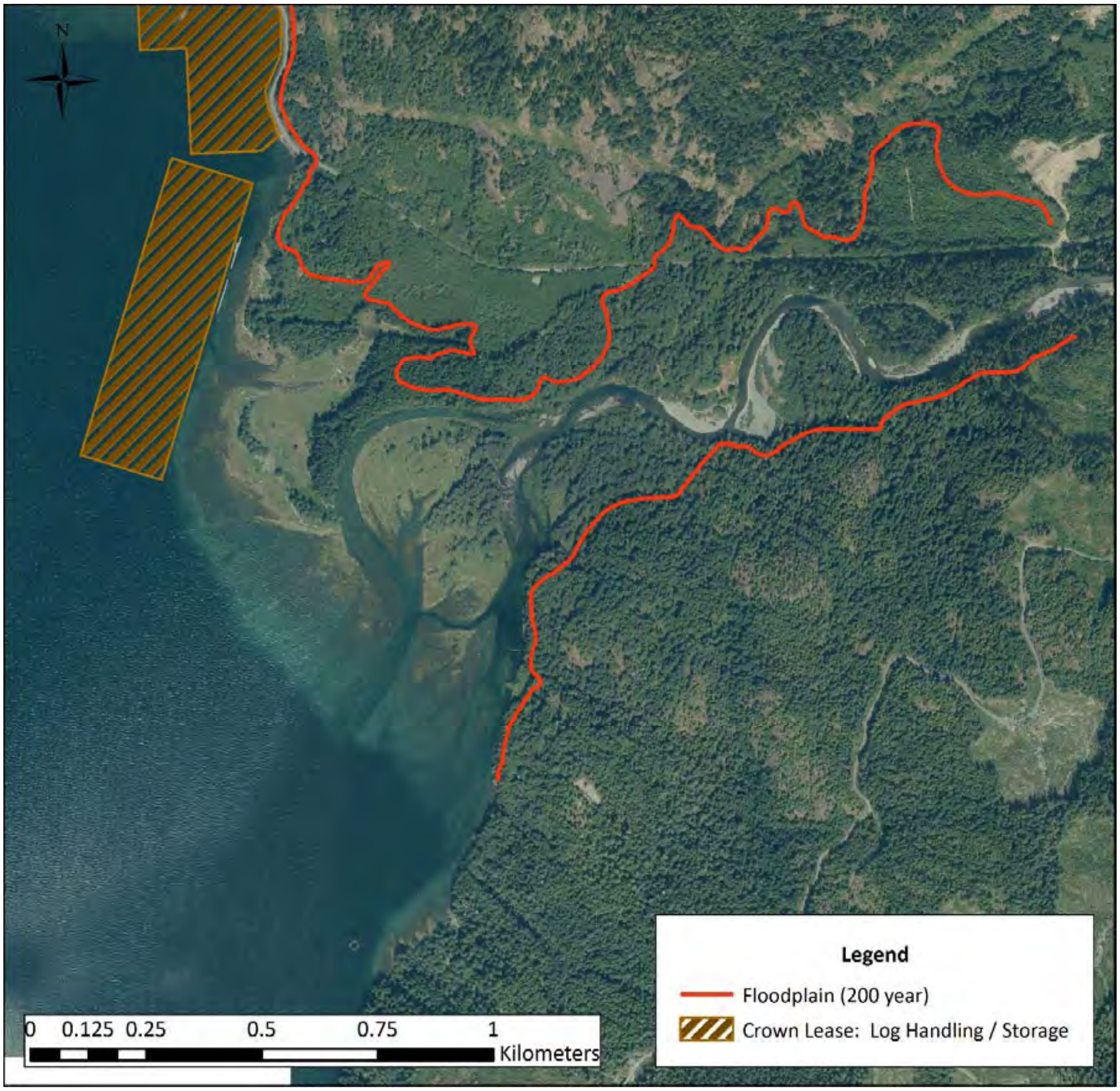

Figure 42. Present-day habitat disturbances in the Leiner River estuary.

Based on the present-day lack of disturbance in the Leiner River estuary, and the perceived trend of increased sedge habitat, this indicator was given a low risk rating. Efforts should continue to see that no future disturbances occur in this area.

4.17 Estuary State Indicator: Permitted Waste Discharges

There are no permitted waste discharges in the Leiner River estuary. As such, this indicator has been ranked as low risk.

4.18 Estuary State Indicator: Estuary Chemistry and Contaminants

A detailed study of habitat in Tahsis Inlet in 1981 documented salinity, temperature, turbidity, and acidity values in the Tahsis and Leiner River estuaries between March and June of 1981. Results showed that surface salinity and temperature were directly correlated with tides. Highest surface salinities were observed during high tides, and bottom salinities remained between 20 to 23 parts per thousand (ppt). Lowest salinities were observed near the mouth of the Tahsis and Leiner rivers (near 0 ppt), where temperatures typically remained below 8°C. Water were also analyzed for turbidity and acidity, which were found to have very low turbidity and neutral pH values (between 6.5 and 7.0) (Sellars, 1992).

No other water quality data was available for the Leiner River estuary. As a result, the risk rating for this indicator is a data gap. Considering the history of log storage in the area, it is possible that there may be some persistent water quality issues. Further efforts should be undertaken in order to assess the present water quality conditions in the estuary to determine if water quality in this area could be a limiting factor to fish production.

4.19 Estuary State Indicator: Dissolved Oxygen

No data with regards to DO levels in the Leiner River estuary were available. Considering the historical log handing that has occurred in the estuary and the known impacts log handling can have on DO levels through wood waste deposition (Picard et al, 2003), impacts to fish habitat can be expected from this indicator. However, based on the absence of information and / or studies, this habitat indicator has been identified as a data gap.

4.20 Estuary State Indicator: Estuarine Habitat Area

The Leiner River estuary has received relatively little impact in the way of reduction of habitat in comparison to the neighbouring Tahsis estuary. No unnatural infilling has taken place in the estuary and as a result, much of the estuary remains in its natural state. Figure 43 presents the composition of habitat within the Leiner River estuary.

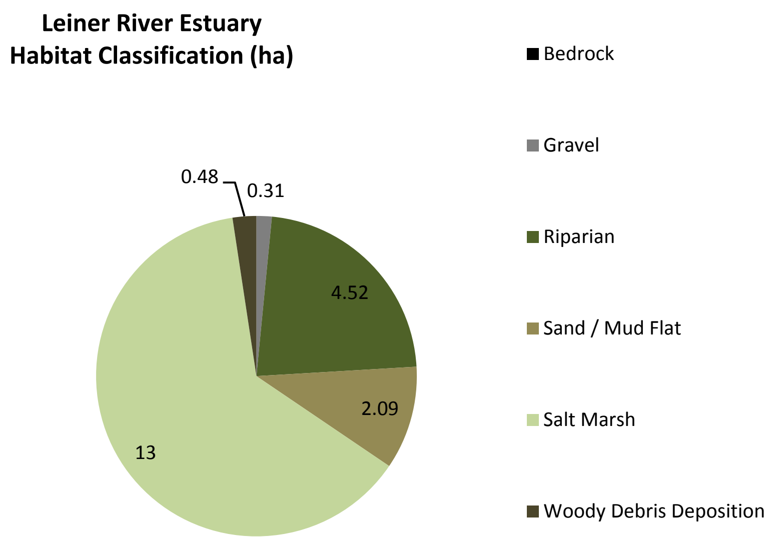

Figure 43. Habitat composition of the Leiner River estuary.

It can be seen in Figure 43 that a significant proportion of the Leiner River estuary is salt marsh, which indicates that the estuary is likely in good health. Figure 44 shows a fairly even distribution of salt marsh across the width of the estuary. There are also some patches of mature forest, which provide valuable marine riparian zones, as well as structural stability to the estuary. As mentioned above, recent observations of the estuary indicate that the sedge habitat has increased over the past 14 years, since the termination of log storage at this site (Tahsis Enhancement Society, 2014).

Given the known importance of the estuaries as a critical rearing and foraging zone for all species of out-migrating salmonids, and the apparent good health of the Leiner River estuary, this location should continue to be protected. Based on its current state, the Leiner River has been given a low risk rating for estuary habitat area.

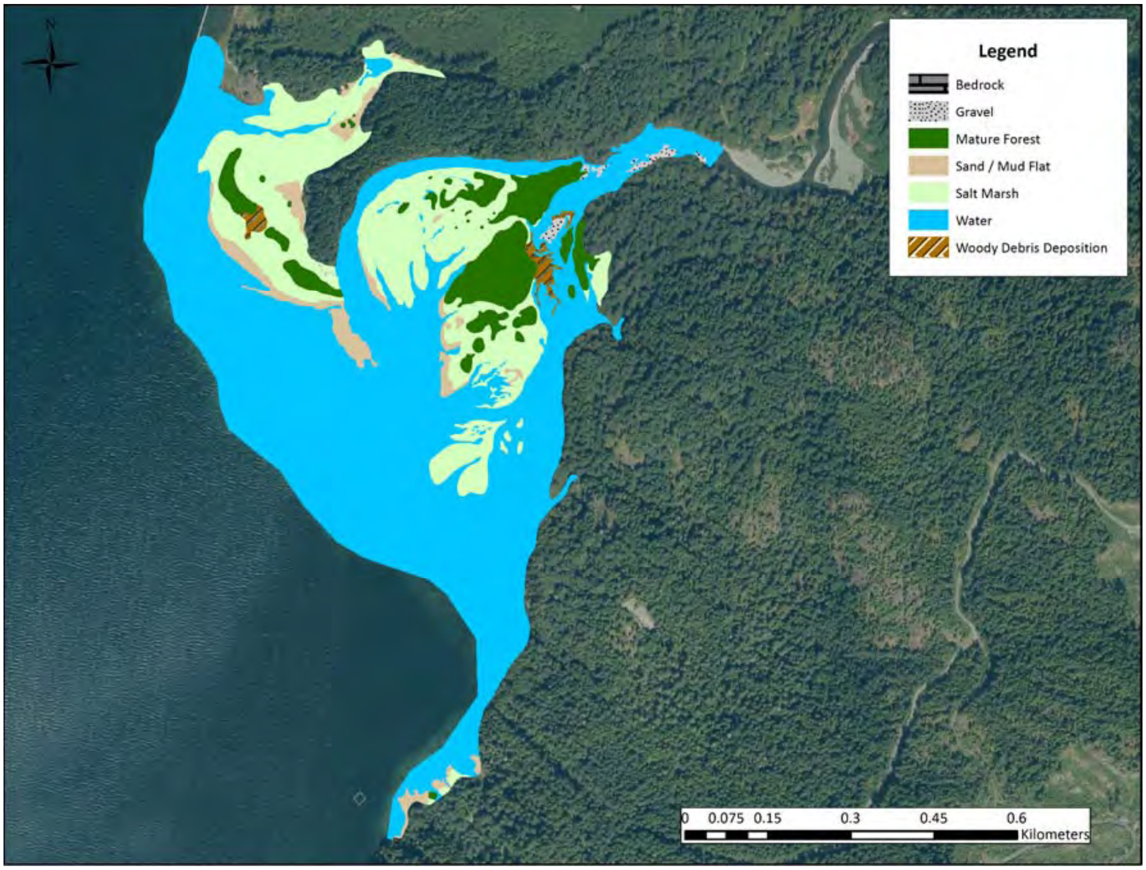

Figure 44. Estuary habitat classification and distribution of the Leiner River estuary.

5.0 SUMMARY OF HABITAT INDICATORS AND DATA GAPS

Based on the results of the habitat assessment of the Leiner River watershed (including the Perry River), it appears that this system is in relatively good health considering the resource extraction and land development that has occurred in certain areas. Due to the steep, constricted morphology in many locations on both the Leiner and Perry river systems, anadromous access is limited to all but the strongest swimming species (e.g., coho). The distributional range of chinook, sockeye, and chum in the Leiner River is restricted to the area downstream of the Leiner River bridge. This area is considered to be quite stable and does not appear to have sustained any significant impact from past land uses. Upstream of the Leiner River bridge the stream is primarily utilized by coho, however, the degree to which this species utilizes this area is not well documented and is a data gap. The Perry River has sustained more impacts from past land use and shows a higher risk rating than the Leiner for several indicators. However, the distribution of salmonids in this system is not well understood, and this data gap will need to be filled during future assessments.

