

# Wild Salmon Policy - Strategy 2: Fish Habitat Status Report for the Canton Creek Watershed

Prepared For:

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## LIST OF ACRONYMS / ABBREVIATIONS USED

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

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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 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 Canton Creek watershed.

### 1.1 Objectives

This report is intended to identify the state and quantity of habitat factors that are potentially limiting fish production in Canton Creek, 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 Canton Creek 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, Leiner and Perry Rivers, Sucwoa River, Tsowwin River, and the Conuma River) has been completed using the same framework.

## 1.2 Canton Creek Watershed

The Canton Creek watershed is located approximately 100km west of Campbell River, B.C., and 28k northwest of Gold River, B.C., on the west coast of Vancouver Island (Figure 1). Canton Creek drains from its headwaters at an elevation of 1,050m, and flows southerly into the north end of Tlupana Inlet at Head Bay (Glova and McCart, 1979). The watershed is comprised of two main branches of the mainstem: East Canton Creek and West Canton Creek, which converge into lower main channel (Canton Creek) approximately 4.5km upstream from the estuary. The Canton Creek watershed encompasses a drainage area of approximately 37.96km<sup>2</sup>.

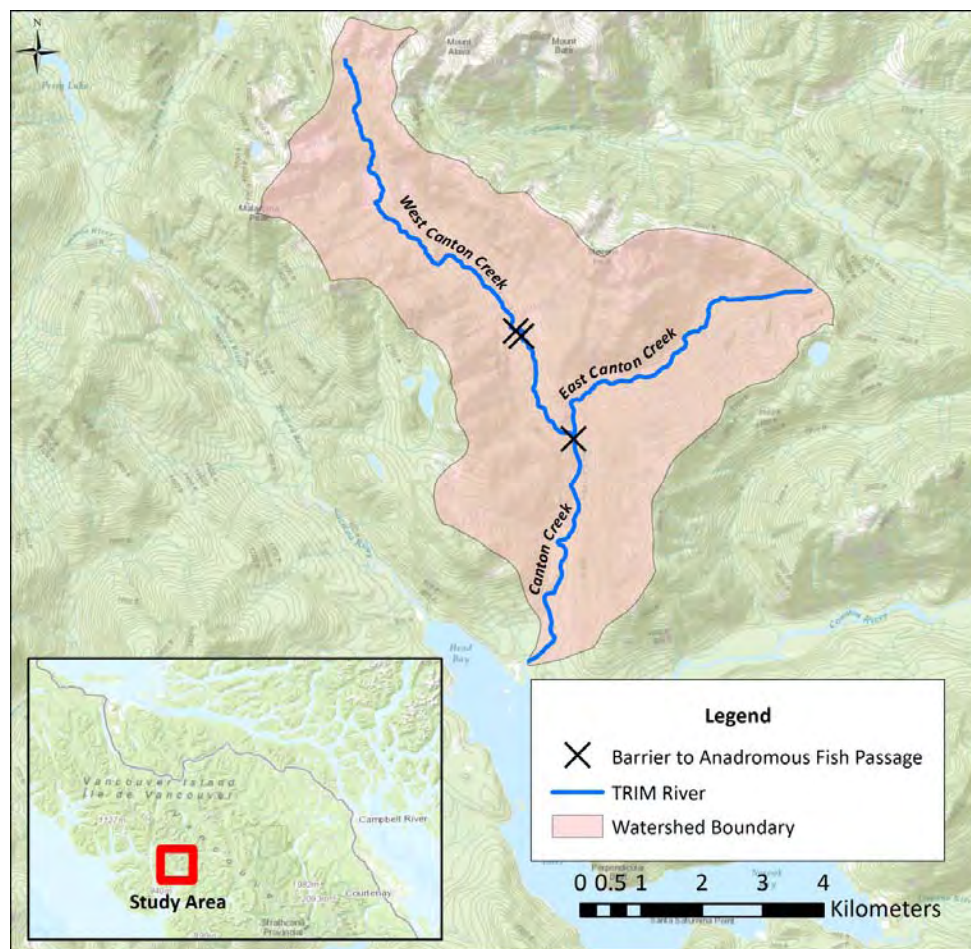


Figure 1. General location of the Canton Creek watershed.



### **1.2.1 Climate, Topography, and Hydrology**

The Canton Creek watershed is situated primarily within the coastal western hemlock (very wet maritime) biogeoclimatic zone, with small components situated in the mountain hemlock (moist maritime) and very small areas in the alpine tundra biogeoclimatic zones (Horel, 2008). This area has a mild oceanic climate with high humidity, with the majority of its annual precipitation received as rain. The closest Environment Canada climate station located at the Conuma River hatchery identifies annual average rainfall in the area to be 3,160mm (Horel, 2008). Given the high annual precipitation, streams in this area experience large-scale, rapid fluctuations in flow (Witt and Clozza, 1980) (Fisheries and Oceans Canada, 2012).

The Canton Creek watershed is characterized by a short, U-shaped main valley with two steep headwater tributaries. The larger tributary, West Canton Creek, extends northwest from the confluence with the smaller, East Canton Creek tributary, which branches northeast (Horel, 2008) (Dobson Engineering Ltd., 1998). The lower main valley has a broad floodplain and alluvial mainstem extending into a delta fan at the estuary. Extensive steep terrain exists above the valley floor, and the valley is surrounded by peaks up to 1,600m in elevation (Horel, 2008). The lower portion of the main channel is wide and aggraded with prominent mid and perimeter gravel bars. Above counting station 5 (approximately 2.5km upstream from the estuary), the main channel increases in gradient, becomes confined, and is considered stable (Fisheries and Oceans Canada, 2012). The east valley has steep slopes with short, entrenched, steep creeks and natural landslides, while the west valley has moderate to steep slopes with predominantly non-alluvial creeks. Both valleys provide an abundant natural supply of sediment, particularly the west valley (Horel, 2008).

### **1.2.2 Watershed Description**

An analysis of watershed indicators by Horel in 2008 identified the Canton Creek watershed to be highly sensitive based on the regional landslide frequency, total area of the watershed in steep terrain (i.e. >60%), occurrence of natural landslides, hillslope connectivity to the mainstem, channel sensitivity, and lack of floodplains. In addition, this watershed was identified as least disturbed based on the frequency of landslides from roads and cutblocks, length of stream channels with inadequate riparian forest to provide LWD, and channel stability maintenance. The watershed trend was identified as improving; however, the system may have sites that are still disturbed. Lower mainstem widening and aggrading has been attributable to pre-Forest Practices Code (FPC) logging, although alder riparian bands indicate channel stability is improving. This watershed indicators work also identified this system to have high to very high fish capacity with large or potentially large anadromous runs (Horel, 2008).

The combined stream length of Canton Creek (East, West, and lower Canton) is approximately 96.2km, 11.7km of which are fish-bearing (Turley, 1997). Canton Creek has been previously divided into two distinct reaches; the first comprised of low gradient, mainly gravel substrates in an unconfined channel and the second (West Canton Creek) characterized by bedrock canyon with pools, falls, and chutes (Witt and Clozza, 1980). A barrier to anadromous fish access (impassable falls) exists approximately 4.8km upstream of the estuary and is also the location of the reach break (Figure 1).

Aggrading has occurred in the lower Canton mainstem (Reach 1) as a result of pre-FPC logging. Increased sediment delivery paired with low channel gradients has resulted in gravel deposition throughout much of the system (Dobson Engineering Ltd., 1998). In 1979, a baseline habitat assessment identified a section of channel (approximately 100m in length) mid-way down Reach 1 where stream flows disappeared beneath the gravel substrates (Witt and Clozza, 1980). Assessments conducted in 1998 identified the lower 2.7km of the mainstem to have contained elevated mid-channel bars and few pools. In addition, alluvial banks susceptible to erosion were identified in the lower 1.3km (Dobson Engineering Ltd., 1998).

### **1.2.3 Watershed History**

Canton Creek resides 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 in the neighbour Tahsis Inlet as early as 1882 (Sellars, 1992).

### ***Resource Extraction***

The Canton Creek watershed has a history of forest harvesting starting in the 1960s - 1970s and much of the lower portion of the watershed has been logged (Turley, 1997) (Glova and McCart, 1979) (Photo 1 and Photo 2). By the mid-1970s, some impacts to side channels from streamside falling were observed, and log jams in the mainstem requiring removal via hand labour, power saws, and explosives became increasingly frequent (Fisheries and Oceans Canada, 1949 - 1994). Reports in 1977 indicated the river to be highly unstable in the lower reaches and suffering from scouring caused by debris, most of which originated from collapsing banks and windfall. Impacts to small tributaries in the lower river resulting from road building were observed in 1993. By 1997, most of the easily accessible timber in the first pass along the valley floor had been harvested, leaving the higher timber on the hillsides for harvest post-1997. By 1998 over 85% of the East Canton mainstem, 20% of the West Canton mainstem and almost 50% of the lower main channel riparian zone had been harvested along both banks (Dobson Engineering Ltd., 1998). The land base is owned by the Crown and licensed for harvest under TFP 19 (Fisheries and Oceans, 2012).





**Photo 1. Canton Creek watershed in 1954, prior to forest harvesting. Note heavy harvesting in the adjacent Sucwoa River watershed.**



**Photo 2. Forest harvesting adjacent to lower Canton Creek in 1980.**

Other developments in the area are restricted to the Head Bay transportation corridor which crosses Canton Creek just upstream of the estuary. Numerous mining claims have been registered in the headwaters of Canton creek, but as of 2012 none were listed as current (Fisheries and Oceans, 2012).



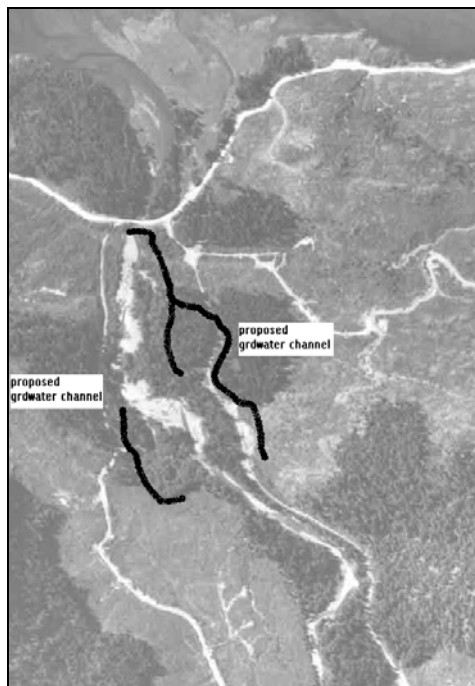
#### **1.2.4 Previous Restoration Initiatives**

##### ***Chum Spawning Back Channel Constructed in 1970s***

During the 1970s the Conuma Hatchery constructed a chum spawning back channel along the left bank of Canton Creek. The channel was to provide stable habitat that was protected from winter floods. The head of the channel began in a wetland approximately 1 km above the Canton Bridge, paralleled the mainstem for approximately 500m, and discharged into a lagoon that connected back to Canton Creek. This channel is no longer maintained by the hatchery. Chum still hold in the lagoon until high water allows access into the channel. In 2012 swim crews observed 150 chum in the channel (Fisheries and Oceans Canada, 2012). There is no documentation on the present condition of the channel; as such, further investigation of the channel condition should be considered to see if any channel maintenance is required.

##### ***Proposed Groundwater Channels***

In 2007, a proposal was developed by Fisheries and Oceans Canada to construct groundwater channels along the left and right banks of Canton Creek, with the intent of improving both chum and coho salmon productivity levels (Photo 3). While 10 shallow test pit wells were installed along the left bank in 2004 as part of a feasibility study, no further construction with respect to this project occurred (Fisheries and Oceans Canada, 2007).



**Photo 3. Proposed location of groundwater channels in Lower Canton Creek (Fisheries and Oceans Canada, 2007)**

### ***Bridge Abutment Reclamation and Sedge Bench Construction***

In 2012, replacement of the Head Bay FSR 41.7km bridge (i.e. Canton Creek bridge) occurred. This new bridge was installed just downstream of the old bridge, resulting in re-alignment of Head Bay Road at the bridge crossing. In an effort to improve productivity levels in Canton Creek the deactivated road prism (and old right bank bridge footing) was reclaimed through the excavation of old fill down to elevations that would support sedge habitat. Following excavation, this area was transplanted with sedges from estuarine habitat within Canton Creek (Photo 4, Photo 5, and Photo 6) (Musial et al, 2012). Recent observations have demonstrated high transplant survival rates and overall expansion of vegetated areas (M.C. Wright and Associates, in-field observations).



**Photo 4. Reclaimed and transplanted sedge habitat along the right bank of the Canton Creek bridge.**





**Photo 5. Reclaimed and transplanted sedge habitat along the right bank of the Canton Creek bridge.**



**Photo 6. Reclaimed and transplanted sedge habitat along the right bank of the Canton Creek bridge.**

## 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 Canton Creek 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 Canton Creek. 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 Canton Creek 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<sup>2</sup> = lower risk

>0.4km / km<sup>2</sup> = 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 Canton Creek 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 for the anadromous reach of the mainstem 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 municipalities. 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 Canton Creek, select water quality data was available through the Ministry of Energy and Mines regional geochemical stream survey dataset.

#### **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 Canton Creek 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 Canton Creek 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-stage 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).

No discharge data was available for Canton Creek and has therefore been identified as a data gap.

#### **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 critical habitats to protect from future industrial initiatives.

Key spawning areas were identified from the following sources: FISS, various technical reports, interviews with 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 and 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 Canton Creek 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 Canton Creek watershed was evaluated through the comparison of historical air photos (1980 and 1995) and recent orthophotographs (2013). Bankfull 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 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 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 Canton Creek 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 estuarine habitat disturbances to the Canton Creek 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 Canton Creek estuary.

### **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.

No relevant chemistry or contaminant data for the Canton Creek 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 Canton Creek 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 Canton Creek 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 CANTON CREEK WATERSHED**

The rivers which flow into Tlupana Inlet, including Canton Creek, have been identified to support relatively large chum, chinook, and coho salmo populations (Witt and Clozza, 1980). Four species of anadromous salmon (*Oncorhynchus tshawytscha*, *O. kisutch*, *O. keta*, and *O. nerka*) are supported by the Canton Creek watershed. Assessment of these stocks occurs primarily

through annual Area Under the Curve (AUC) snorkel surveys during the spawning season. 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 in Canton Creek are ocean-type chinook. These chinook typically enter the river in mid-September, with peak spawning observed in early October, and the end of the run observed in mid-October (Fisheries and Oceans Canada, 2012). Distribution is limited to the lower 4.47km of the river (Figure 2).