The greatest perceived risk for the Leiner River and Perry River watersheds is a lack of large woody debris (LWD). Off-channel habitats may also be a high risk indicator; however, not enough data exists to support this risk rating. The next highest risk rating in the Leiner and Perry River watershed is road density. The Perry River received a high risk rating due to the fact that the road density in this area exceeds the benchmark (Stalberg et al, 2009). The Leiner River watershed has not been as heavily logged and as a result, road density was slightly lower in this area. The alluvial geology of the upper reaches of the Perry watershed has resulted in some instability, and several development-related landslides have occurred in this region.

While there are many data gaps for the Leiner River estuary, it appears that it is in good health. Historically, the estuary was used for log storage, however, it has not been used for this purpose in recent years and some recovery has been observed.

Table 8 summarizes the results of ranked assessed habitat indicators and identifies indicator data gaps:

Table 8. Summary of assessed habitat indicators and data gaps.

Indicator	Type	Leiner Risk Rating	Perry Risk Rating	Data Gaps (Y/N)?	Comments
Large woody debris	Stream: State	HIGH	HIGH	N	Pieces of functional LWD per bankful width remains below suggested benchmarks in Johnston and Slaney (1996) for all assessed reaches.
Watershed road development	Stream: Pressure	MODERATE	HIGH	Y	Higher density of roads in the Perry River as it has been logged much more extensively than the Leiner.
Habitat composition	Stream: State	LOW	HIGH	PARTIAL	**Distribution of fish in the Perry River will need to be confirmed in order to determine the effect of habitat on fish production.** The Leiner River was classified as low risk as the pool content was roughly equal to that listed in Johnston and Slaney (1996) and a comparison to 1995 habitat composition displayed an increasing trend.
Total land cover alterations	Stream: Pressure	LOW	MODERATE	PARTIAL	Land cover alteration primarily located in lower reaches of Leiner. Perry River more heavily impacted but recovering. Partial data gap due to missing age class data in lower Leiner River.
Channel stability	Stream: State	LOW	MODERATE	N	Leiner River given a low risk rating due to its stability and minimal, natural channel migration over recent years. The Perry River was given a moderate rating due to the past impacts and channel over-widening. It is, however, showing a trend of recovery.
Stream crossing density	Stream: Pressure	LOW	MODERATE	PARTIAL	**Further assessments will be required in order to determine the status and true number of stream crossings in each watershed.**
Riparian disturbance	Stream: Pressure	LOW	LOW	PARTIAL	Much of the riparian forest in both the Leiner and Perry Rivers is mature coniferous. Partial data gap in that the distribution of salmon in the Perry River is not well understood. Consequently the relative impact of riparian forest to each species in this system is not clear. Ground-truthing of riparian stand age required.

Indicator	Type	Leiner Risk Rating	Perry Risk Rating	Data Gaps (Y/N)?	Comments
Water extraction	Stream: Pressure	LOW	LOW	N	No active water extraction on either river. Applications are present on both systems for non-consumptive uses (power generation).
Water temperature: Migration and spawning	Stream: State	LOW	LOW	Partial	Recorded water temperatures during spawn surveys from 2006 – 2013 showed only one occurrence of temperatures approaching the UOTR for adult salmonids. Remainder of values were consistently below this benchmark. Partial data gap due to limited number of sample points.
Permitted waste management discharges	Stream: State	LOW	LOW	N	There are presently no waste or waste water disposal permits in the Leiner River or Perry River watersheds.
Estuary habitat disturbance	Estuary: State	LOW	N/A	N	Historically the Leiner estuary was used for log storage for the Tahsis sawmill. Logs have not been stored here for 14 years, which has resulted in increased sedge habitat. No infilling from industrial uses.
Estuary habitat area	Estuary: State	LOW	N/A	N	No unnatural infilling has taken place in the estuary and as a result, much of the estuary remains in its natural state.
Permitted waste management discharges	Estuary: State	LOW	N/A	N	No permitted waste discharges identified in the Leiner River estuary.
Water quality	Stream: State	Not ranked – data gap	Not ranked – data gap	Y	**Limited water quality data available for the Leiner or Perry Rivers.** Geochemical sampling indicated that all metal assays tested below guidelines. Sampling of more parameters will be required to determine the risk rating for this category.
Water temperature: Juvenile rearing and migration	Stream: State	Not ranked – data gap	Not ranked – data gap	Y	**No water temperature data available outside of the fall swim survey period.** This metric important to understand water temperature's influence on emergence timing and potential egg freezing events during winter low flows.
Stream discharge	Stream: State	Not ranked – data gap	Not ranked – data gap	Y	**Limited discharge data available for the Leiner River, no discharge data available for the Perry. MAD not well understood, therefore could not**

Indicator	Type	Leiner Risk Rating	Perry Risk Rating	Data Gaps (Y/N)?	Comments
					compare to benchmark for risk rating.
Estuary chemistry and contaminants	Estuary: State	Not ranked – data gap	N/A	Y	**No water quality data (with the exception of historical pH, salinity, and temperature information) available for the Leiner River estuary.**
Estuary dissolved oxygen	Estuary: State	Not ranked – data gap	N/A	Y	**No DO data available for the Leiner River estuary.** Given historical log handling initiatives in this zone a fiber mat likely exists in the subtidal zone. These fiber mats are known to result in reduced DO levels in the marine environment (Picard et al, 2003)
Accessible stream length	Stream: State	N/A	N/A	Y	**The distribution of all species in the Perry River requires verification.** Requires temporal comparison of change over time to determine indicator risk.
Key spawning areas (length)	Stream: State	N/A	N/A	Y	**Requires identification of coho spawning areas in the Leiner River upstream of the bridge. Key spawning areas have yet to be identified in the Perry River.** Requires temporal comparison of change over time to determine indicator risk.

In addition to the data gaps presented above, an additional important habitat indicator (beyond the scope of Stalberg et al [2009]) lacking information was identified: the quantification of inter-gravel flows and DO levels in known spawning grounds. Understanding inter-gravel flows and DO levels was identified as a critical component of egg to fry survival, and must be understood to determine if the infilling of interstitial spaces reducing intergravel flows and / or lack of oxygen are reducing survival.

In many cases data gaps prevented a full assessment of state and pressure indicators. Based on the results of this habitat status assessment, recommendations can be broken down as follows: restoration, data gaps to be addressed, and best functioning habitats requiring protection. The following sections discuss these recommendations.

5.1 Recommended Restoration Projects

When compared to the other watersheds in Nootka Sound, the Leiner River watershed (including the Perry River drainage) appears to be in relatively good condition. The lower, high productivity section of the Leiner River (e.g., counting stations 4 down to tidal water) is generally quite stable and at low risk from many of the indicators examined. Additionally, the estuary appears to be in good health with little evidence of impact from past land uses. Other sections of the watershed may require restoration in the future; however, it would be prudent to gather more data in order to improve the understanding of fish status and limiting factors in the watershed before proceeding with any potential projects (i.e. re-establishment of potentially disconnected off-channel habitats. Consequently, the Leiner River watershed is not a priority location for restoration projects in Nootka Sound.

5.2 Data Gaps and Recommended Studies

The following table presents a prioritized list of data gaps identified during this study and recommendations for future initiatives to address these gaps:

Table 9. Data gaps and recommended studies for habitat indicators in the Leiner and Perry Rivers.

Data Gap	Priority	Recommendation
Adult salmonid distribution and habitat use in the Perry River	High	Include the Perry River in future escapement assessment swims.
Adult coho distribution and habitat use in the Leiner River upstream of counting station 7	High	Several swims should be completed throughout the entire length of the known coho distribution (or above) during each year's escapement assessment.
Off-channel habitat accessibility, quality, and utilization	High	Off-channel habitat should be assessed to determine its connectivity and utilization by species such as coho and sockeye.
Intergravel flows and DO levels	High	Direct field efforts to collect this information at known spawning grounds.
Stream discharge and rating curve establishment	Moderate	A water level data logger could be installed on the Leiner River to collect water level data, which in conjunction with regular discharge measurements, could be used to develop a rating curve. Continuation of DFO's river surveyor program will facilitate the

Data Gap	Priority	Recommendation
		establishment of a stage-discharge relationship for this system.
Juvenile habitat utilization	Moderate	Juvenile salmonid trapping could be conducted in various locations throughout the watershed to determine the spatial and temporal distribution of juvenile salmonids.
Water temperature: juvenile rearing and migration	Low	Temperature data loggers should be installed in the Leiner and Perry rivers to determine if temperatures in the system fall within the appropriate benchmarks.
Riparian classification of tributaries and off channel habitats including wetlands	Low	Direct field efforts to map tributary locations, side channels, and wetlands (within fish-bearing reaches). Classify riparian of these locations based on 2013 orthophotographs.
Water quality (instream)	Low	Implement water quality monitoring program at several sites distributed throughout the Leiner and Perry Rivers.
Water quality (estuary)	Low	Implement water quality monitoring program at several sites distributed throughout the Leiner River estuary.
Number and condition of stream crossings in the watershed	Low	A culvert/stream crossing assessment could be conducted to determine if any of the stream crossings in the watershed are causing fish access or hydrological issues.

5.3 Best Functioning Habitats Requiring Protection

The protection of existing known functioning habitats is important to maintain existing fish productivity levels and prevent the loss of these important zones. Figure 45 summarizes all of the known spawning, holding, and juvenile rearing and migration habitat identified during this assessment. All of these habitats have been considered critical and therefore require consideration and protection from future industrial initiatives. Monitoring of these locations on a periodic basis is also recommended to determine if these habitats are improving or degrading over time. Continued assessment of the Perry River is recommended in order to determine the location of critical habitat in this section of the watershed.

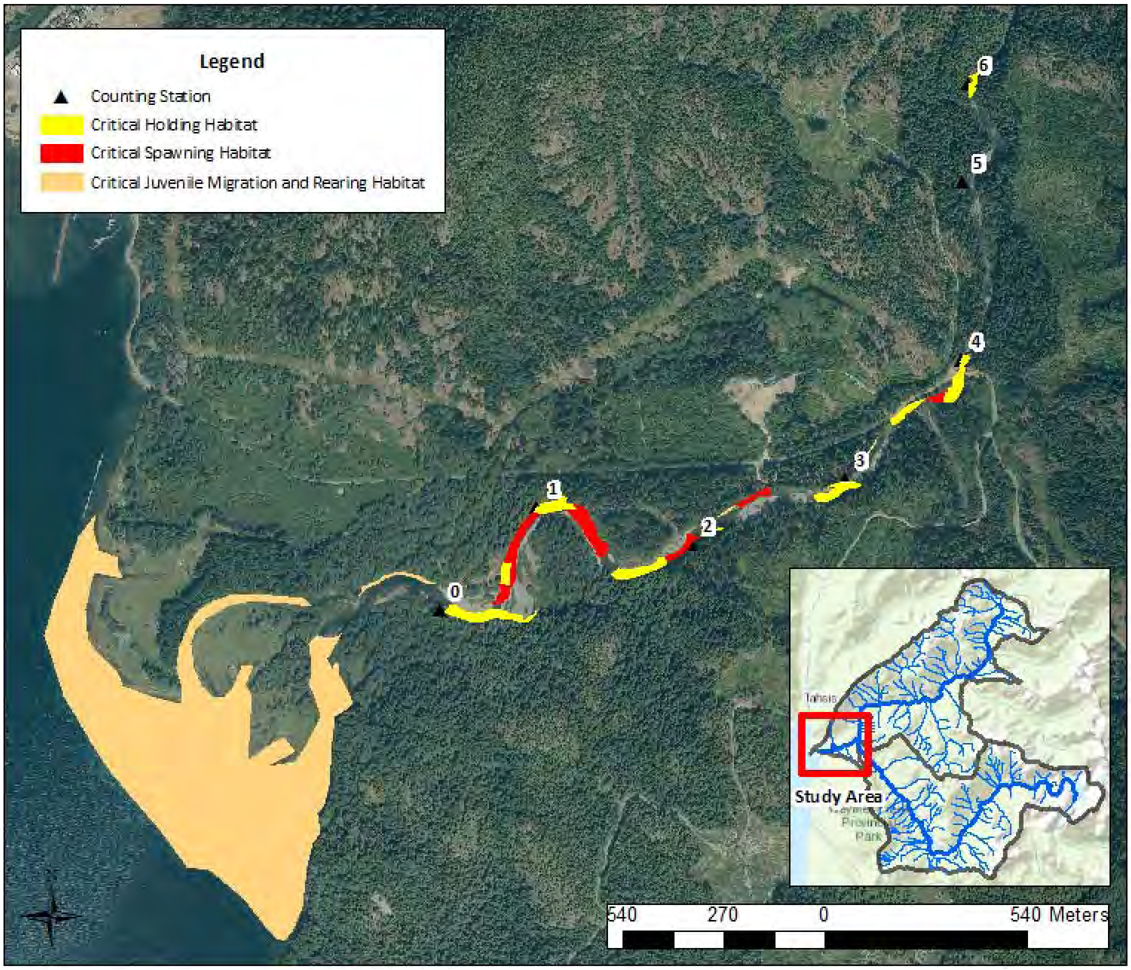

Figure 45. Best known functioning (i.e. critical) habitats in the Leiner River watershed that are recommended for protection.