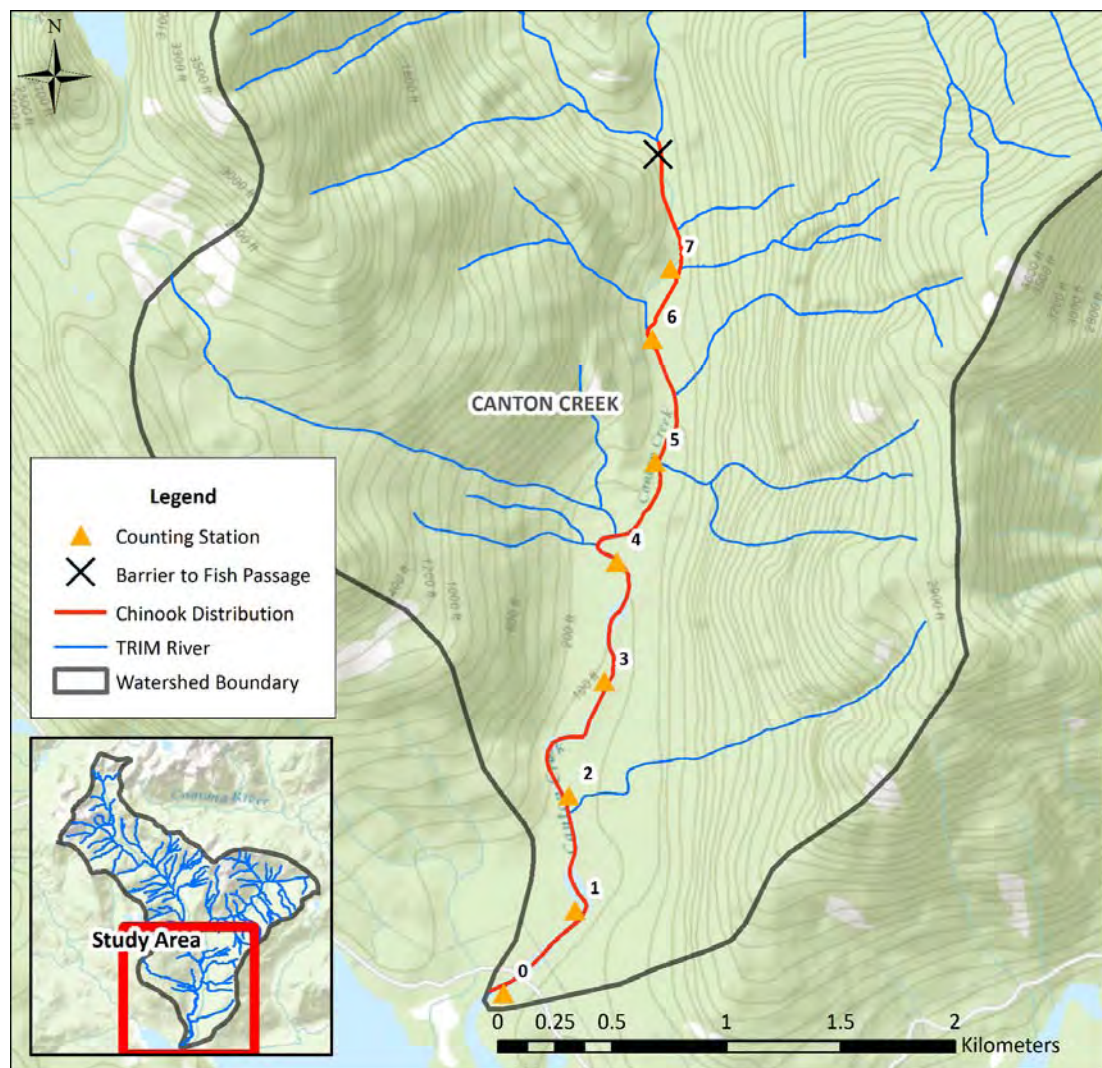


Figure 2. Known chinook distribution in the Canton Creek watershed.

During upstream migration to the spawning grounds, adult chinook utilize the deep pool beneath the Canton Creek bridge as an early staging area. As this pool is partially tidal, it likely facilitates osmoregulation as these fish transition from the marine to freshwater environment. A large pool just downstream of counting station 1 is heavily utilized for holding and provides excellent cover for these fish. Consistent holding is observed in the deeper glides and upper pool between counting stations 2 and 3, and small numbers of chinook are often observed holding in a small pool just upstream of counting station 6 (Fisheries and Oceans Canada, 2012) (Figure 3).

As chinook salmon eggs have the largest surface area to volume ratio when compared with other pacific salmon species, 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 Canton Creek, chinook spawn throughout the anadromous reach of the river. Some spawning is observed in riffles between counting stations 0 and 2, and heavy spawning occurs in the glide below counting station 4. Between counting stations 4 and 5, glide habitats are consistently targeted by spawners. Small numbers of chinook have also been observed in key glides and riffles between counting stations 5 and 7 (Figure 3).



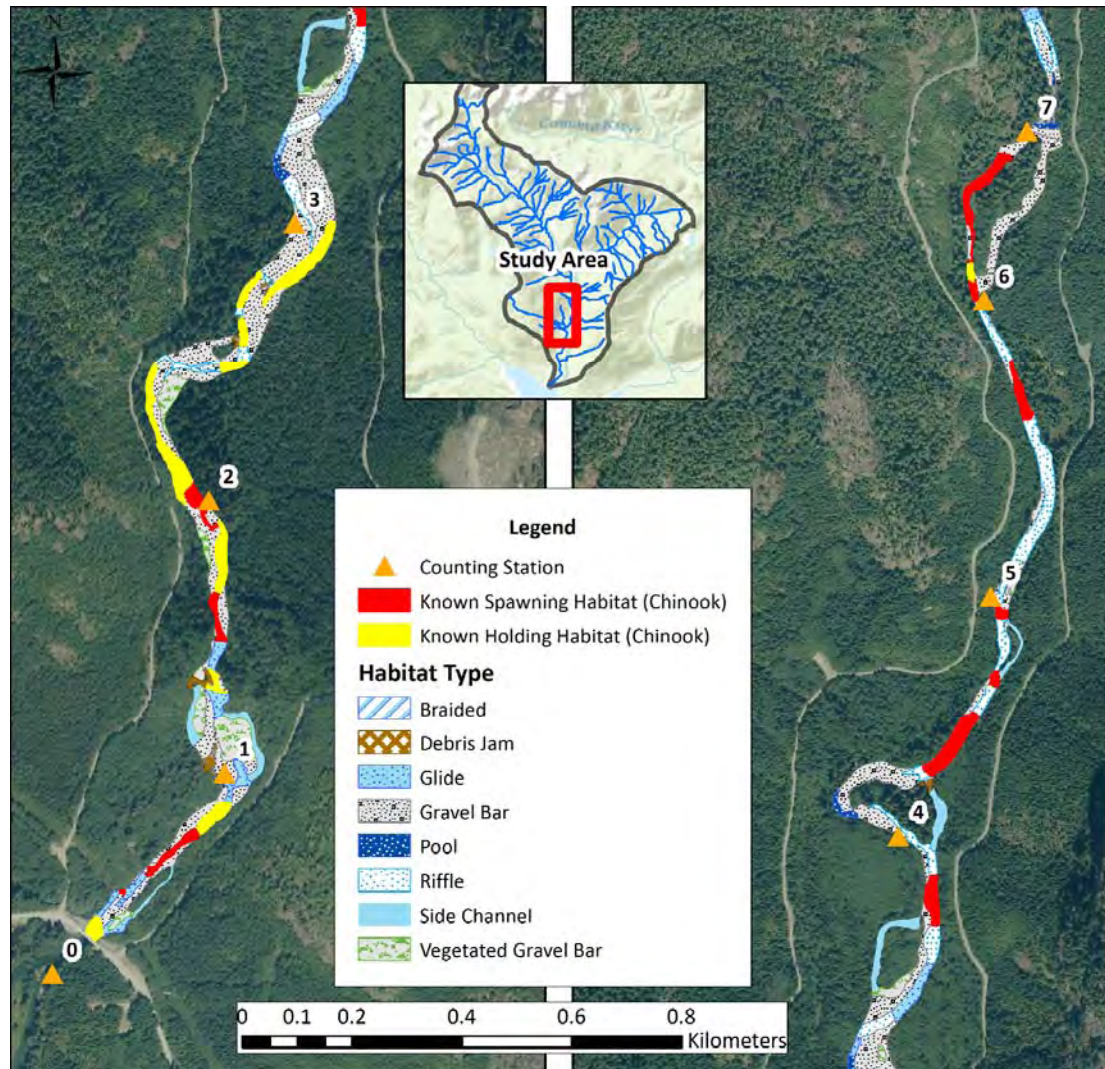


Figure 3. Known adult chinook holding and spawning habitat in Canton Creek.

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. Migration usually occurs between April and June for ocean-type chinook (note that the specific migration timing for the Canton Creek system is unknown). During downstream migration, fry typically target reduced flows at the river edges. Given this requirement migration habitat for chinook fry has been inferred for Canton Creek based on characteristics observed from the orthophotographs. In addition, chinook are known to rear and forage in the estuary and associated intertidal channels (Diewert, 2007) (Figure 4).

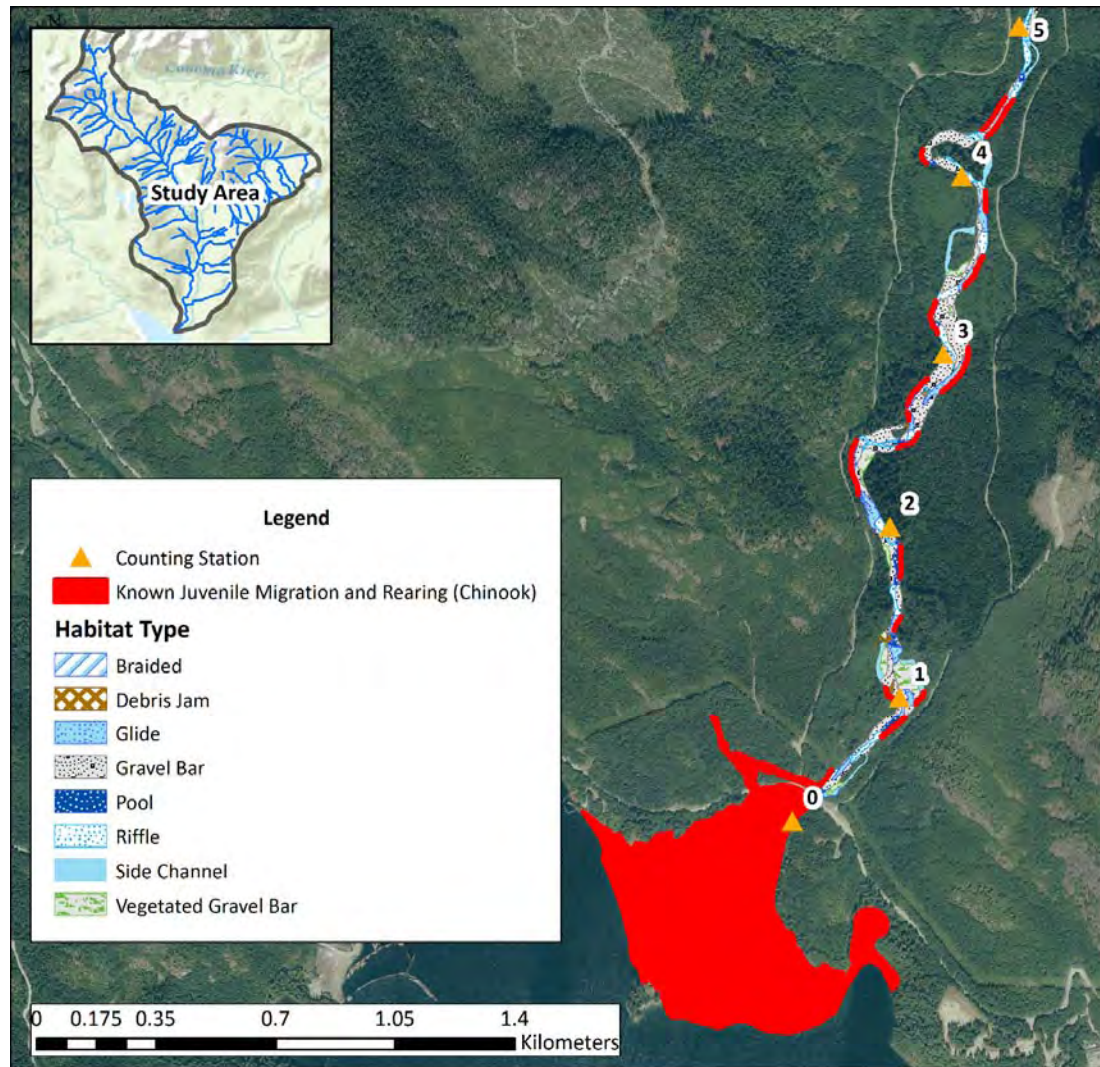


Figure 4. Known juvenile chinook migration and rearing habitat in Canton Creek.

### 3.1.2 Escapement

Historic Chinook escapement numbers have been typically low, generally below 600 fish for the period from 1953-1991. Since 1992 escapement numbers have increased, ranging from 100 to 5,000 fish, with 2,246 recorded in 2011 and 3,000 recorded in 2013 (Figure 5). Considering the close proximity of the Canton Creek and Conuma River estuaries, and the current practice rearing of Conuma hatchery fry in nearby Moutcha Bay, recent high counts of chinook are believed to be due in part by straying of Conuma River hatchery stock.