6.0 CONCLUSION

Over all, the Leiner River watershed is in relatively good condition in comparison to the other watersheds in Nootka Sound. The Leiner River has anadromous access for all species of salmonids up to the bridge at counting stations 4 and to beyond counting station 7 for coho. This section of the river is considered stable and is rated low risk for most of the assessed indicators. Upstream of the bridge, the river is quite constricted and access is only available to coho salmon. Due to the fact that the DFO spawner escapement assessments generally focus on fish downstream of the Leiner River bridge, the status of coho in the upper portions of the Leiner River is not well understood and should be addressed in future surveys.

The Perry River is known to support runs of coho and sockeye salmon, however, the status of these runs is unknown. Additionally, there are historical accounts of chinook and chum in this system but nothing from recent years. It is recommended that the DFO spawner escapement assessments include some swims in the Perry River to determine the status of salmon in this system. Historical land use practices, such as road building due to logging, have resulted in some instability in the upper portions of the Perry River watershed. This has resulted in several slides, stream bed aggradation, and channel over widening. The system, however, is showing a trend of recovery. Assessments in the area have concluded that the lower sections of the watershed are likely buffered from the effects of this instability because of the effect of sediment trapping by Perry Lake and the downstream wetland.

There are many data gaps that need to be addressed in future assessments of the Leiner River watershed. Primarily, the status of fish in the Perry River needs to be examined to determine the species present, their distribution, and locations of critical habitat. Locations of critical coho habitat in the Leiner River (above counting station 7) also need to be determined. The accessibility, utilization, and quality of off-channel habitat should also be assessed during future surveys, in addition to the quality of known spawning grounds (i.e. inter-gravel flows and spawning substrate condition). Additional data gaps include water quality (in-stream and estuary) water temperature during spring and summer months, a stage-discharge relationship, stream crossing status, and riparian classification of tributaries and other off-channel habitats.

Despite the fact that there are still many data gaps regarding the status of the Leiner and Perry Rivers watershed, it appears to be in good condition in comparison to the other watersheds in Nootka Sound. As a result, this watershed is not considered a priority for restoration projects at this time. However, data collection in this watershed should continue in order to address all known data gaps, and critical habitats should continue to be identified and protected.

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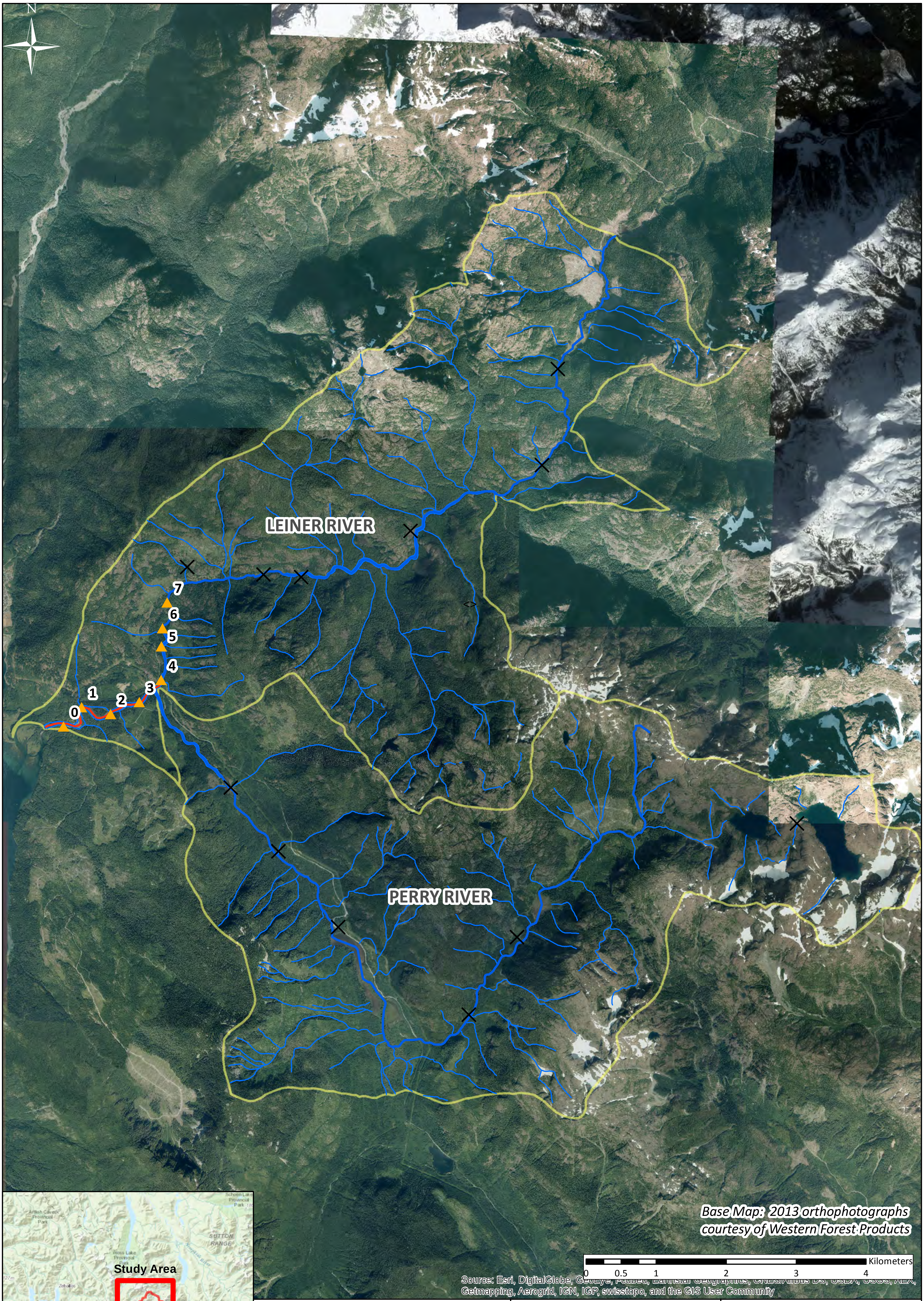
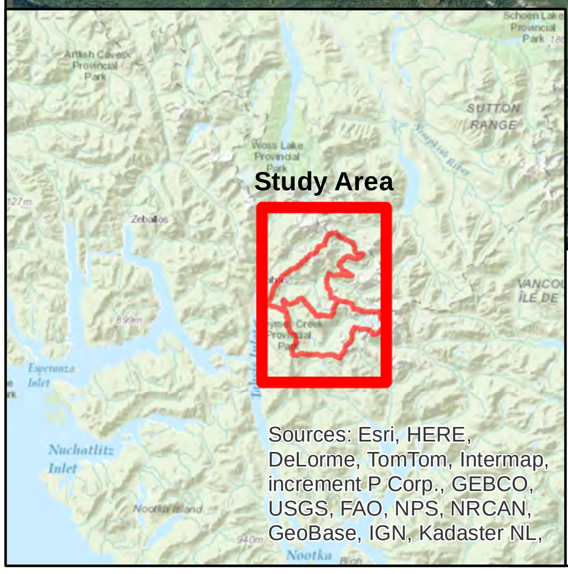
APPENDIX 1: LEINER RIVER WATERSHED MAP ATLAS





Legend

- Barrier to Fish Passage
- Counting Station
- Known Chinook Distribution
- TRIM River
- Watershed Boundary

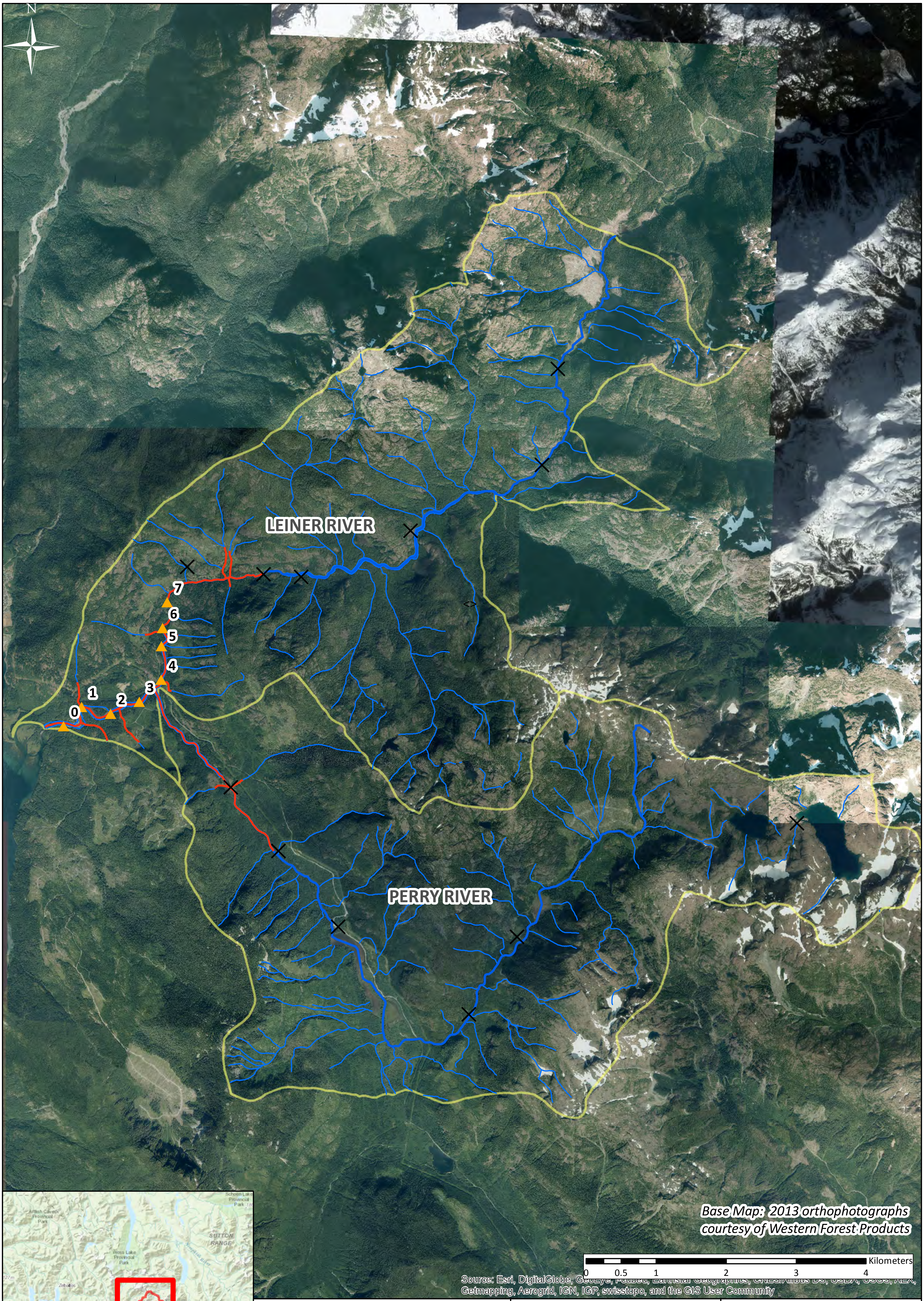
Prepared For: Nootka Sound Watershed Society