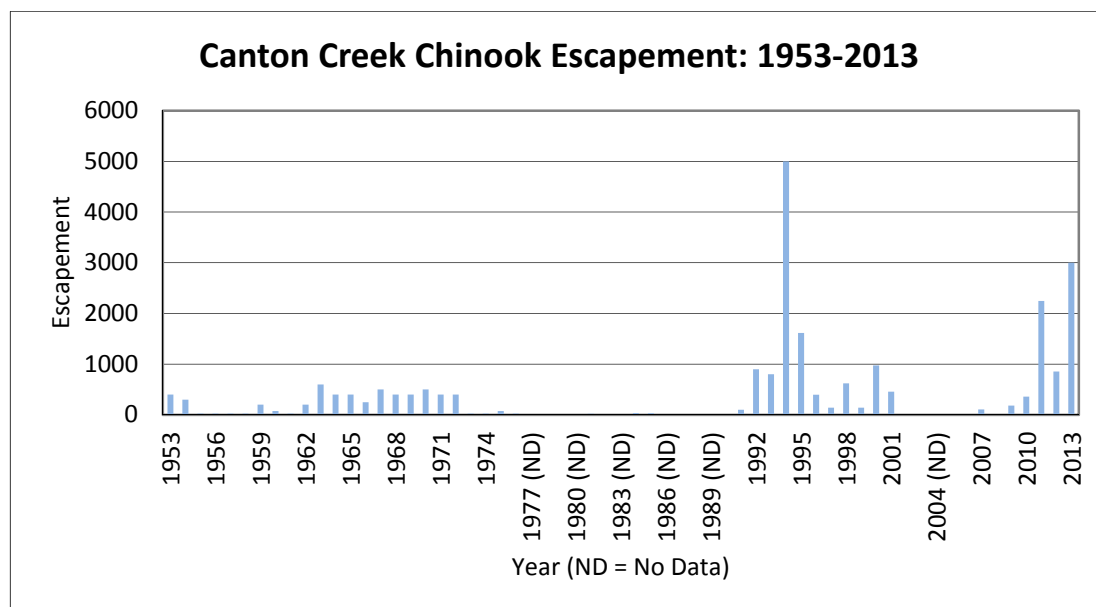


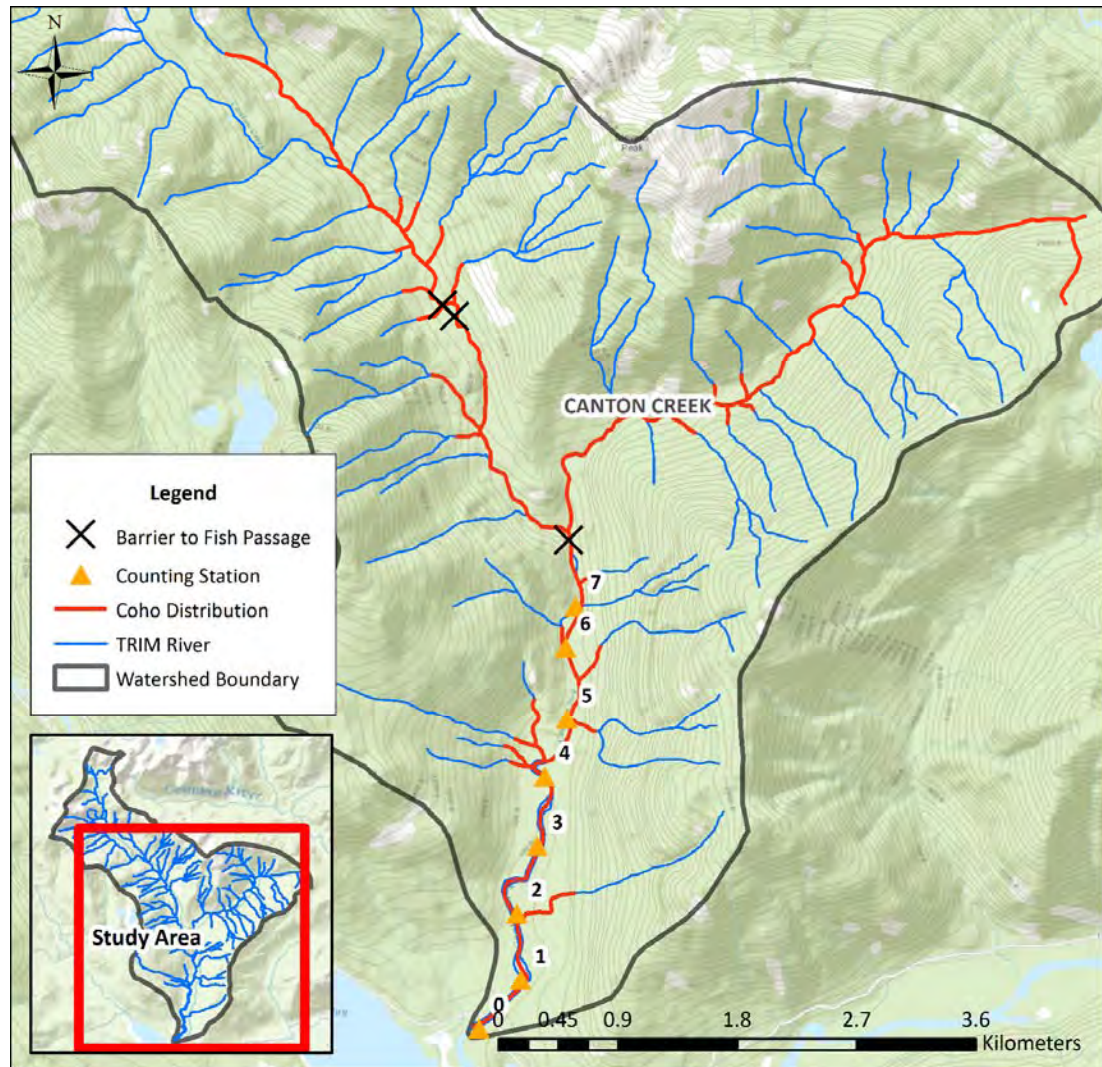
Figure 5. Chinook escapement in Canton Creek between 1953 and 2013 (compiled from DFO's NuSEDs database)<sup>i</sup>.

## 3.2 Coho Salmon

### 3.2.1 Biology, Distribution, and Known Habitats

Coho salmon typically arrive in Canton Creek in mid-to-late September and spawning continues through late December. Peak spawning typically occurs in mid-October (Fisheries and Oceans Canada, 2012). While coho distribution has been reported in the Fisheries and Oceans Canada stream narrative as up to approximately 4.8km upstream from the estuary (just upstream of counting station 7) (Fisheries and Oceans Canada, 2012), juvenile coho were sampled further upstream during stream classifications conducted in 2001 (FishFor Contracting, 2001). As such, coho distribution was extended to reflect these sampling results and the upstream extents of anadromous fish access based on MOE's fish passage modeling data (MFLNRO Fish Passage Technical Working Group Web Page, 2013) (Figure 6).

<sup>i</sup> 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.

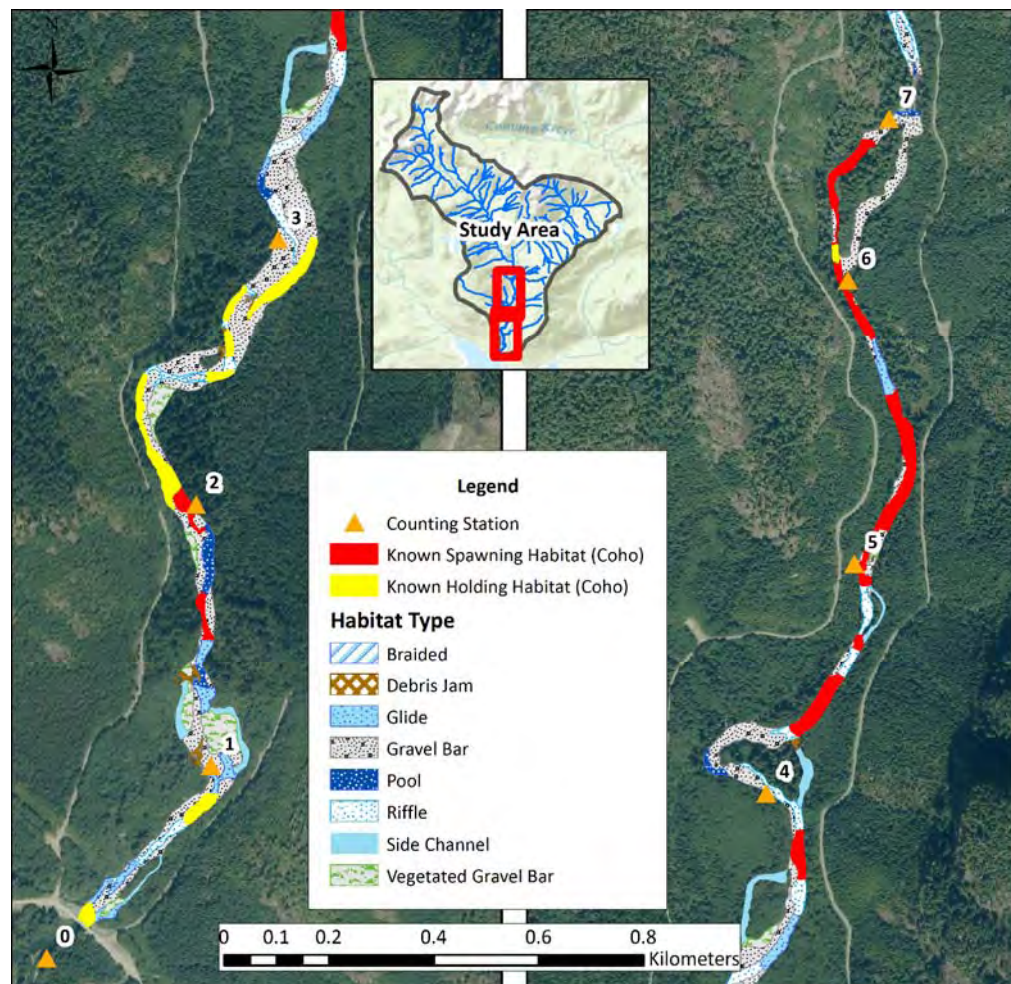


**Figure 6. Known and modeled coho distribution in the Canton Creek watershed.**

During upstream migration to the spawning grounds, adult coho take advantage of several key holding pools, notably between counting stations 0 and 1 and counting stations 2 and 3. Between counting stations 0 and 1, the large pool beneath the bridge is heavily utilized for holding. As this pool is within the upper extent of tidal influence it is an extremely critical zone for the physiological transition between the marine and freshwater environments (R. Dunlop, pers. comm.). The section of river between counting stations 2 and 3 offers the greatest area of holding habitat in the system, and fish are also observed between counting stations 6 and 7, where coho often hold prior to migrating beyond the survey area during higher water levels (Fisheries and Oceans Canada, 2012) (Figure 7). Note that coho holding habitat beyond counting station 7 has been identified as a data gap as no adult fish utilization data exists upstream. Future investigations should be undertaken to determine the location of upstream coho holding in both East and West Canton creeks.



Coho spawning habitat is very diverse, and can range from large river systems to small headwater streams and / or tributaries (Diewert, 2007). In Canton Creek, known coho spawning grounds within the survey area have been identified in key riffles, glides, and pool tailouts between counting stations 1 and 2 and counting stations 3 and 7. Heaviest coho spawning has been identified in the glide downstream of counting station 4 and in the glides and pool tailouts between counting stations 5 and 6 (Figure 7). Note that coho spawning habitat beyond counting station 7 has been identified as a data gap as no adult fish utilization data exists upstream. Future investigations should be undertaken to determine the location of upstream coho spawning in both East and West Canton creeks.



**Figure 7. Known adult coho holding and spawning habitat in Canton Creek. Note that spawning and holding habitat upstream of counting station 7 has been identified as a data gap.**

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 (Diewert, 2007). Fry remain in freshwater for one to two years before migrating to sea as coho smolts (Witt and Clozza, 1980)

During early development in the river, pools, backwaters, side channels, and small tributaries are sought out as rearing habitat. By late fall / 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 Canton Creek watershed; however, it has been noted that coho fry are particularly abundant near debris accumulations (Fisheries and Oceans Canada, 2012). Habitats depicted in Figure 8 have been modeled from both known coho life history requirements and the location of debris accumulations in Canton Creek.



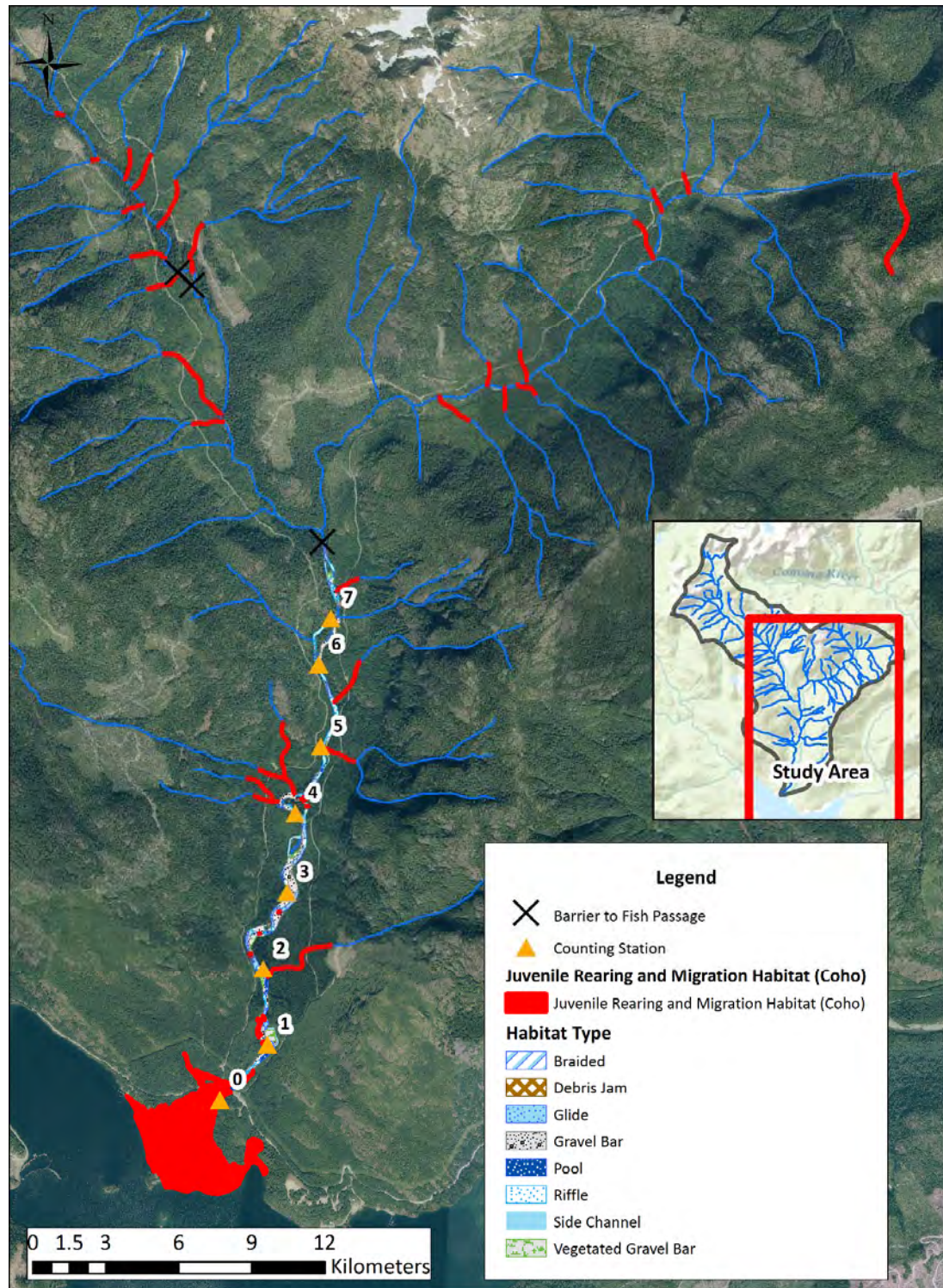


Figure 8. Known and modeled juvenile coho migration and rearing habitat in the Canton Creek watershed.

### 3.2.2 Escapement

Historical records for coho populations show maximum escapements of 1,500 between 1953 and 1999 (Figure 9). A peak count of 3,418 fish was recorded in 2000 with counts from 2001 onward appearing similar to historical escapement numbers (<1,500 fish). Based on the known distribution of coho beyond the survey area, escapement estimates presented in Figure 9 are likely an underestimation of the actual population size.