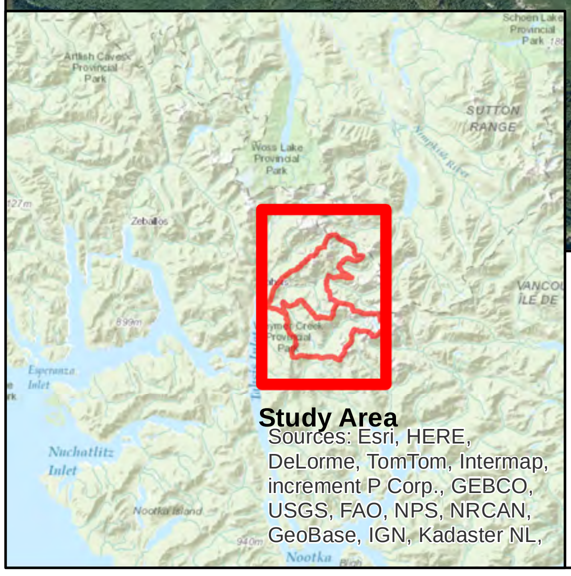
Prepared By: M.C. Wright and Associates Ltd.
June 15, 2015

Nootka Sound Watershed Society
M. C. Wright and Associates Ltd. Biological Consultants
NCompas Software Development

MAP 1

Leiner River Watershed Known Chinook Distribution





Legend

- Barrier to Fish Passage
- Counting Station
- Known and Modeled Coho Distribution
- TRIM River
- Watershed Boundary

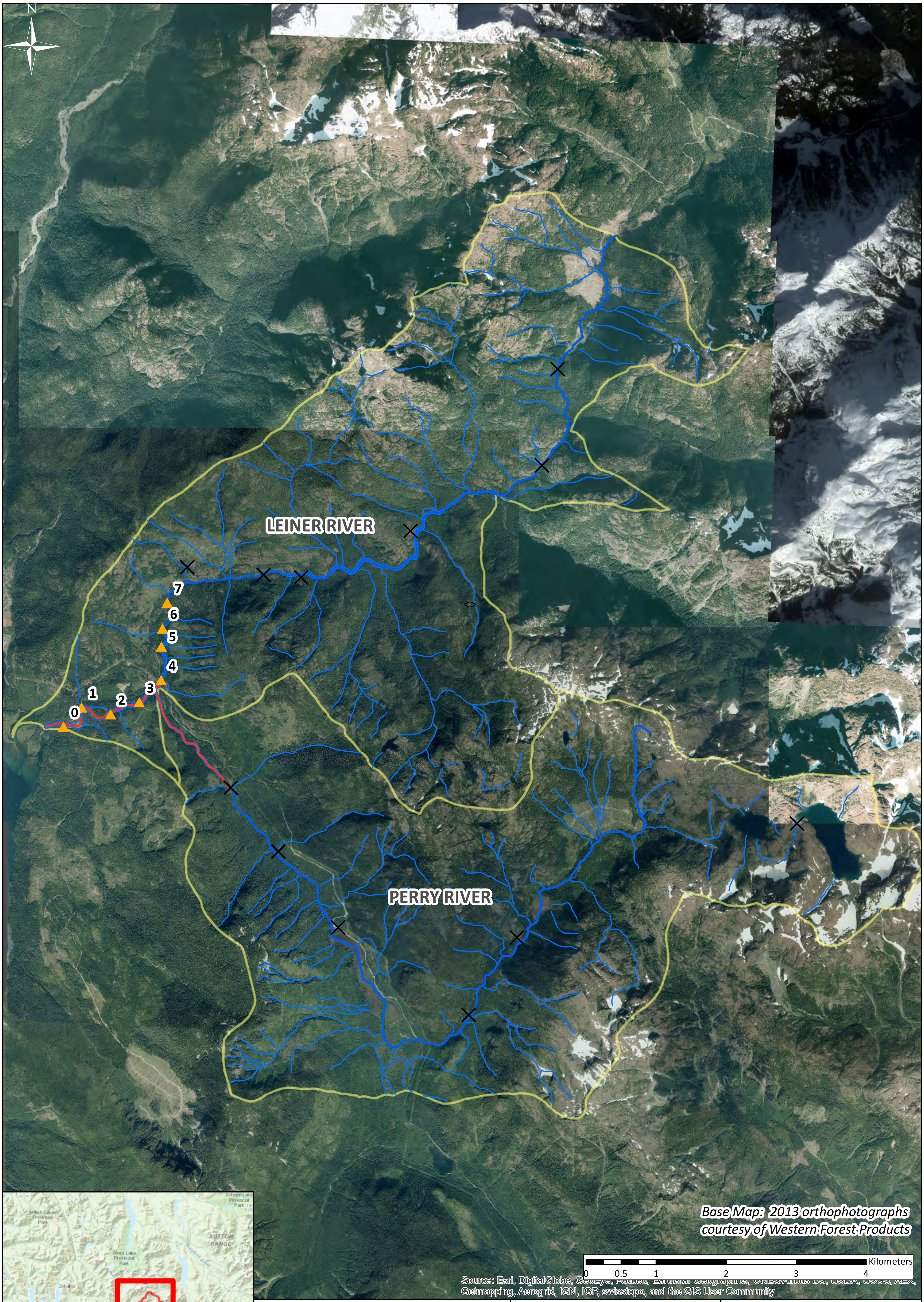
Prepared For: Nootka Sound Watershed Society

Prepared By: M.C. Wright and Associates Ltd.
June 15, 2015

Nootka Sound Watershed Society
M. C. Wright and Associates Ltd.
NCompas

MAP 2

Leiner River Watershed Known and Modeled Coho Distribution



Legend

- Barrier to Fish Passage
- Counting Station
- Known Sockeye Distribution
- TRIM River
- Watershed Boundary

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Prepared By:

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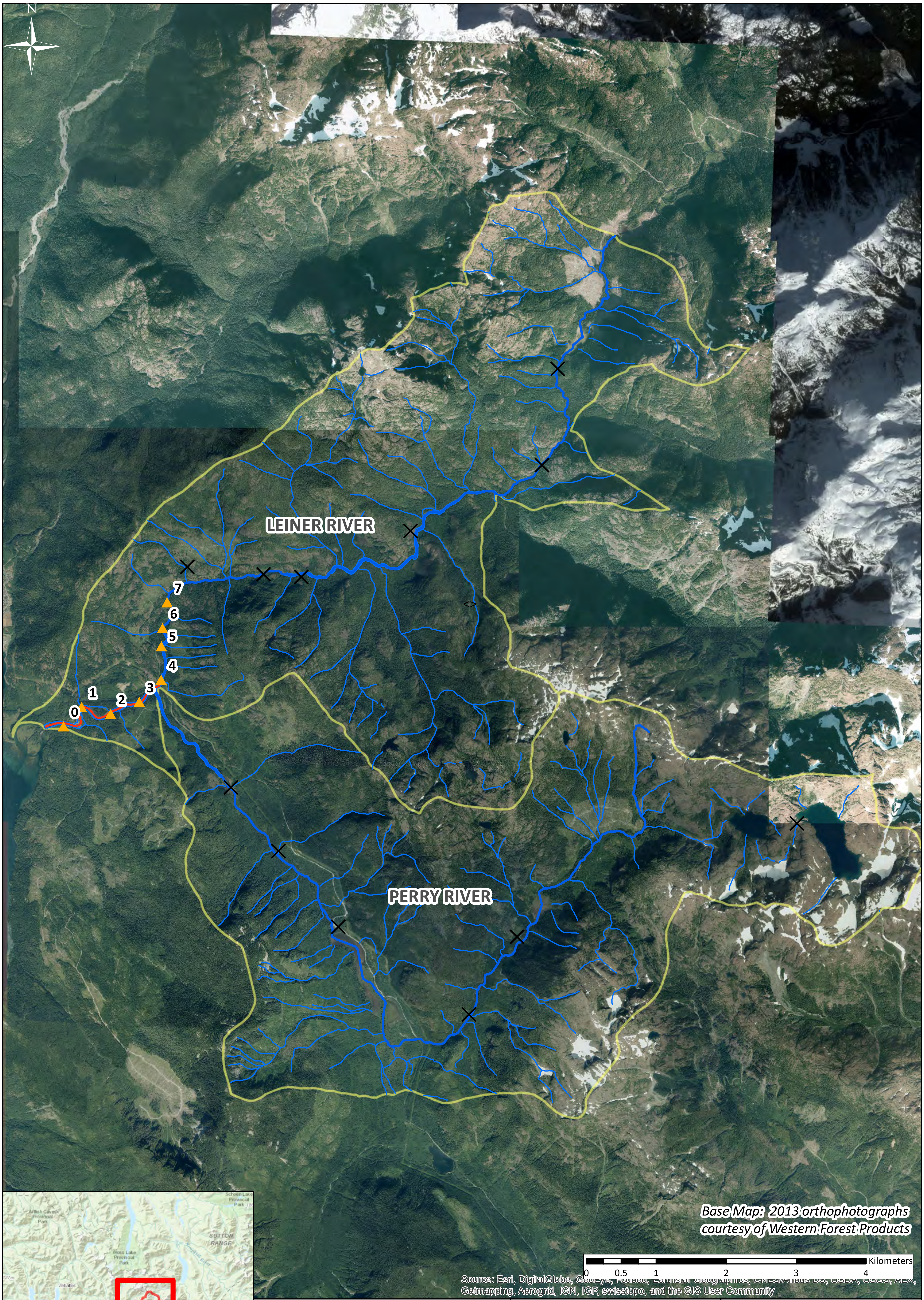
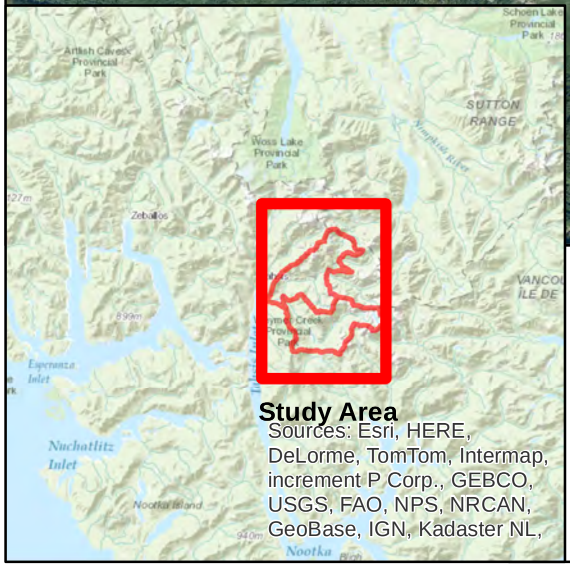
MAP 3

Leiner River Watershed Known Sockeye Distribution





Legend

- Barrier to Fish Passage
- Counting Station
- Known Chum Distribution
- TRIM River
- Watershed Boundary