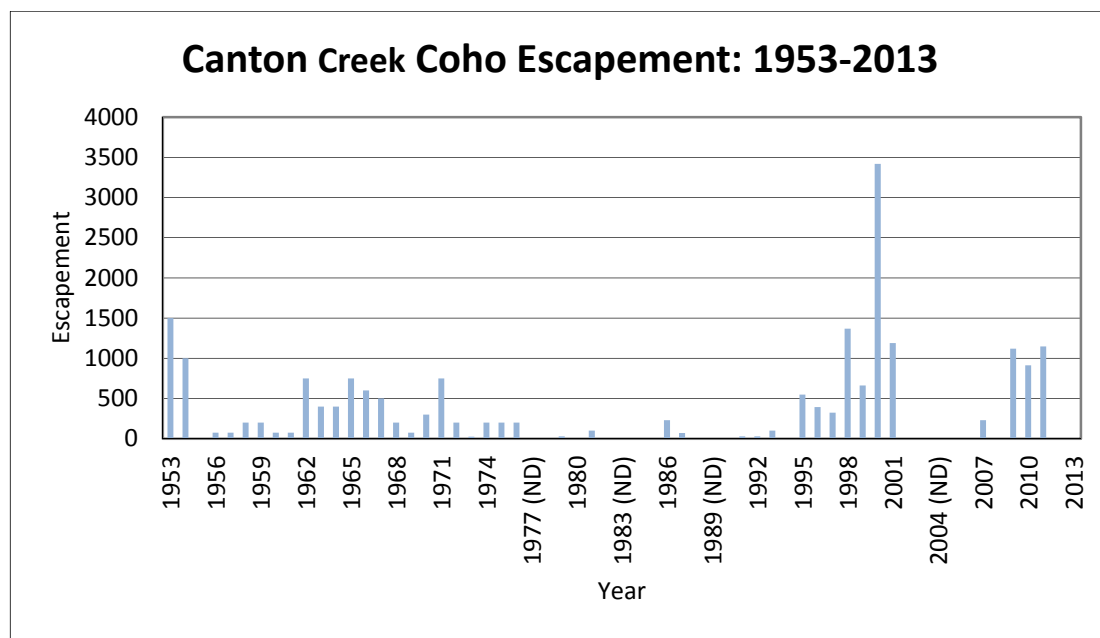


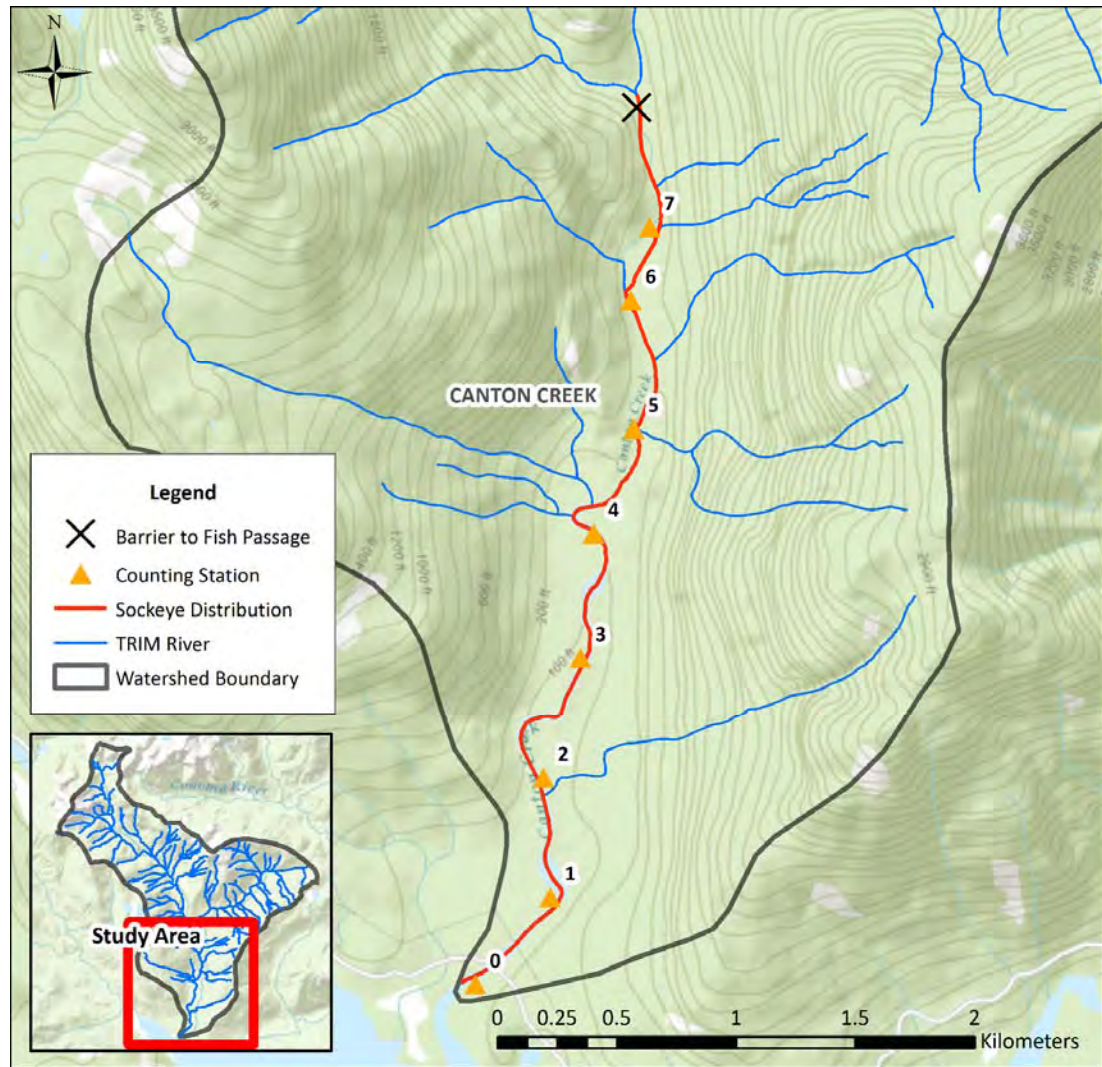
Figure 9. Coho escapement in Canton Creek between 1953 and 2013 (compiled from DFO's NuSEDs database).

## 3.3 Sockeye Salmon

### 3.3.1 Biology, Distribution, and Known Habitats

Sockeye arrive in Canton Creek in early August and begin spawning in late October. Peak spawning is usually observed in early November, with the run complete by the end of December. Distribution is observed approximately 4.5km upstream of the estuary, just upstream of counting station 7 (Figure 10).



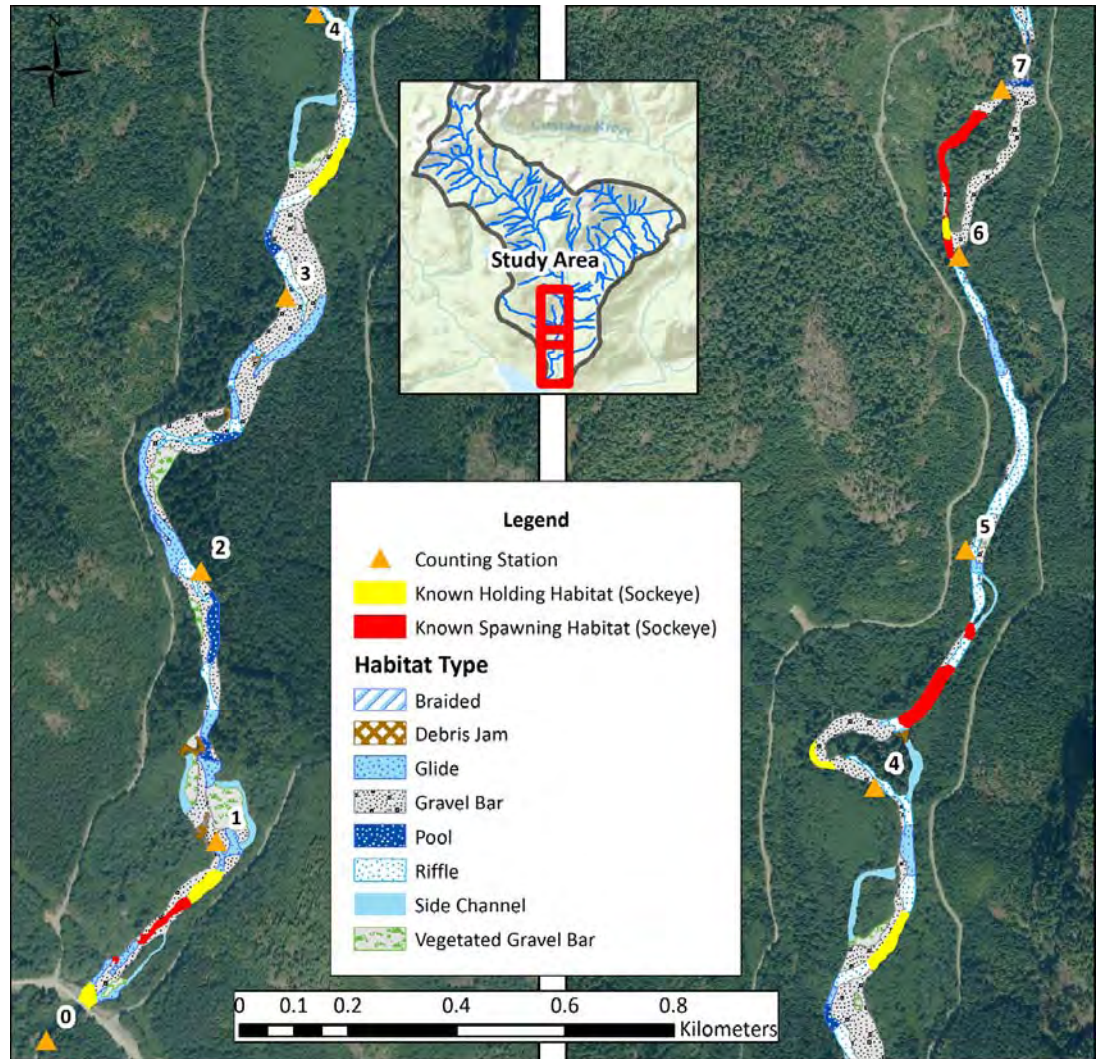


**Figure 10. Known sockeye distribution in the Canton Creek watershed.**

During upstream migration to the spawning grounds, adult sockeye take advantage of several key holding pools, notably between counting stations 0 and 1 and counting stations 6 and 7. Between counting stations 0 and 1, the large pool beneath the bridge is heavily utilized for holding. As this pool is within the upper extent of tidal influence it is an extremely critical zone for the physiological transition between the marine and freshwater environments (R. Dunlop, pers. comm.). Other key holding areas include a deep glide between counting stations 3 and 4, and several small pools between counting stations 4 and 6 (Figure 11) (Fisheries and Oceans Canada, 2012).

Key sockeye spawning areas include riffles between counting stations 0 and 1 and glides between counting stations 4 and 5. Some spawning has been observed in riffles between

counting stations 6 and 7; however, utilization is limited (Fisheries and Oceans Canada, 2012) (Figure 11).



**Figure 11. Known adult sockeye holding and spawning habitat in Canton Creek.**

In Canton Creek, sockeye in this system are likely sea-type, and migrate downstream following emergence and rear in the estuary prior to entering the marine environment (Figure 12). Little data exists on freshwater sockeye rearing habitats for Canton Creek, and future investigations should seek to identify the location of these habitats.



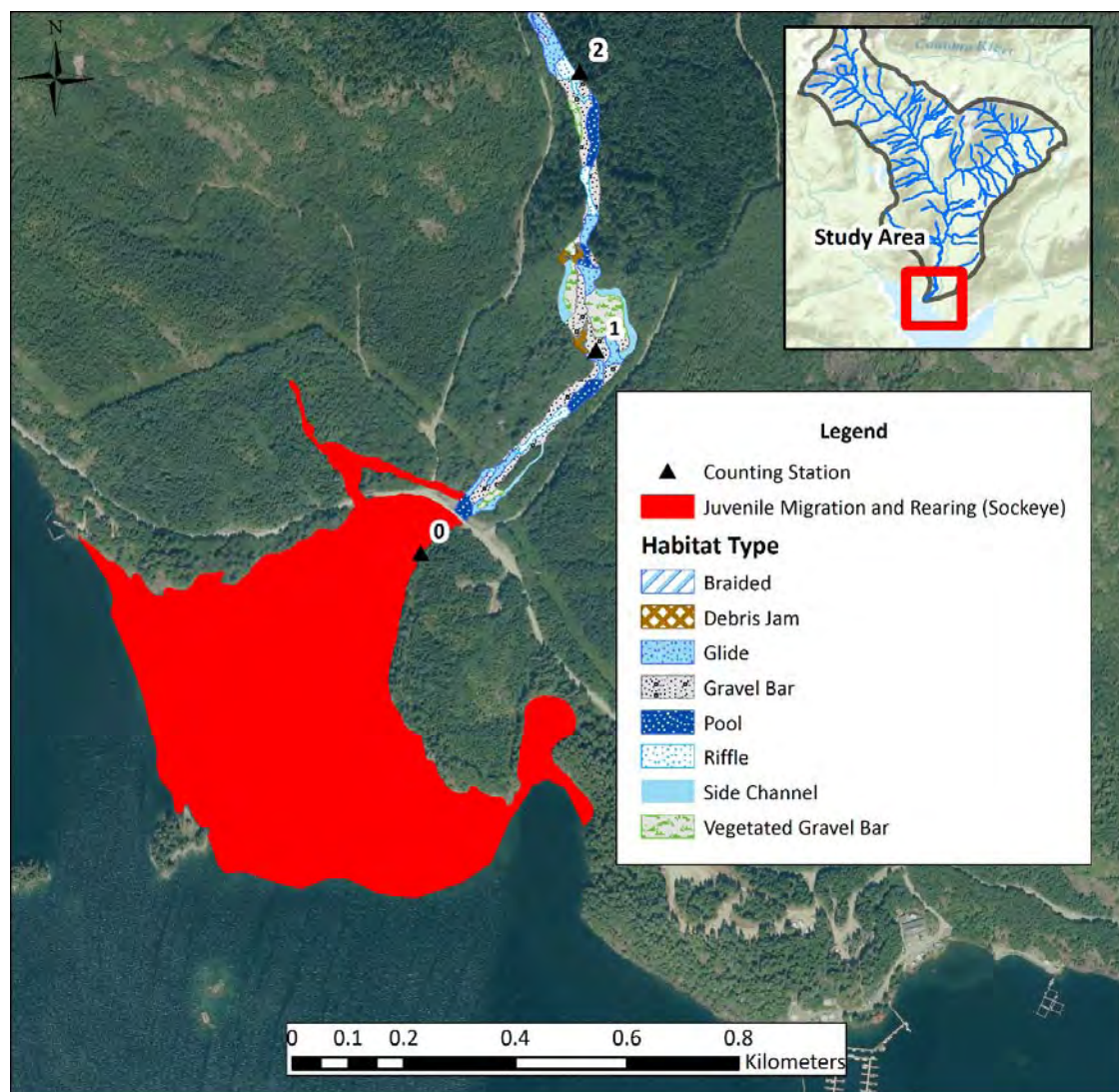
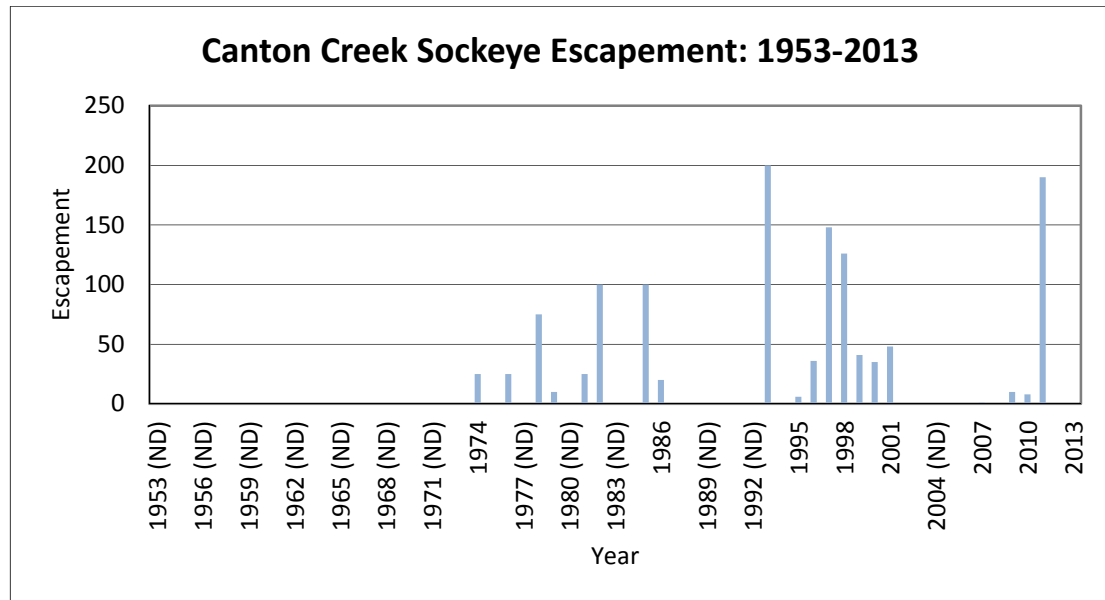


Figure 12. Known sockeye juvenile migration and rearing habitat in Canton Creek.

### 3.3.2 Escapement

The population of sockeye in Canton Creek typically remains below 200 fish, with a peak escapement estimate of 180 fish observed in 2011. Limited escapement estimate data exists in this system, and no information with respect to sockeye numbers exists prior to 1974 (Figure 13).