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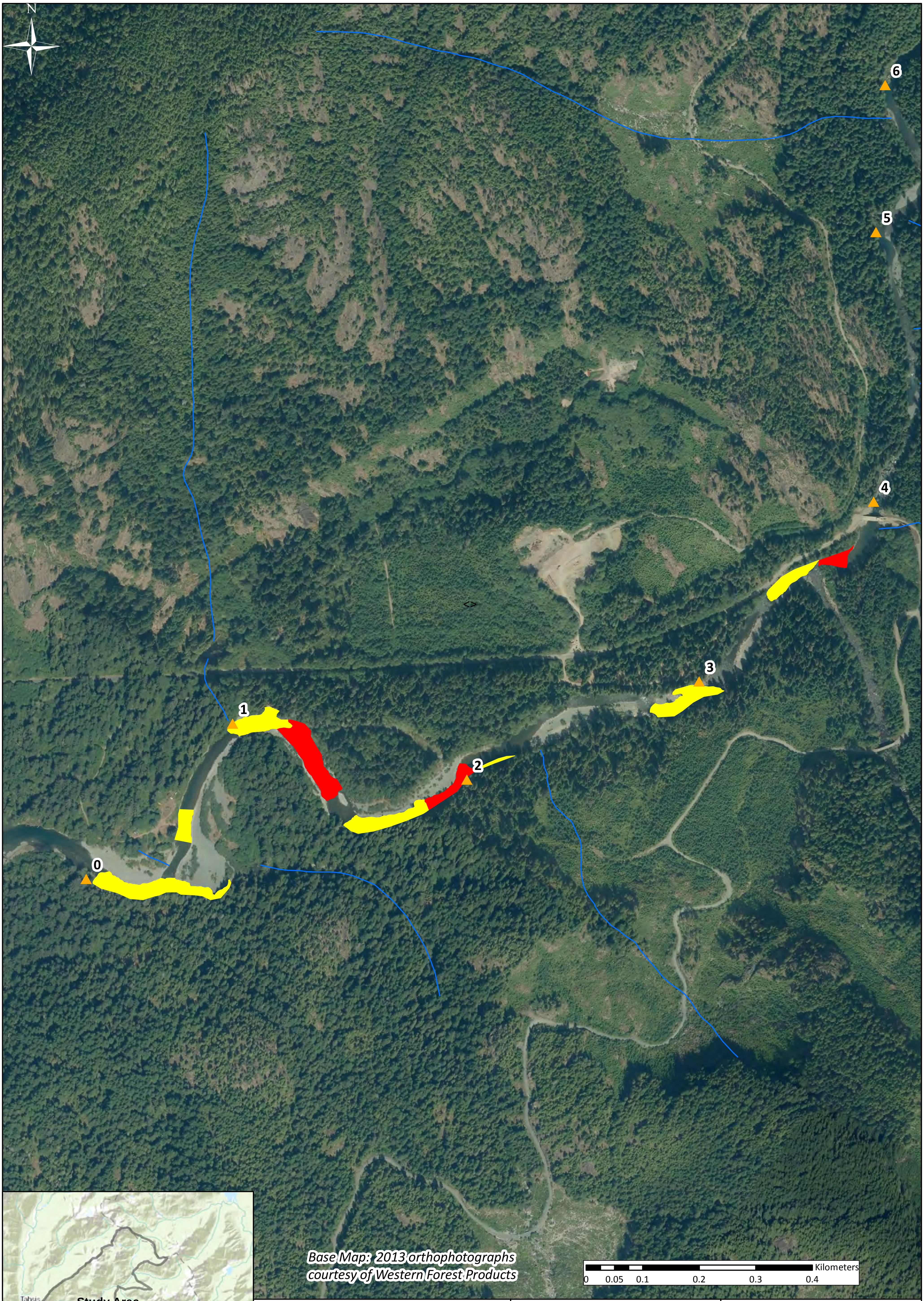
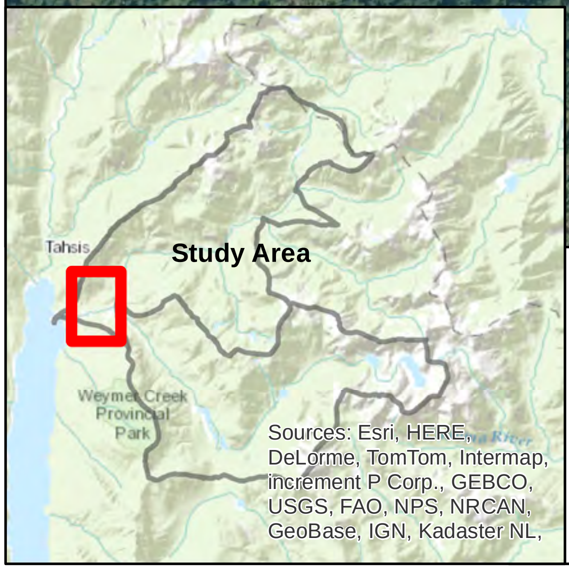
MAP 4

Leiner River Watershed Known Chum Distribution





Legend

- ✕ Barrier to Fish Passage
- ▲ Counting Station
- Known Holding Habitat (Chinook)
- Known Spawning Habitat (Chinook)
- TRIM River

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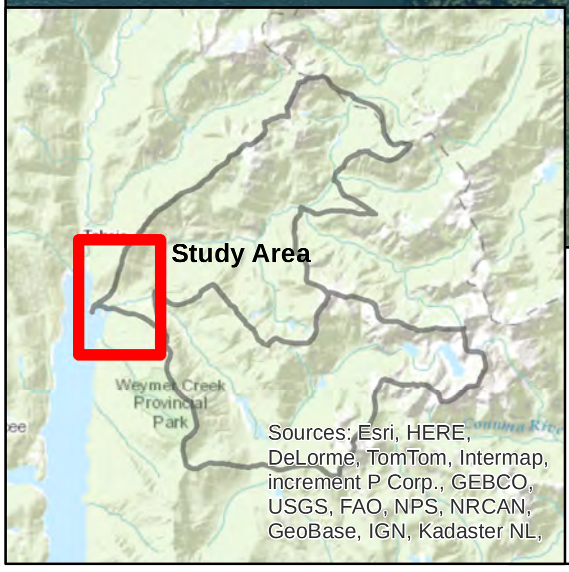
MAP 5

Leiner River Watershed
Known Chinook Habitat:
Adult Holding and Spawning



Legend

- Barrier to Fish Passage
- Counting Station
- Known and Modeled Juvenile Rearing
- TRIM River

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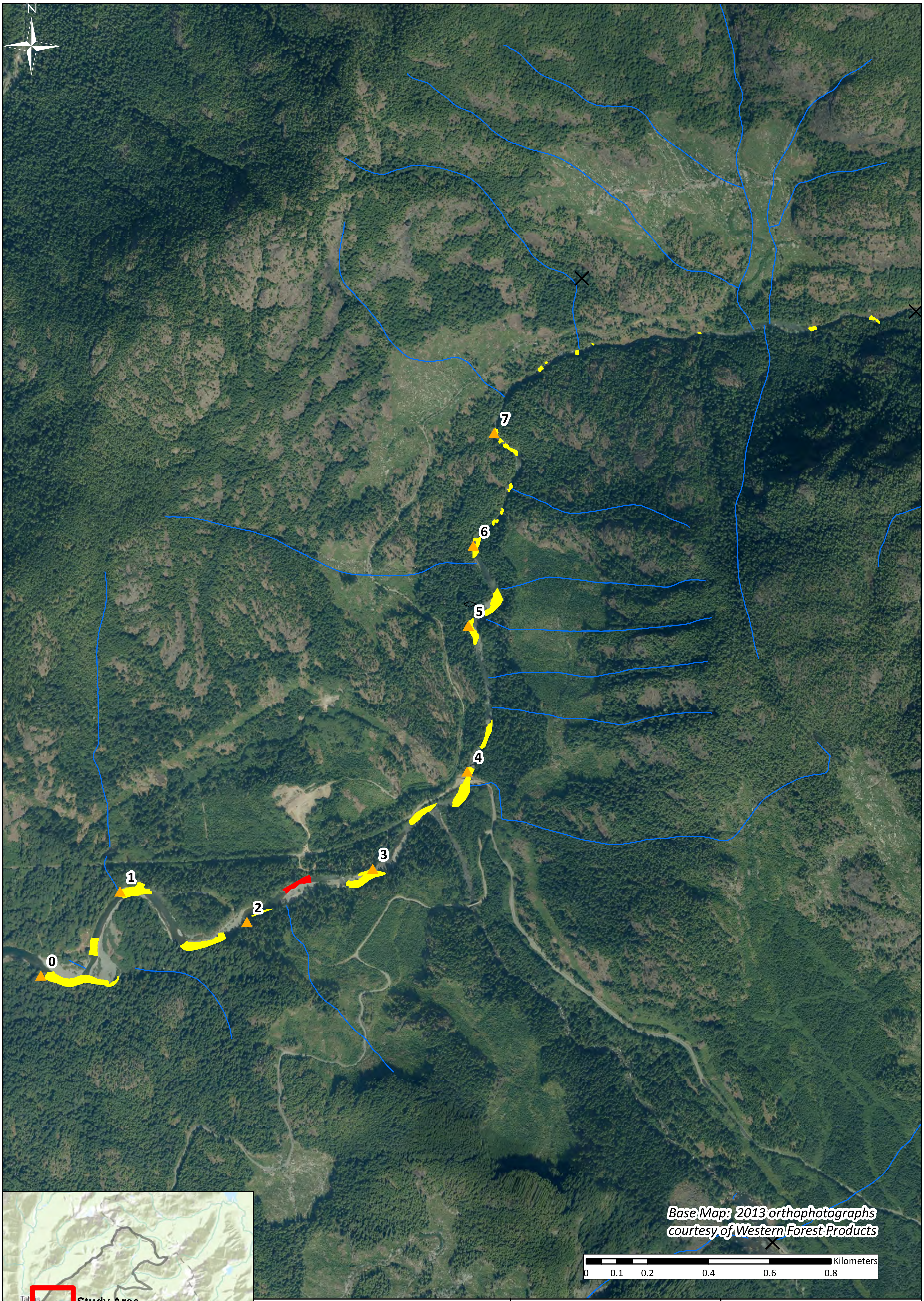
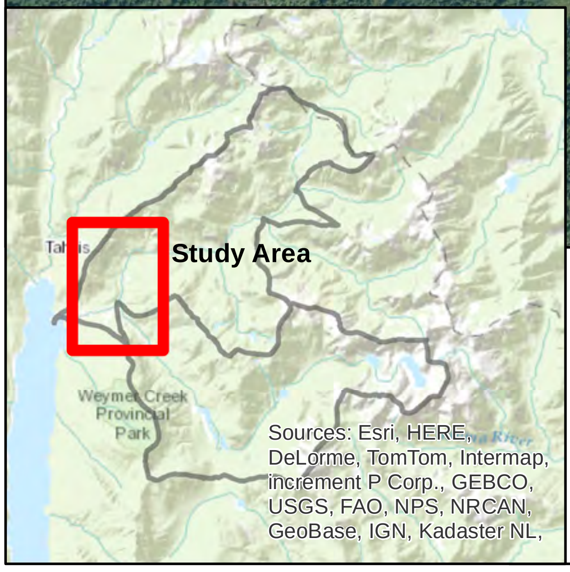
MAP 6

**Leiner River Watershed
Known and Modeled Chinook
Habitat: Juvenile Rearing**





Legend

- Barrier to Fish Passage
- Counting Station
- Known Holding Habitat (Coho)
- Known Spawning Habitat (Coho)
- TRIM River

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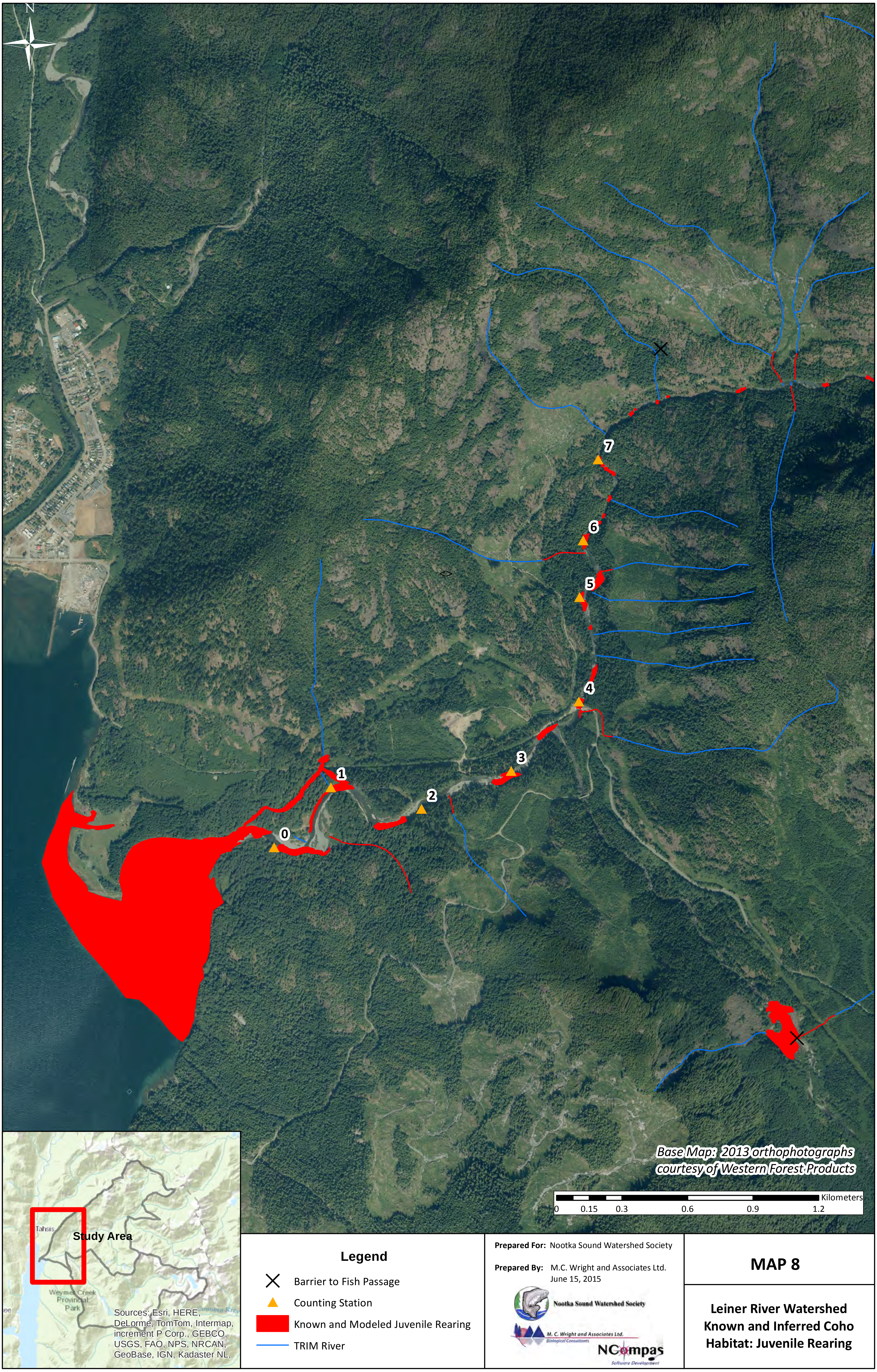
MAP 7

Leiner River Watershed Known Coho Habitat: Adult Holding and Spawning



N
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Base Map: 2013 orthophotographs
courtesy of Western Forest Products
0 0.15 0.3 0.6 0.9 1.2
Kilometers
Tahsis
Study Area
Weymer Creek Provincial Park
Sources: Esri, HERE, DeLorme, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL,
Legend
Barrier to Fish Passage
Counting Station
Known and Modeled Juvenile Rearing
TRIM River
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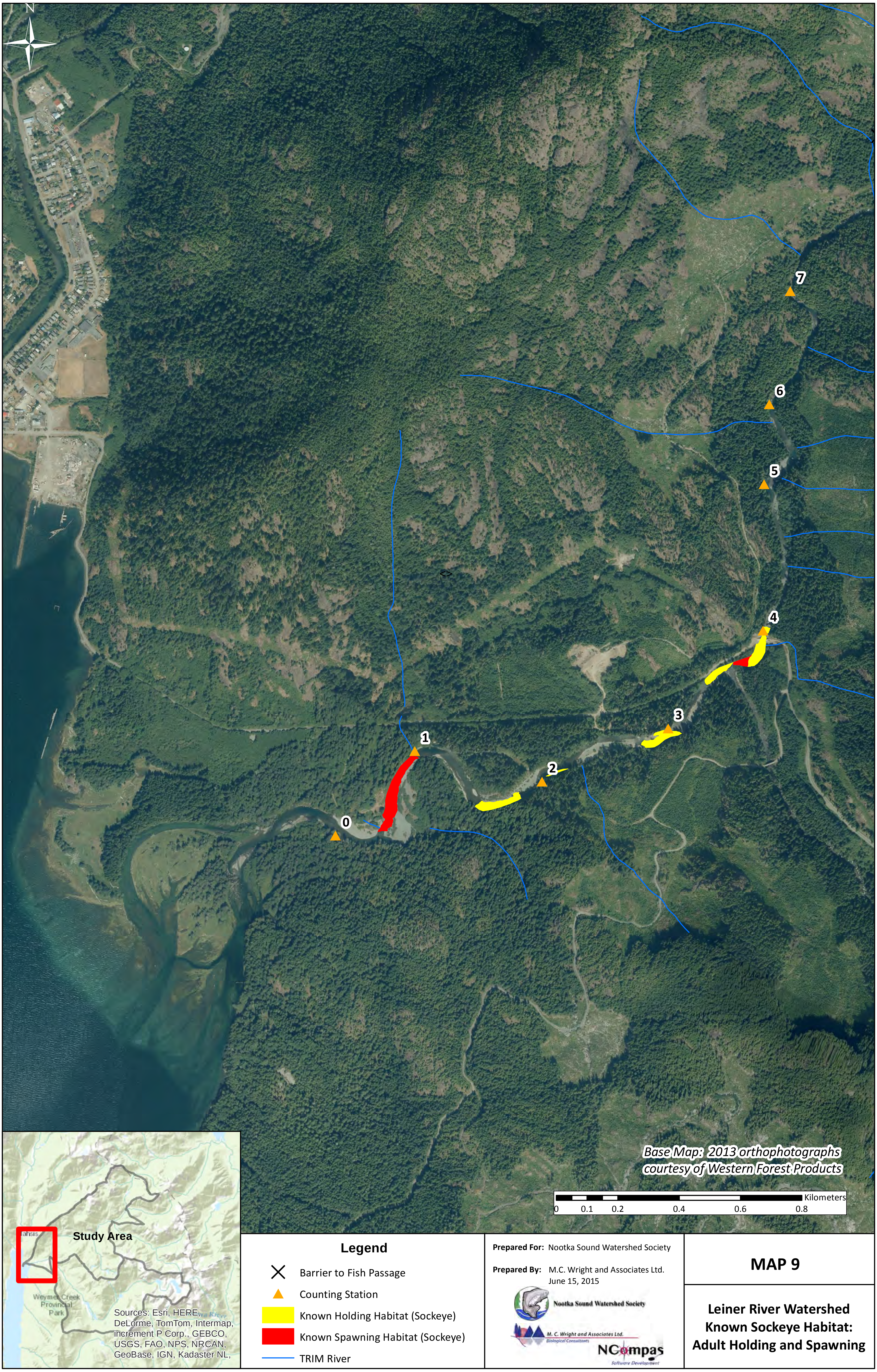
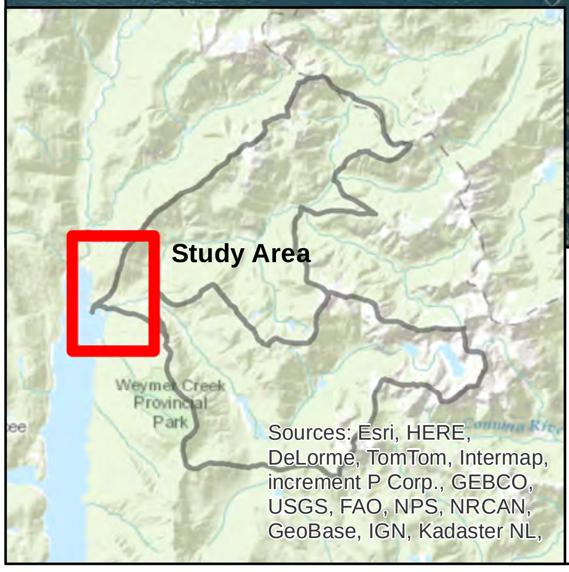
MAP 8
Leiner River Watershed
Known and Inferred Coho
Habitat: Juvenile Rearing



MAP 9

Leiner River Watershed Known Sockeye Habitat: Adult Holding and Spawning



Legend

- Barrier to Fish Passage
- Counting Station
- Known and Modeled Juvenile Rearing
- TRIM River

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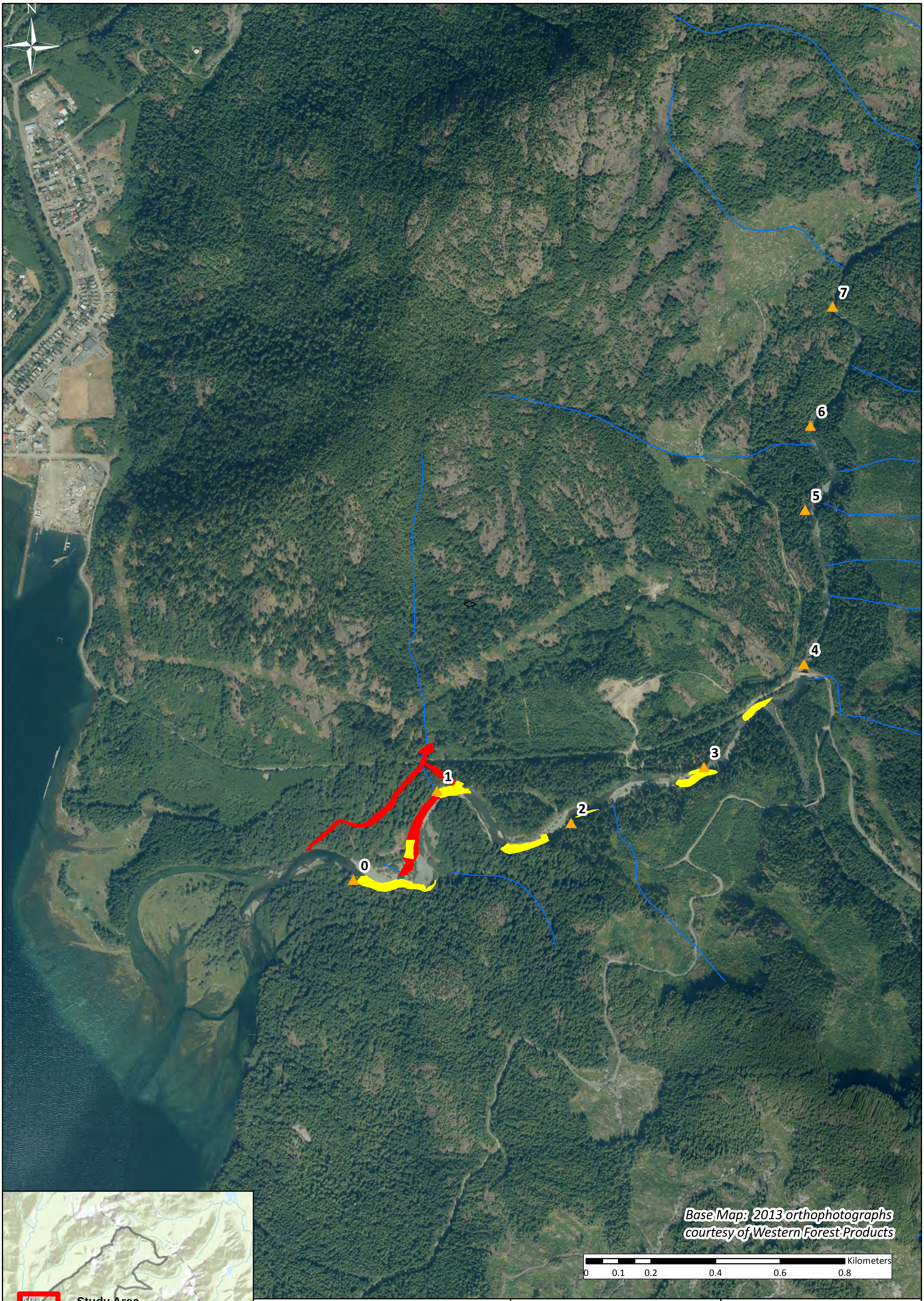
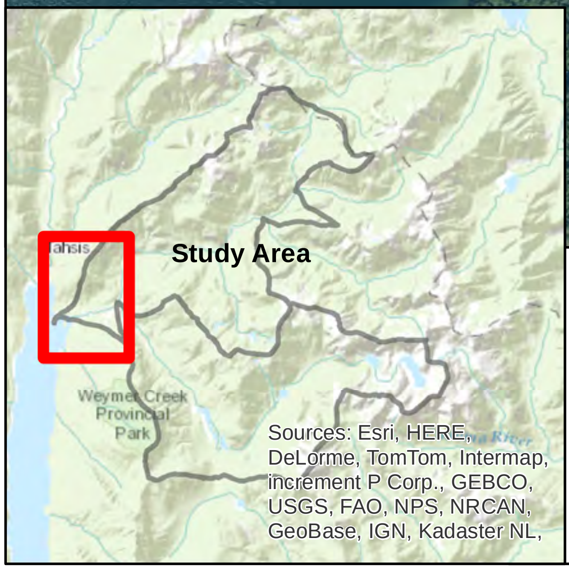
MAP 10