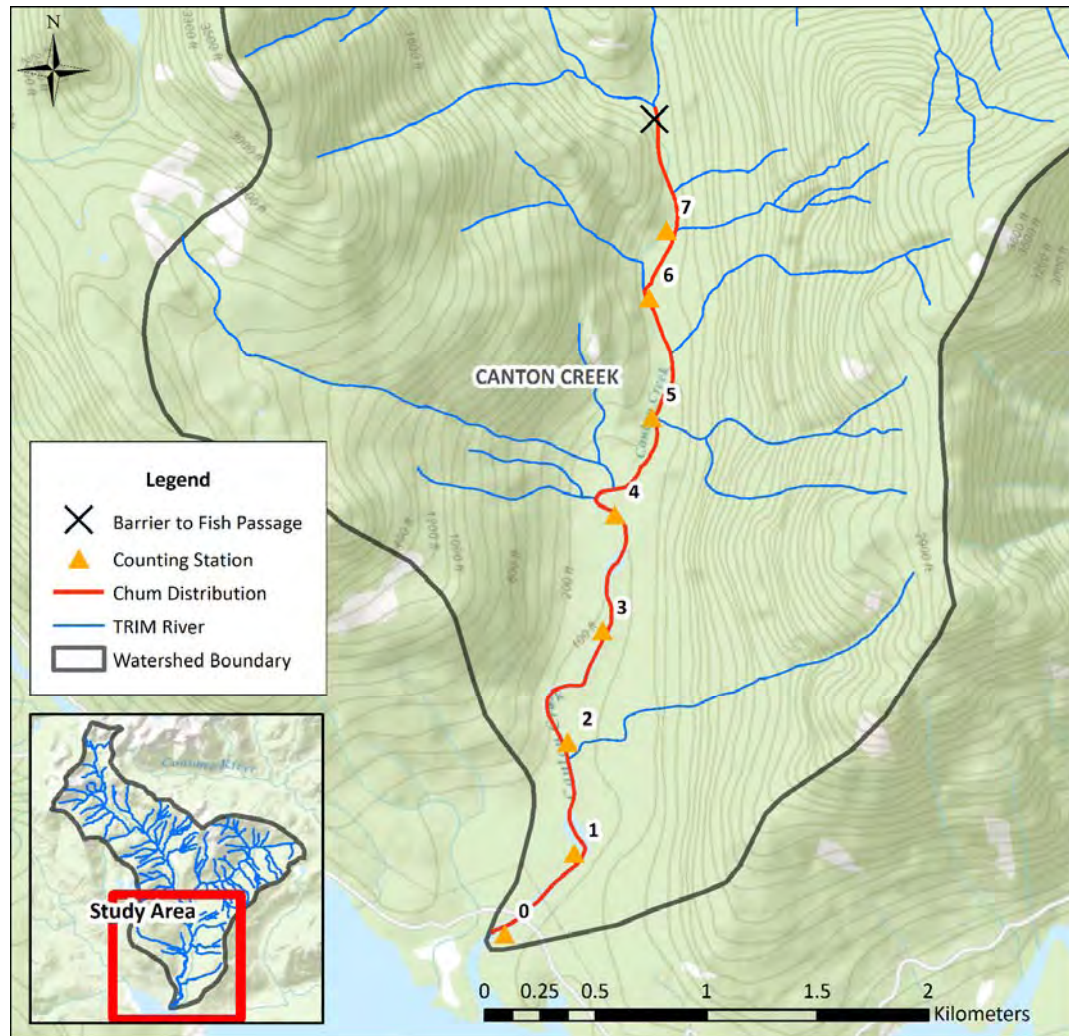
**Figure 13.** Known sockeye escapement in the Canton Creek watershed between 1953 and 2013 (compiled from DFO's NuSEDs database).

### **3.4 Chum Salmon**

#### **3.4.1 Biology, Distribution, and Known Habitats**

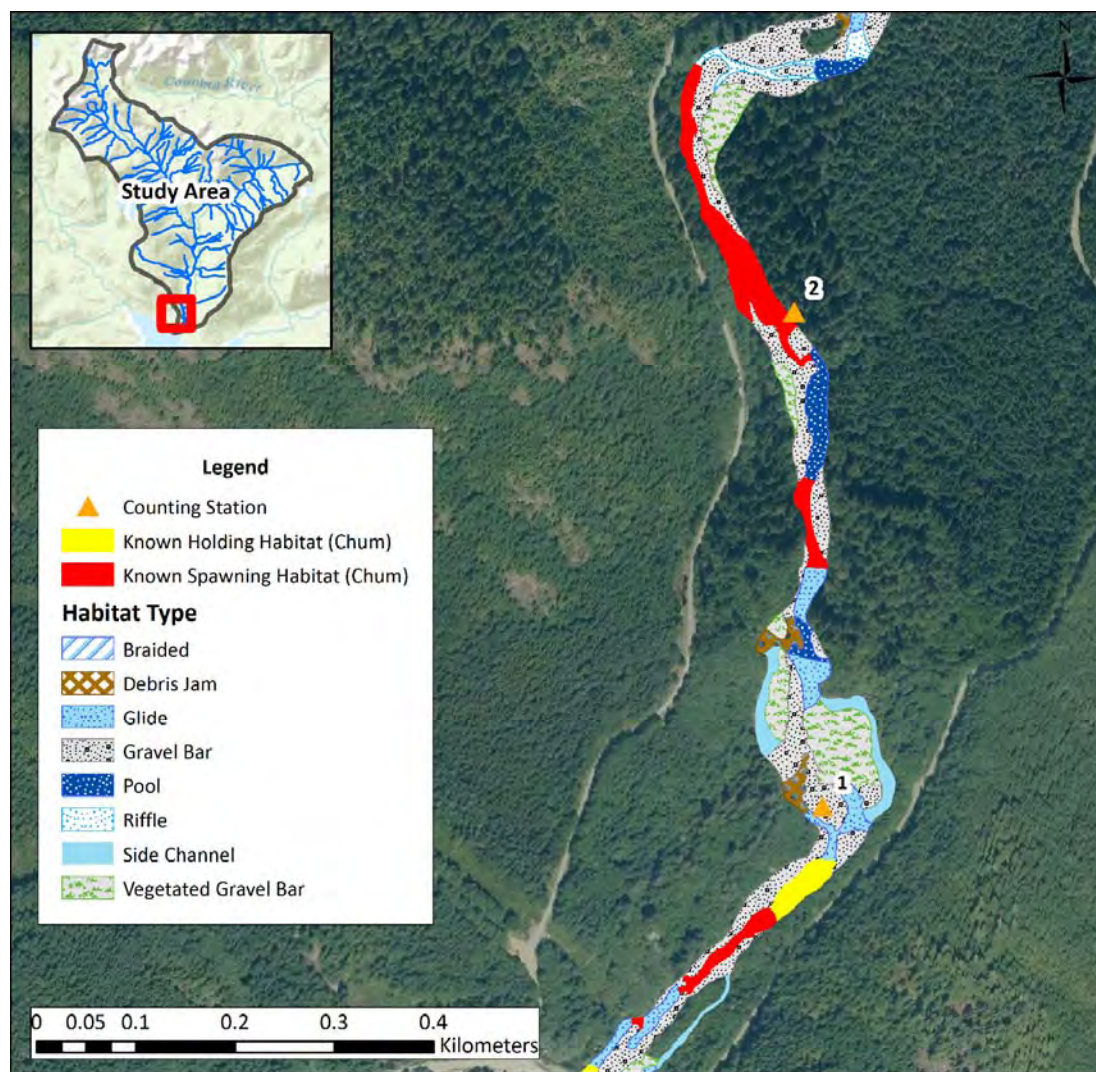
Chum salmon typically enter Canton Creek and begin spawning in early October, with peak spawning observed in mid-October, and the end of the run observed in late October. Chum distribution is observed approximately 4.5km upstream of the estuary, just upstream of counting station 7 (Fisheries and Oceans Canada, 2012) (Figure 14).





**Figure 14. Known chum distribution in the Canton Creek watershed.**

While chum distribution has been observed beyond counting station 7, the majority of adult holding and spawning occurs in the lower sections of the river. Key holding areas include the pool beneath the bridge (just upstream of counting station 0 and a physiological transition zone) and a pool just downstream of counting station 1. Spawning is observed between counting stations 0 and 1; however, heaviest spawning typically occurs within glide and riffle habitat between counting stations 2 and 3 (Figure 15).



**Figure 15. Known chum holding and spawning habitat in Canton Creek.**

Like other species in the Canton Creek watershed, the length of time required for egg incubation is partially dependant on water temperature. Upon emergence 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 (Diewerts, 2007). Given this important life history requirement, the Canton Creek estuary has been classified as known juvenile migration and rearing habitat (Figure 16).



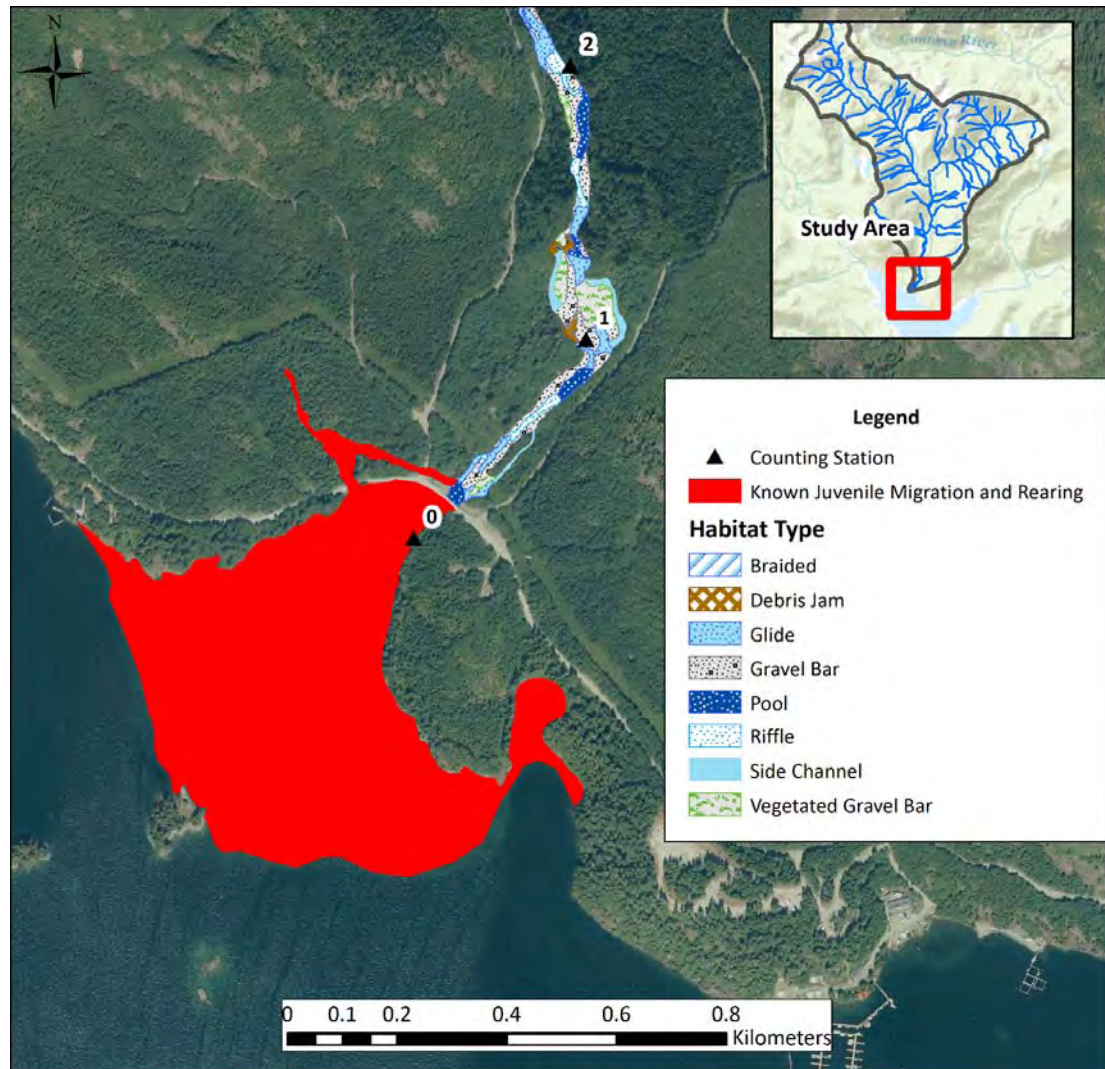
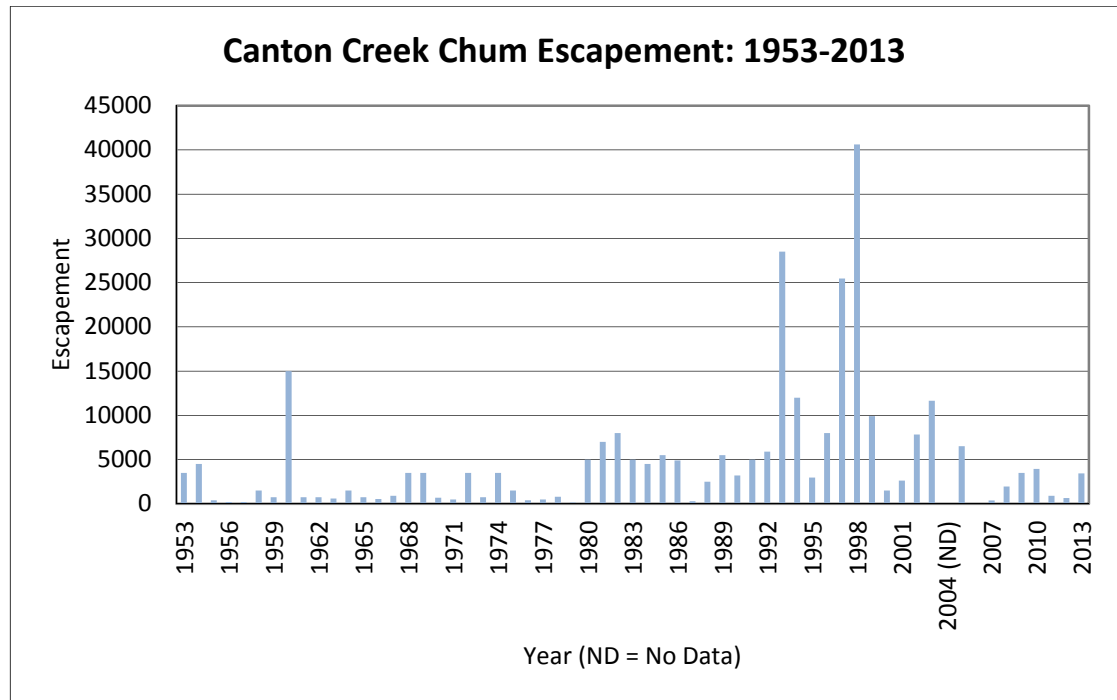


Figure 16. Known chum juvenile migration and rearing habitat in Canton Creek.

#### 3.4.2 Escapement

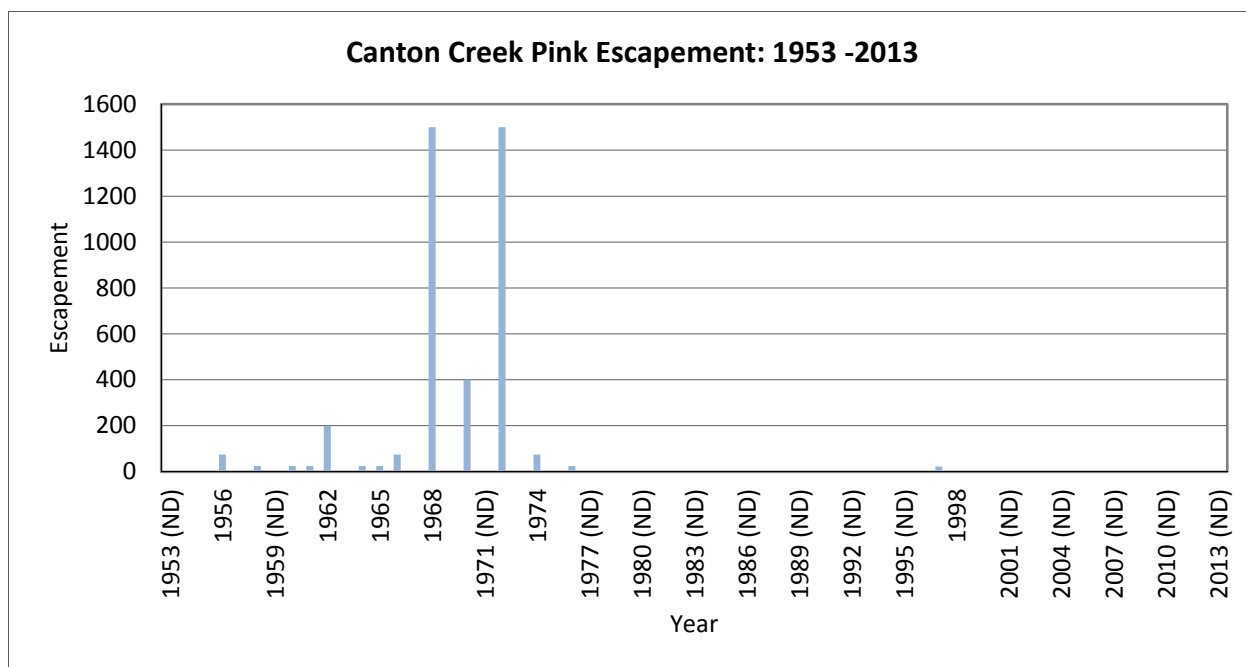
Prior to operation of the Conuma Hatchery, mean escapement estimates for Canton Creek from 1953 to 1979 was 1,894 adults (Fisheries and Oceans Canada 2007). The maximum recorded escapement during this period was 3,500 adults. Following hatchery operations escapements have increased to a mean of 9,108 adults. The highest escapement recorded was 40,629 in 1998. Declining returns have been observed since 1999. Low escapements have been observed over the past 5 years, a trend that has been observed in chum populations coast-wide (Figure 17) (Fisheries and Oceans Canada, 2012) (M. Wright, pers. comm.).



**Figure 17. Chum escapement in the Canton Creek watershed between 1953 and 2013 (compiled from DFO's NuSEDs database).**

### **3.5 Pink Salmon**

Historically, small numbers of pink salmon returned bi-annually to Canton Creek with numbers averaging around 55 fish (between 25 and 1,500 fish enumerated between 1947 and 1976). Since 1976, very limited escapement data has been collected for pink salmon, with the exception of 1997 and 1998 where 23 and 1 fish were enumerated, respectively (Figure 18) (Fisheries and Oceans Canada, 2012). Based on the low numbers of pink salmon in Canton Creek and limited available data, this species is not considered in further discussions of habitat indicators and limiting factors.



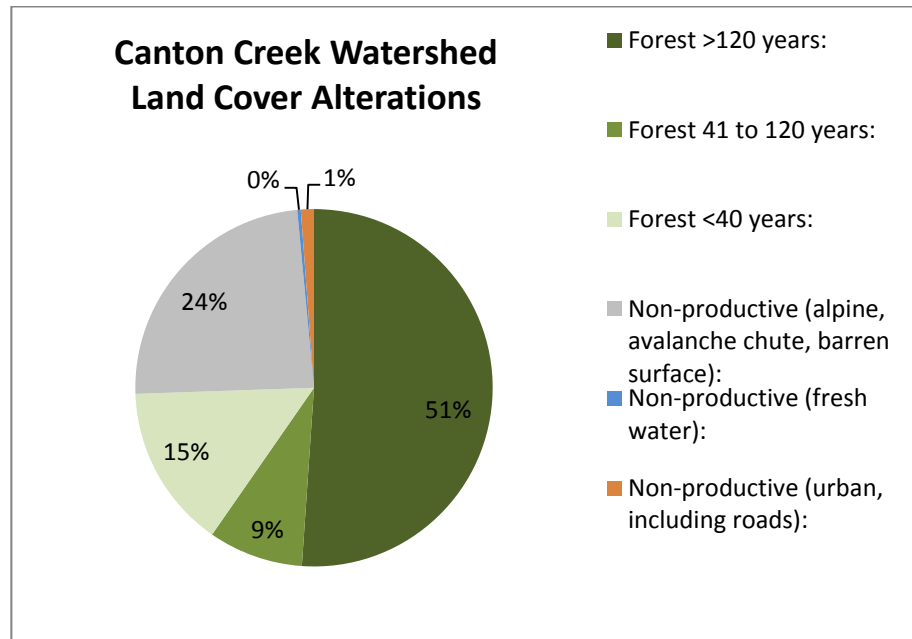
**Figure 18. Pink escapement in the Canton Creek watershed between 1953 and 2013 (compiled from DFO's NuSEDs database).**

## 4.0 HABITAT INDICATOR ASSESSMENT RESULTS

The following sections present the results of the assessed habitat status indicators in the Canton Creek watershed.

### 4.1 *Stream Pressure Indicator: Total Land Cover Alterations*

Total land cover alterations for the Canton Creek watershed are summarized in Figure 19:



**Figure 19. Total land cover alterations, by percent, for the Canton Creek watershed.**

Based on this figure, approximately 75% of the total area of the Canton Creek watershed remains unaltered, with mature forests (i.e. >120 years) comprising the majority of this area, and non-productive alpine, avalanche chutes, and barren surfaces constituting the remainder. Approximately 1% of the watershed has been altered as roads, and approximately 24% of the watershed remains as altered forests (i.e. <120 years old).

An analysis of the distribution of altered land cover areas demonstrated that while a large component of the watershed remains unaltered, altered areas are situated in areas adjacent to and / or within known salmonid habitats (i.e. riparian zone of the mainstem and the Canton Creek estuary) (Figure 20). A Coastal Watershed Assessment Procedure (CWAP) produced in the late 1990s demonstrated that as of 1997 approximately 49% of the fish-bearing length of the mainstem had been logged, and that approximately 60% of the roads in the watershed were within 100m of a stream (Turley, 1997). Considering the proximity of land cover alterations to known salmonid habitats, the Canton Creek watershed has been classified as high risk for total land cover alterations.



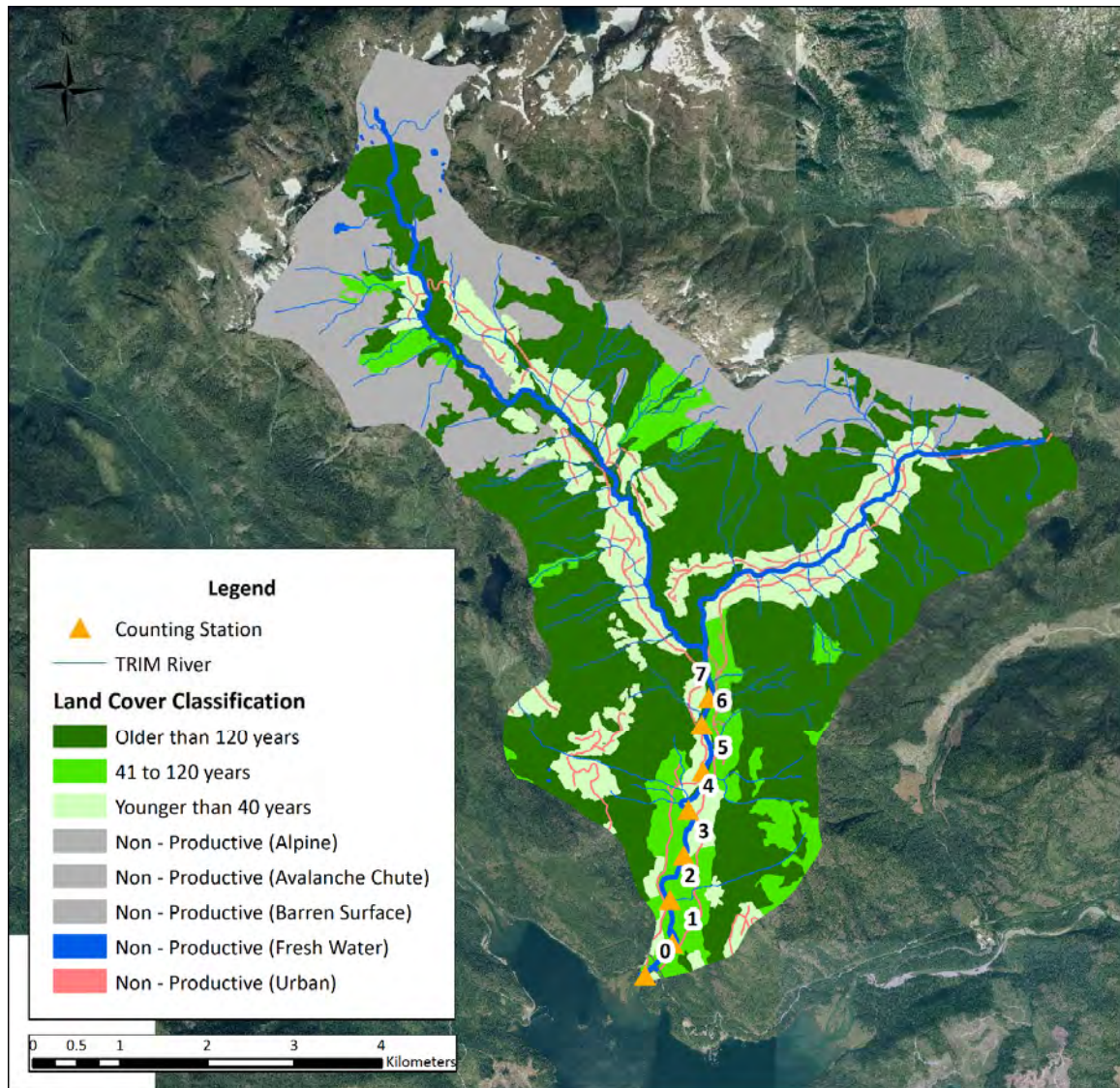
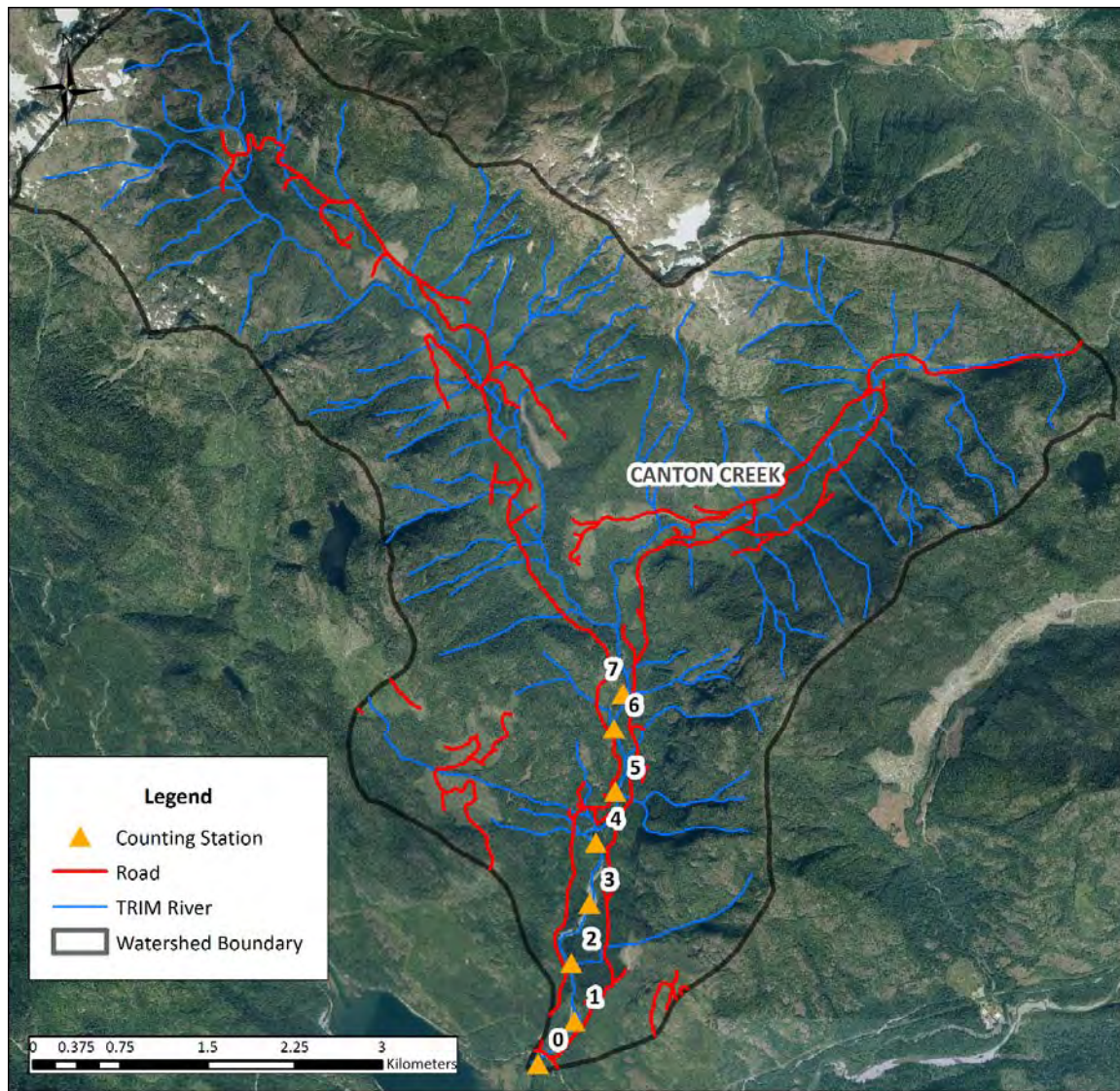


Figure 20. Total land cover alterations in the Canton Creek watershed.

#### 4.2 Stream Pressure Indicator: Watershed Road Development

Watershed road development for the Canton Creek watershed was calculated at 1.06km / km<sup>2</sup>, which was well above the suggested benchmark of 0.4km / km<sup>2</sup> (Stalberg et al, 2009) (Figure 21). Despite the high road density calculation, 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 21. Canton Creek watershed road density.**

Based on the benchmark presented in Stalberg et al (2009) watershed road density in Canton Creek is identified as high risk. However, data gaps exist with respect to the condition of these roads, which has the potential to elevate or lower risk levels in the watershed. As such, road density has been classified as high risk with partial data gaps.