Leiner River Watershed Known and Modeled Sockeye Habitat: Juvenile Rearing





Legend

- Barrier to Fish Passage
- Counting Station
- Known Holding Habitat (Chum)
- Known Spawning Habitat (Chum)
- TRIM River

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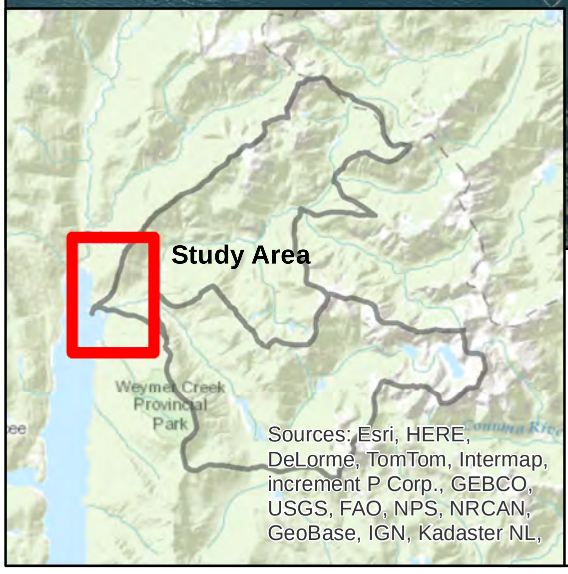
MAP 11

Leiner River Watershed Known Chum Habitat: Adult Holding and Spawning



Legend

- Barrier to Fish Passage
- Counting Station
- Known Juvenile Rearing
- TRIM River

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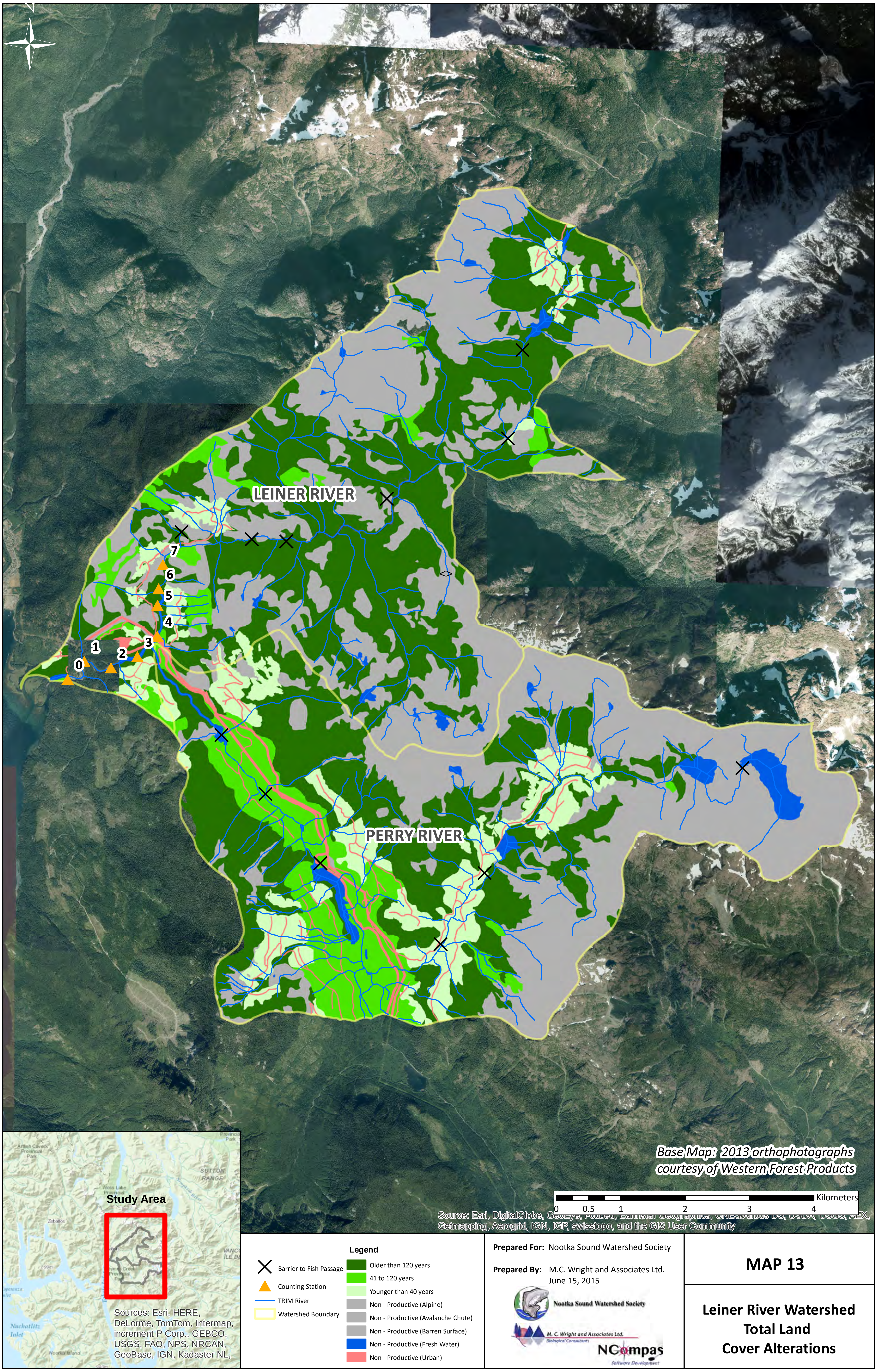
MAP 12

Leiner River Watershed
Known Chum Habitat:
Juvenile Rearing



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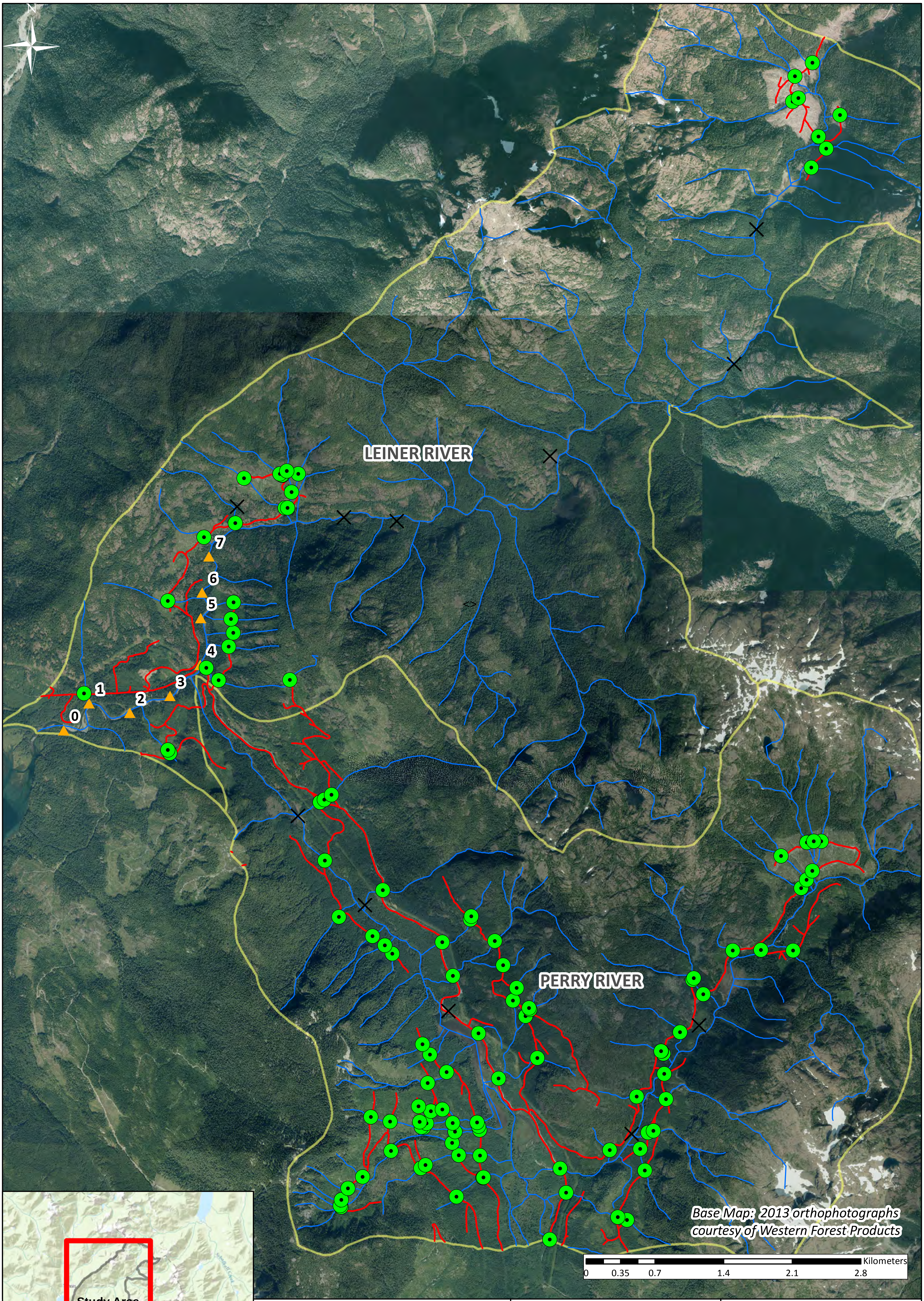
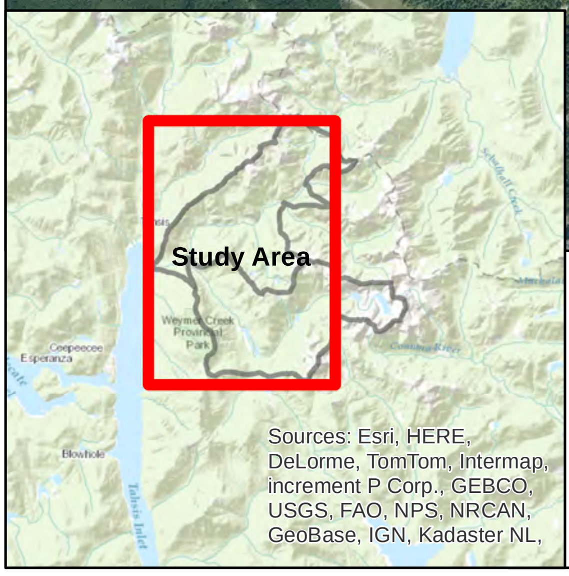
MAP 13

Leiner River Watershed Total Land Cover Alterations





Legend

- Stream Crossing
- Barrier to Fish Passage
- Counting Station
- TRIM River
- Road
- Watershed Boundary

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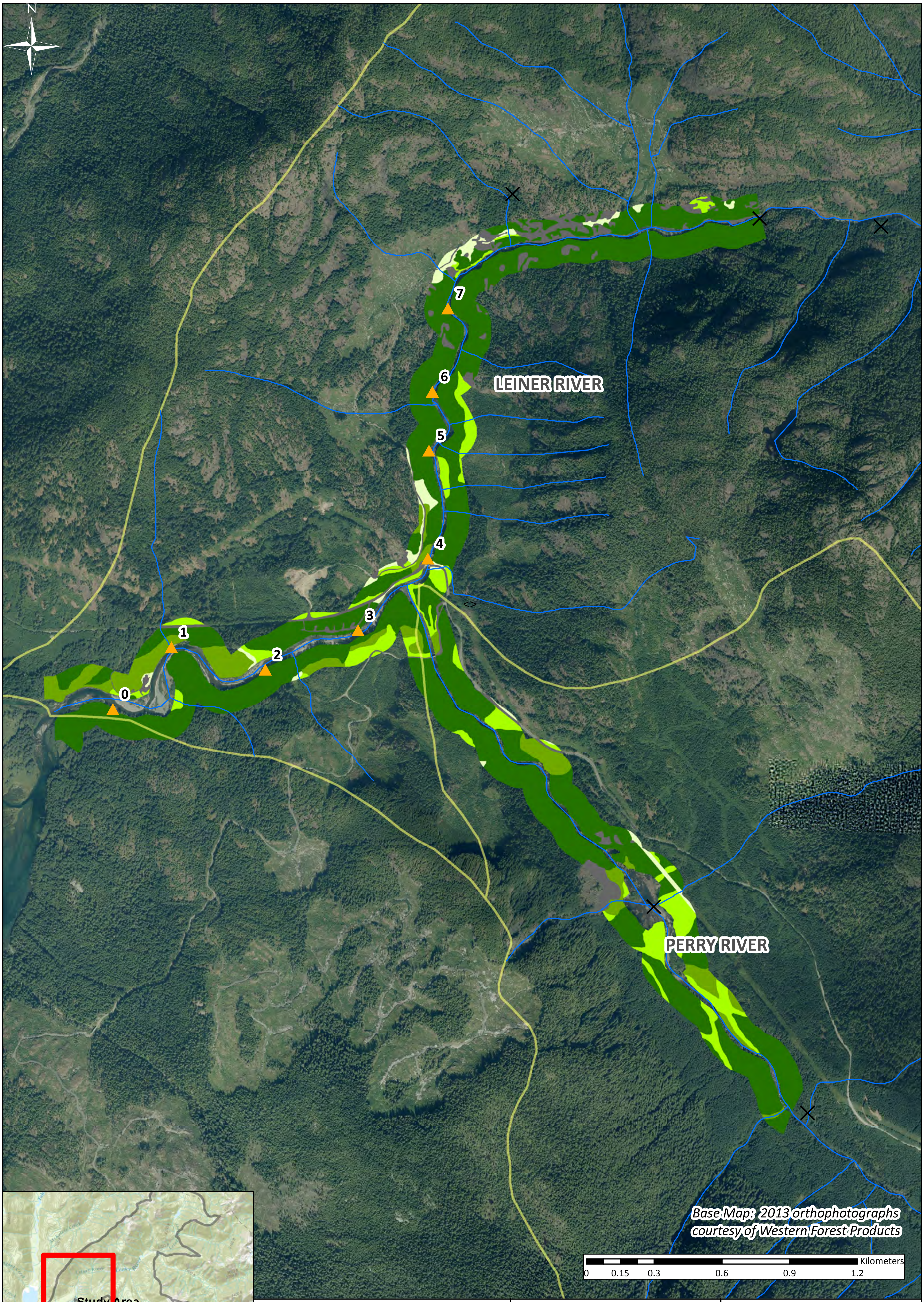
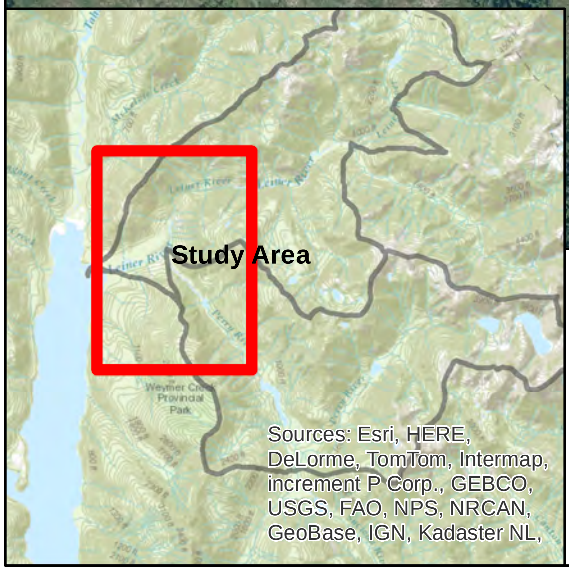
MAP 14

Leiner River Watershed Road Density and Stream Crossings





Legend

- Barrier to Fish Passage
- Counting Station
- TRIM River
- Watershed Boundary

Riparian Classification

- Mature Conifer
- Mature Mixed
- Deciduous or Regenerating
- Early Regenerating
- Bedrock
- Non-Productive

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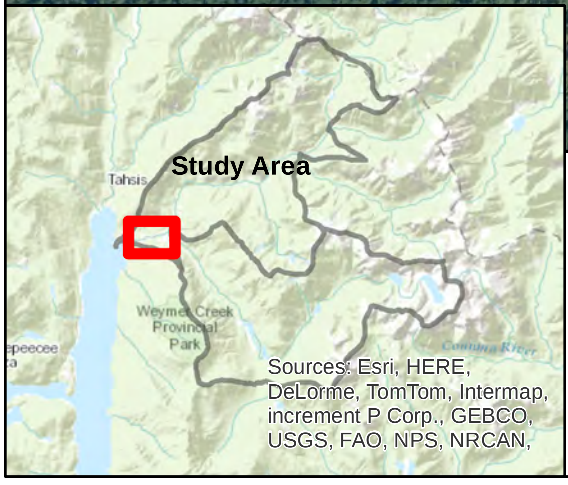
MAP 15

Leiner River Watershed Riparian Disturbance



Legend

Habitat Type

- Braided
- Debris Jam
- Glide
- Gravel Bar
- Pool
- Riffle
- Secondary or Side Channel
- Vegetated Gravel Bar

- Counting Station
- TRIM River

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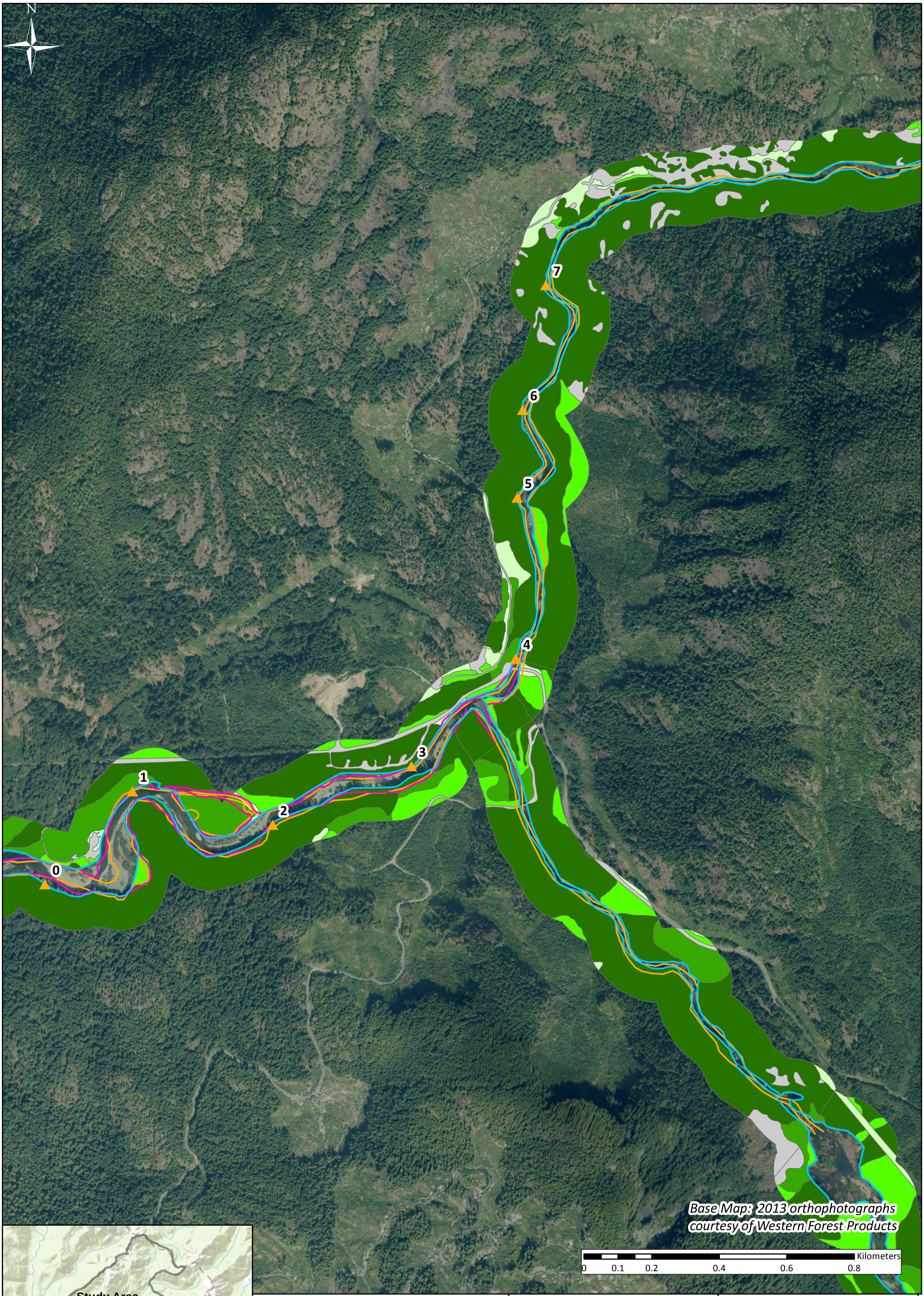
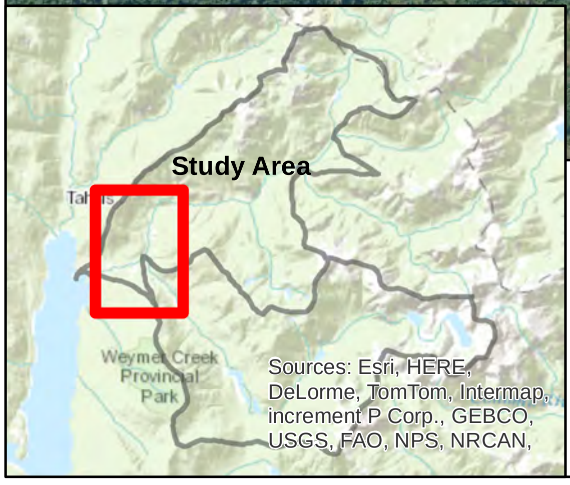
MAP 16

Leiner River Watershed Habitat Composition 1995 vs. 2013





Legend

Bankful Width (2013)	**Riparian Classification**
Bankful Width (1995)	Deciduous or Regenerating
Bankful Width (1980)	Early Regenerating
Counting Station	Mature Conifer
	Mature Mixed
	Non-Productive
	Bedrock

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MAP 17

Leiner River Watershed Channel Bank Stability 1980 to 2013