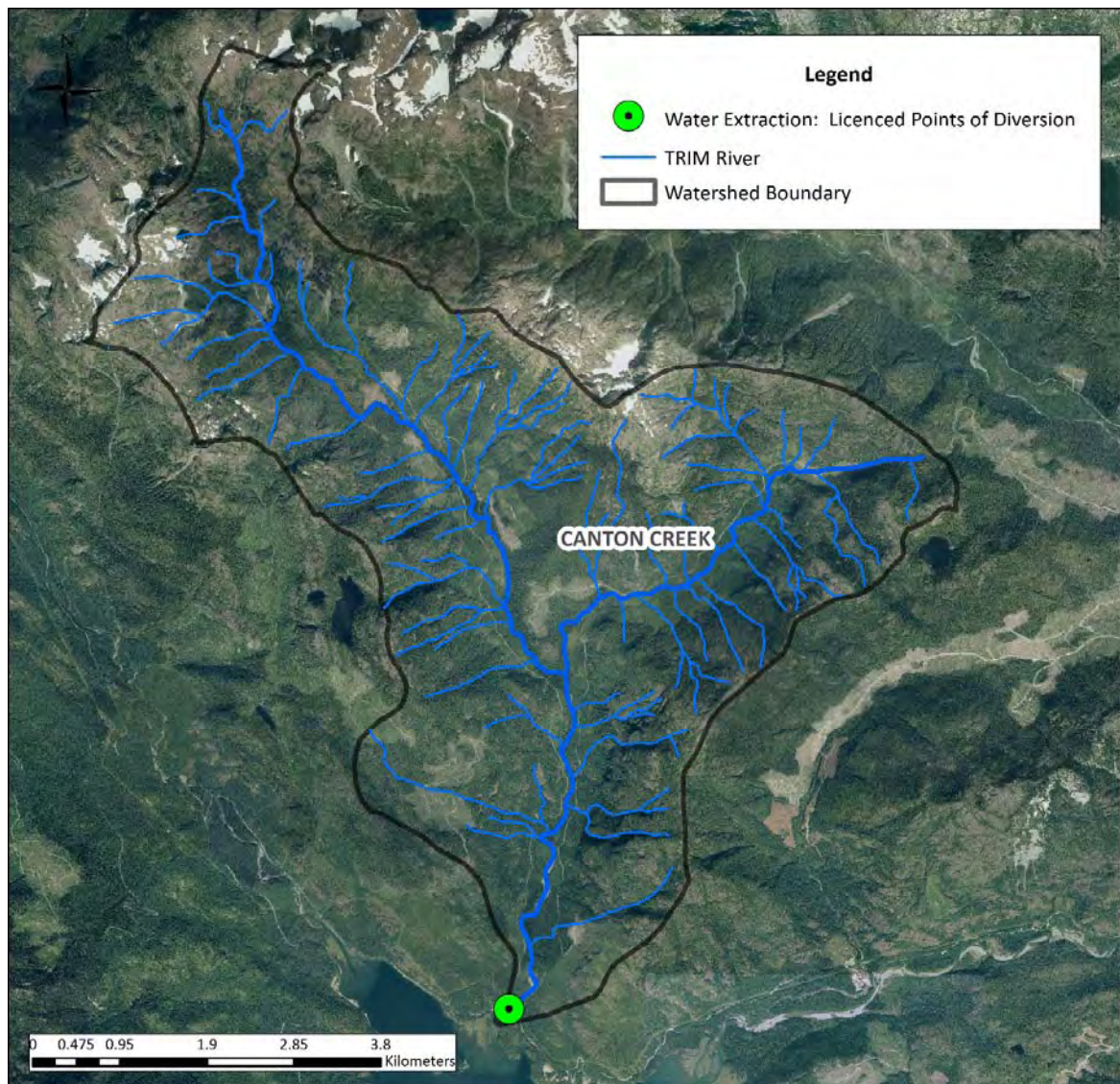
#### **4.3 Stream Pressure Indicator: Water Extraction**

There is currently one active water licence near the bottom of Canton Creek (Figure 22). This licence is for enterprise purposes (i.e. water used for hotels, motels, trailer parks, service stations, restaurants, commercial campgrounds, mobile home parks, or similar commercial



enterprises which are owned and operated for profit). The total demand for this licence is 9.092m<sup>3</sup>/day.

While the presence of a extractive water licence indicates a moderate watershed risk according to the recommended metrics presented in Stalberg et al (2009), considering the downstream area of the Canton Creek mainstem affected by this extraction is limited (Figure 22), this risk rating has been downgraded to low. The majority of known spawning, rearing, and migration habitats upstream in Canton Creek remain unaffected by this extraction.



**Figure 22. Licenced water extractions in the Canton Creek watershed.**



#### 4.4 Stream Pressure Indicator: Riparian Disturbance

The calculated riparian disturbance in Canton Creek was significant with the mainstem dominated by a primarily deciduous and / or regenerating stand. Exceptions to this composition included the northeastern left bank of West Canton Creek, the northwestern right bank of East Canton Creek, and the headwaters of East Canton Creek, which were comprised predominantly of mature forest. The most significant disturbances were observed within Lower Canton Creek between counting stations 0 and 1 and counting stations 3 and 7 (Figure 23).

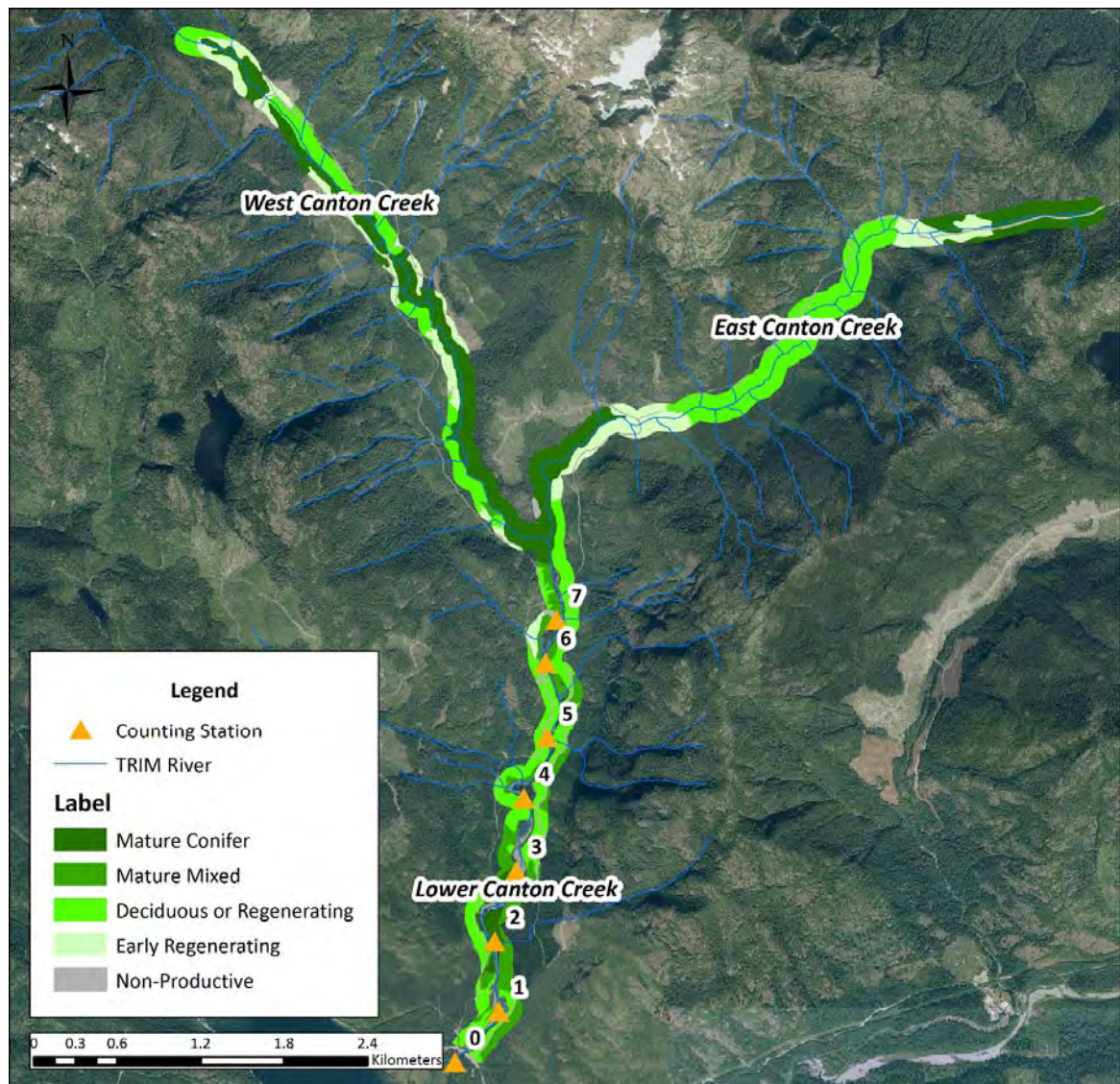
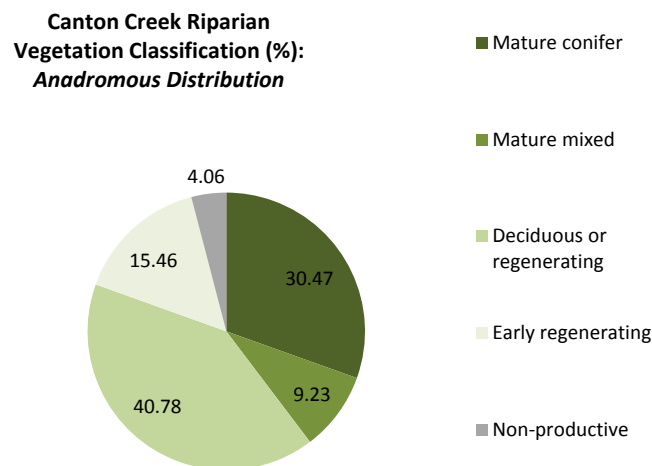


Figure 23. Riparian disturbance in the Canton Creek watershed.

The Canton Creek floodplain has experienced significant channel instability and loss of LWD as a result of degraded riparian zones. Throughout the anadromous zone, spawning and rearing habitats continue to be affected by a compromised riparian stand consisting of 41% deciduous and / or regenerating forest, 15% early regenerating forest, and 4% non-productive areas (Figure 24). Habitat bordering the existing riparian zone will continue to be unstable until the riparian forest becomes a predominantly mature coniferous forest, which will require silviculture treatments. It will take decades to achieve a mature coniferous dominated riparian forest that will provide critical functions to the aquatic environment, including: temperature regulation, sufficient root structure to hold soils together, which will control sediment input and provide a source of LWD to increase channel structure and stability. Given the low component of mature riparian forest bordering anadromous habitats (particularly in the lower reach of Canton Creek), the risk rating for riparian disturbance in the Canton Creek watershed was classified as high.



**Figure 24. Riparian vegetation composition for all species in the Canton Creek watershed.**

An analysis of riparian condition for tributaries to Canton Creek was not possible based on uncertainty on 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.

#### **4.5 Stream Pressure Indicator: Permitted Waste Management Discharges**

There are currently no permitted waste management discharges in the Canton Creek watershed. As such, this indicator has been ranked low risk.

#### **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 Canton Creek through EMNG regional geochemical stream survey monitoring sites. A total of four monitoring sites have been established in the watershed, with two situated in close proximity to each other in West Canton Creek, one situated in East Canton Creek, and one situated in Lower Canton Creek (Figure 25).

Data collected in 2007 showed water pH levels to range between 6 and 6.4. All parameters detected in the samples (fluoride, uranium, and sulphate) remained below the Canadian Water Quality Guidelines for the Protection of Aquatic Life (Canadian Council of Ministers of the Environment, 1999). Note that no water quality data with respect to in-stream and intergravel DO was available for the Canton Creek watershed. While the data available indicated that (of the limited sampled parameters) no issues were identified, the spatial and temporal distribution of this data was not robust or diverse enough to determine the influence of water quality on fish production in this watershed. As such, the water quality habitat indicator has been identified as a data gap.



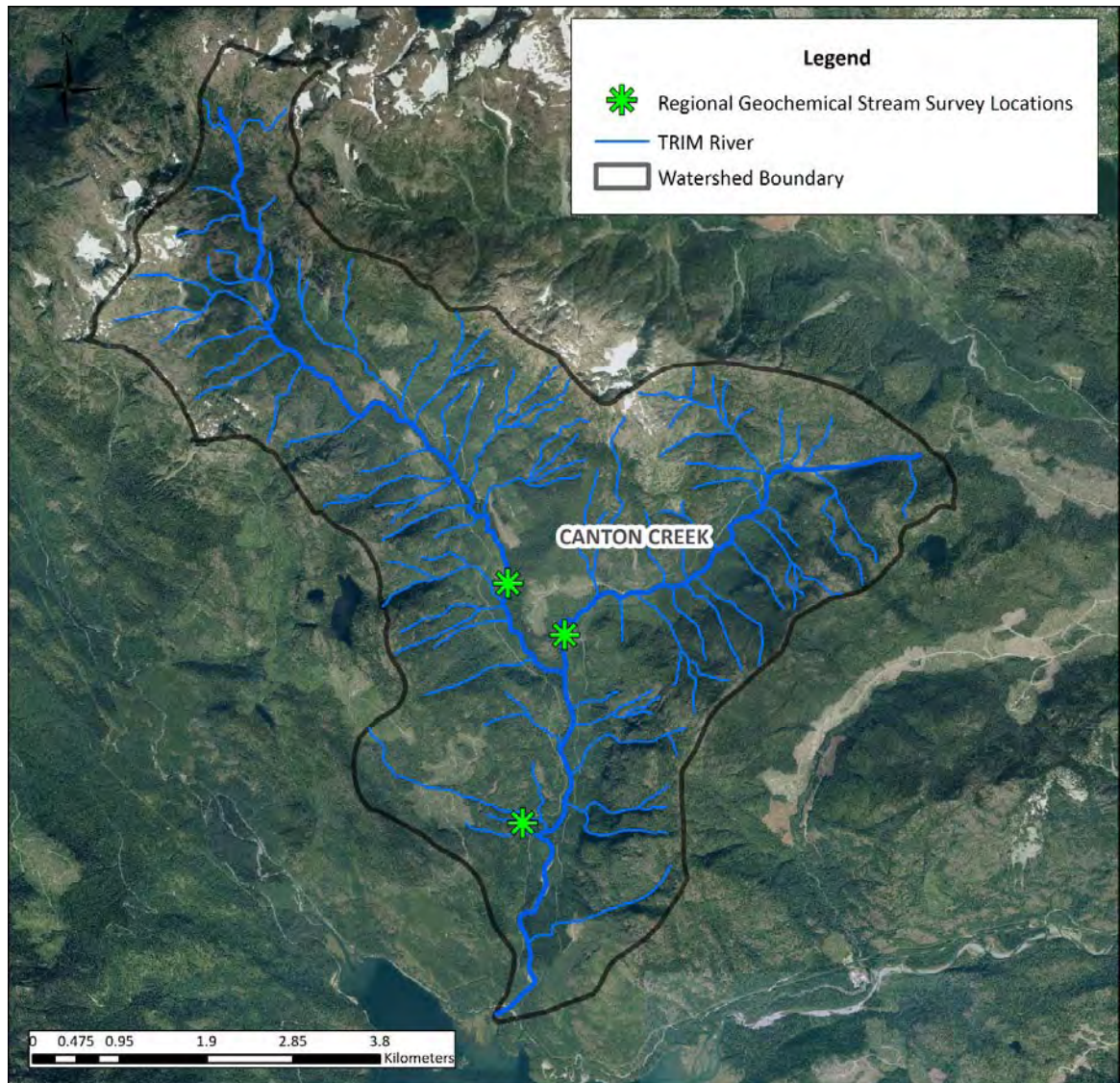


Figure 25. Regional geochemical stream survey locations in the Canton Creek watershed.

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

Interviews with local experts indicated water temperatures in the Canton Creek watershed typically remain cool (NSWS, 2015). Compilation of SIL data during the spawning period in Canton Creek demonstrated water temperatures to have remained below the UOTR (between 15°C and 20°C) for all species between 2006 and 2013 (Table 2). 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 2007 to 2012 for Canton Creek during adult migration and spawning.**

CANTON CREEK						
Year	Date	Temperature (°C)	Species Present			
			SK	CO	CH	CM
2007	Oct. 16	7.5	X	X	X	
2009	Oct. 11	8	X	X	X	X
	Oct. 22	9	X	X	X	X
	Nov. 4	8		X	X	X
2010	Sept. 18	9	X	X	X	X
	Oct. 11	6		X	X	X
	Oct. 18	8.5	X	X	X	X
2011	Sept. 12	9.5	X	X	X	X
	Sept. 20	9	X	X	X	X
	Oct. 1	10	X	X	X	X
	Oct. 10	9	X	X	X	X
	Oct. 16	7	X	X	X	X
	Dec. 5	4	X	X		
2012	Oct. 11	9		X		X
	Oct. 17	8				X

#### **4.8 Stream State Indicator: Discharge**

No discharge data for Canton Creek was available. There is no WSC flow gauge or DFO hydromet station on the river, and no other recent discharge data was available through Fisheries and Oceans Canada. As such, this indicator has been classified as a data gap.

#### **4.9 Stream State Indicator: Accessible Stream Length**

Information on accessible stream length for the Canton Creek watershed was compiled from the Canton Creek stream narrative (Fisheries and Oceans Canada, 2012), FISS, and relevant stream classification reports provided by WFP (FishFor Contracting, 2001). Based on the GIS distribution data presented in Figure 2, Figure 4, Figure 6, and Figure 14, the following Table summarizes accessible stream length by species:

**Table 3. Accessible stream lengths, by species, for the Canton Creek watershed.**

	Chinook	Coho	Sockeye	Chum
Mainstem	4.47km	15.07km	4.47km	4.47km
Tributary	-	7.43km	-	-
<b>Total</b>	4.47km	22.50km	4.47km	4.47km

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 3, Figure 7, Figure 11, and Figure 15. Note that coho spawning area lengths are an underestimation as the location of coho spawning habitat beyond the survey area (i.e. counting station 7) is unknown.

**Table 4. Key spawning area lengths, by species, for Canton Creek.**

Chinook	Coho	Sockeye	Chum
2.42km	2.92km	1.38km	1.34km

As observed in Table 4, chum salmon have been identified to have the smallest spawning grounds (by length) on the river, and coho the largest. It should be noted that the spatial extent of each species' spawning grounds was not well defined (particularly in the upper reaches of accessible stream length). Accurate assessment of the upstream and downstream extents of each of these zones would improve our assessment of this habitat indicator, and would also provide a baseline from which future assessments could determine if this indicator is improving or deteriorating over time. In addition, efforts should be directed towards mapping the location and extent of coho spawning grounds upstream of the survey area.

#### 4.11 Stream State Indicator: Stream Crossing Density

The following table summarizes the available stream crossing data for the Canton Creek watershed:

Stream crossing Density: CANTON CREEK	
# of Crossings:	84
# of Fish-Bearing:	38
# of Non-Fish Bearing:	46
Crossing Density:	2.21 / km <sup>2</sup>

The results based on the PSCIS database indicate that the Canton Creek watershed has a higher stream crossing density than the neighbouring Leiner River and Tahsis River watersheds (0.78 / km<sup>2</sup> and 0.09 / km<sup>2</sup> respectively) and a similar stream crossing density to the Perry River watershed (2.16 / km<sup>2</sup>) (Abbott et al, 2015) (deVisser and Wright, 2015). The suggested benchmark for this indicator is a relative watershed comparison of crossing density and number of modeled fish-bearing crossings (Stalberg et al, 2009). In the Canton Creek watershed, 45% of crossings are modeled as fish-bearing, whereas 55% of crossings are modeled as non-fish bearing. For comparative purposes, the percentage of fish-bearing crossings in the Leiner, Perry, and Tahsis rivers are 60%, 37%, and 42% respectively.

Based on the higher stream crossing density when compared with other watersheds in Nootka Sound, this indicator could be considered as high risk. However, no ground-truthing of these modeled crossings exists. The risk associated with this indicator has therefore been classified as a data gap until further field assessments have been performed on crossings in the area.

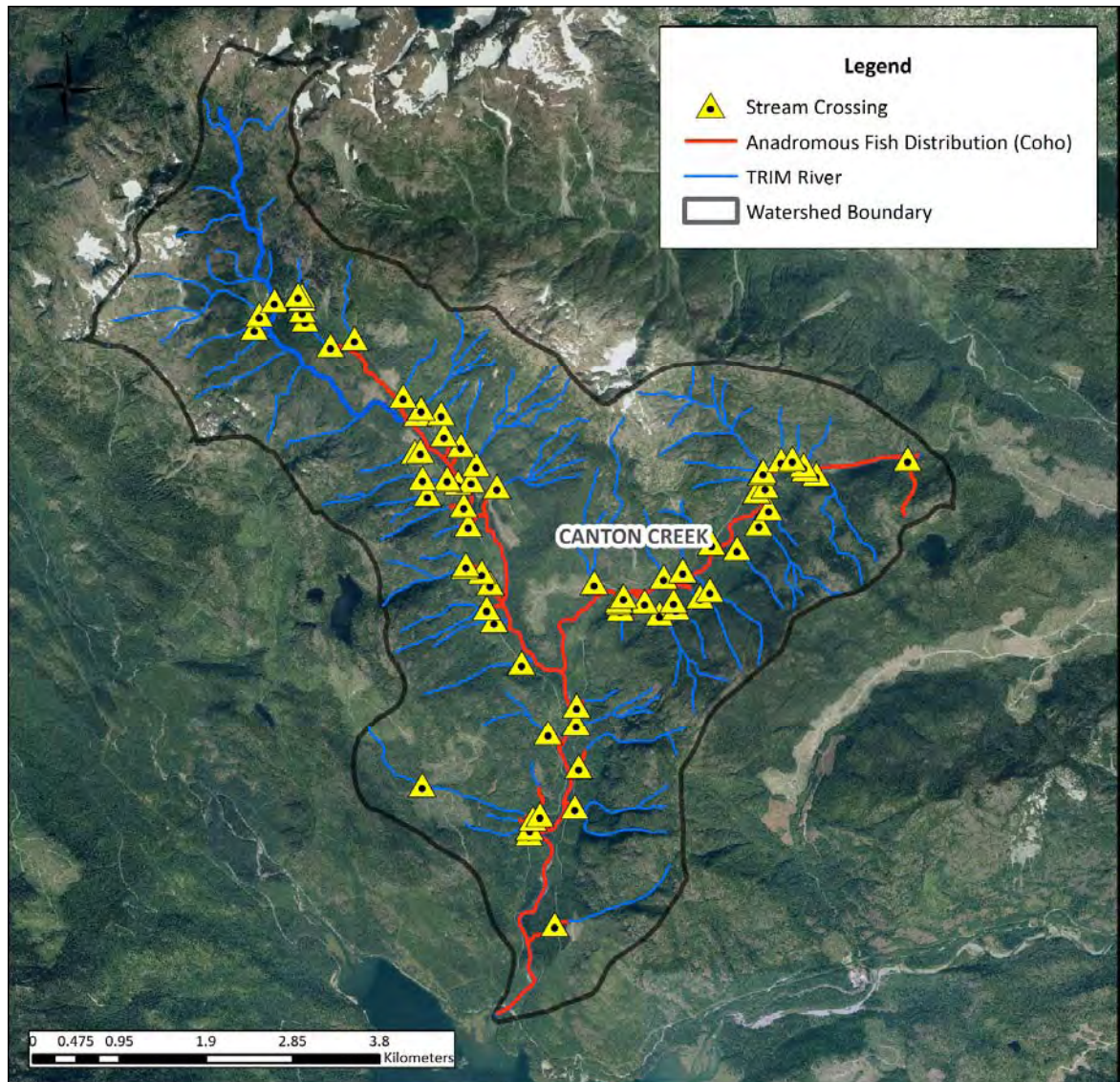
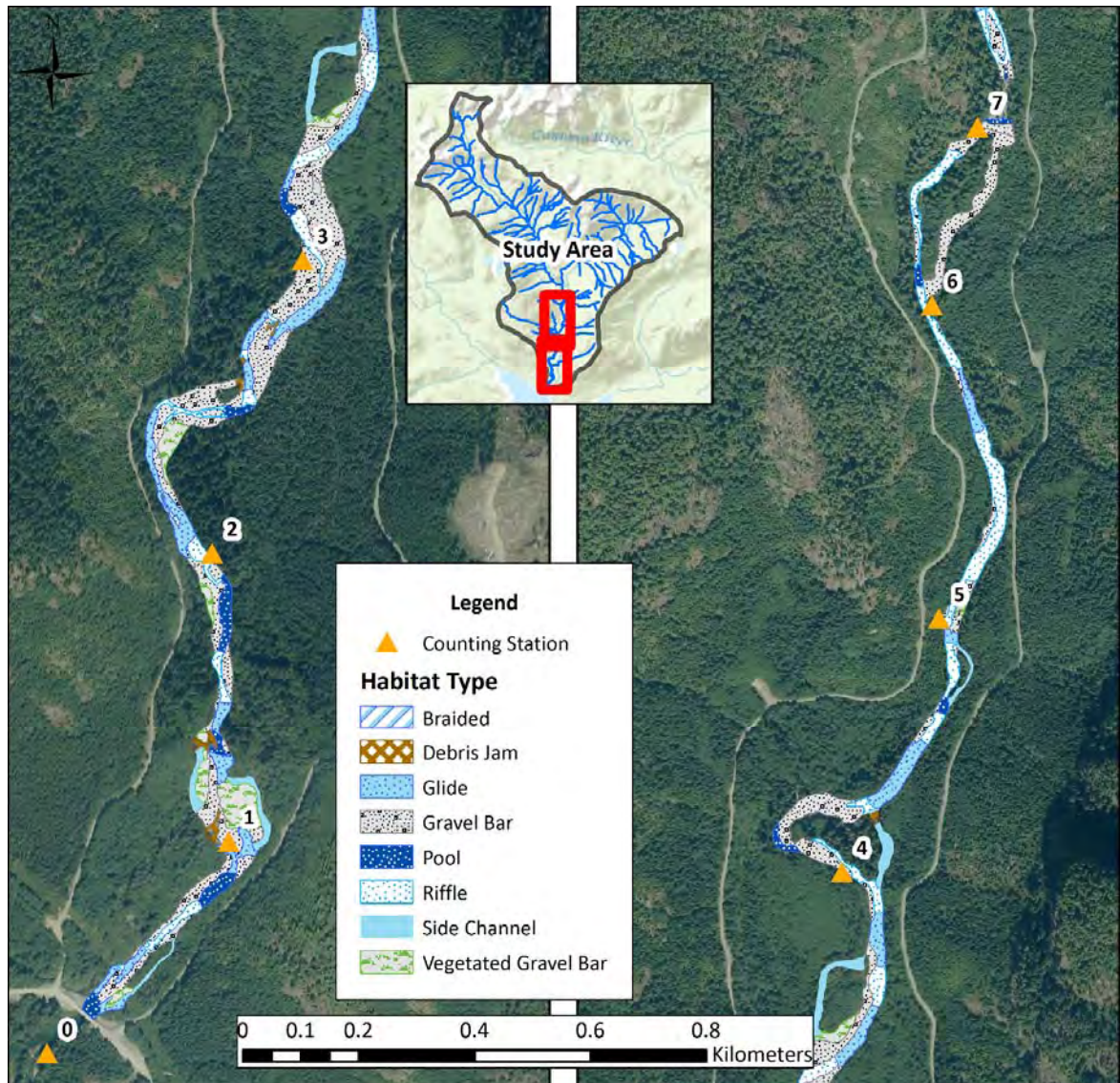


Figure 26. PSCIS modeled stream crossings in the Canton Creek watershed.

#### 4.12 Stream State Indicator: Habitat Composition

An analysis of habitat in lower Canton Creek indicated this system to be dominated by gravel bars and contain very little pool habitat. Habitat between counting stations 0 and 2 demonstrated the highest frequency of pools. Between counting stations 2 and 4, gravel bars and aggraded sections became more frequent, with sections of channel over-widened and overwhelmed with sediments. Upstream of counting station 4, gravel bars became less frequent, and habitat was dominated by a series of riffles and glides (Figure 27).



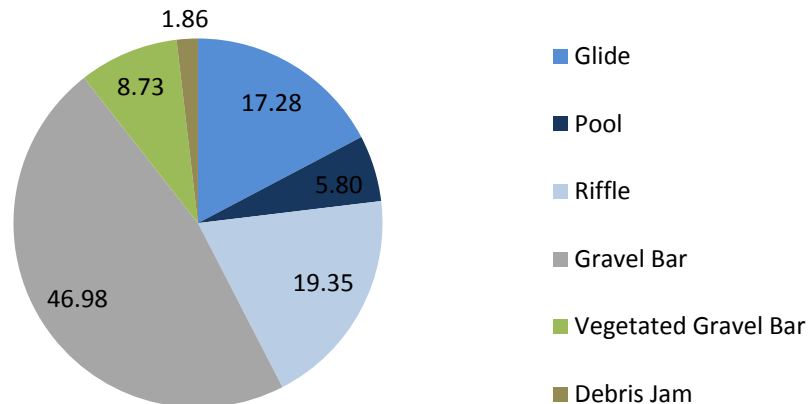


**Figure 27. Habitat unit classification (2013) of lower Canton Creek.**

Note that continuous habitat unit classification upstream of counting station 7, for both East and West Canton creeks, was not possible based on shadows and / or canopy cover obscuring the river. As such, an analysis of habitat unit composition was possible only for the anadromous reach within the AUC survey area (i.e. counting station 7 and below) (Figure 27). Habitat unit compositions presented in Figure 28 may be under representative of coho habitats, as this species is known to utilize reaches upstream of counting station 7 (Figure 6).



### **Canton Creek Habitat Unit Composition (%): 2013**

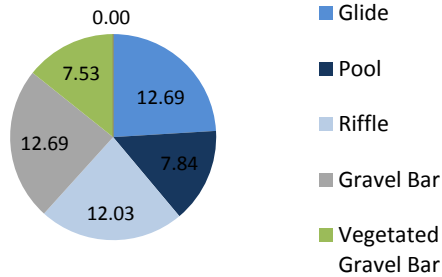


**Figure 28. Habitat unit composition (2013) for Canton Creek between counting stations 0 and 7.**

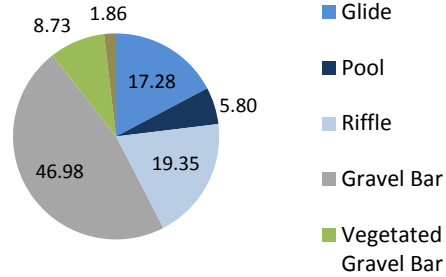
The benchmarks described in Johnston and Slaney (1996) indicate that for systems less than 15m and with gradients of <2%, poor salmonid habitat condition for summer and winter rearing occurs with <40% pool habitat area by reach. Similar conditions are experienced in systems with gradients between 2% and 5% where <20% pool habitat area is observed. While Canton Creek is greater than 15m in average width, this metric still provides a useful comparison of pool habitat composition. When gravel bars, vegetated gravel bars, and debris jams are removed from the composition analysis, percent pool habitat increases from 5.80 to 13.68%. Considering this value still remains below the suggested benchmark, the habitat composition indicator for Canton Creek has been classified as high risk, as pool frequencies in the system remain well below the suggested benchmarks.

A comparison of habitat unit composition between 1995 and 2013 (where data overlapped between counting stations 0 and 5) has demonstrated a decrease in pool habitat from 7.84% to 5.8%, indicating continuing aggradation is occurring in this system (Figure 29). Loss of pool habitat was observed throughout the system, and increases in gravel bars were most prevalent between counting stations 2 and 4. Some recovery (i.e. re-vegetation of gravel bars) was observed just upstream of counting station 1 and partway between counting stations 3 and 4 (Figure 30).

**Canton Creek Habitat  
 Unit Composition (%):  
 1995**



**Canton Creek Habitat  
 Unit Composition (%):  
 2013**



**Figure 29. 1995 versus 2013 habitat unit compositions in Canton Creek, between counting stations 0 and 4.**

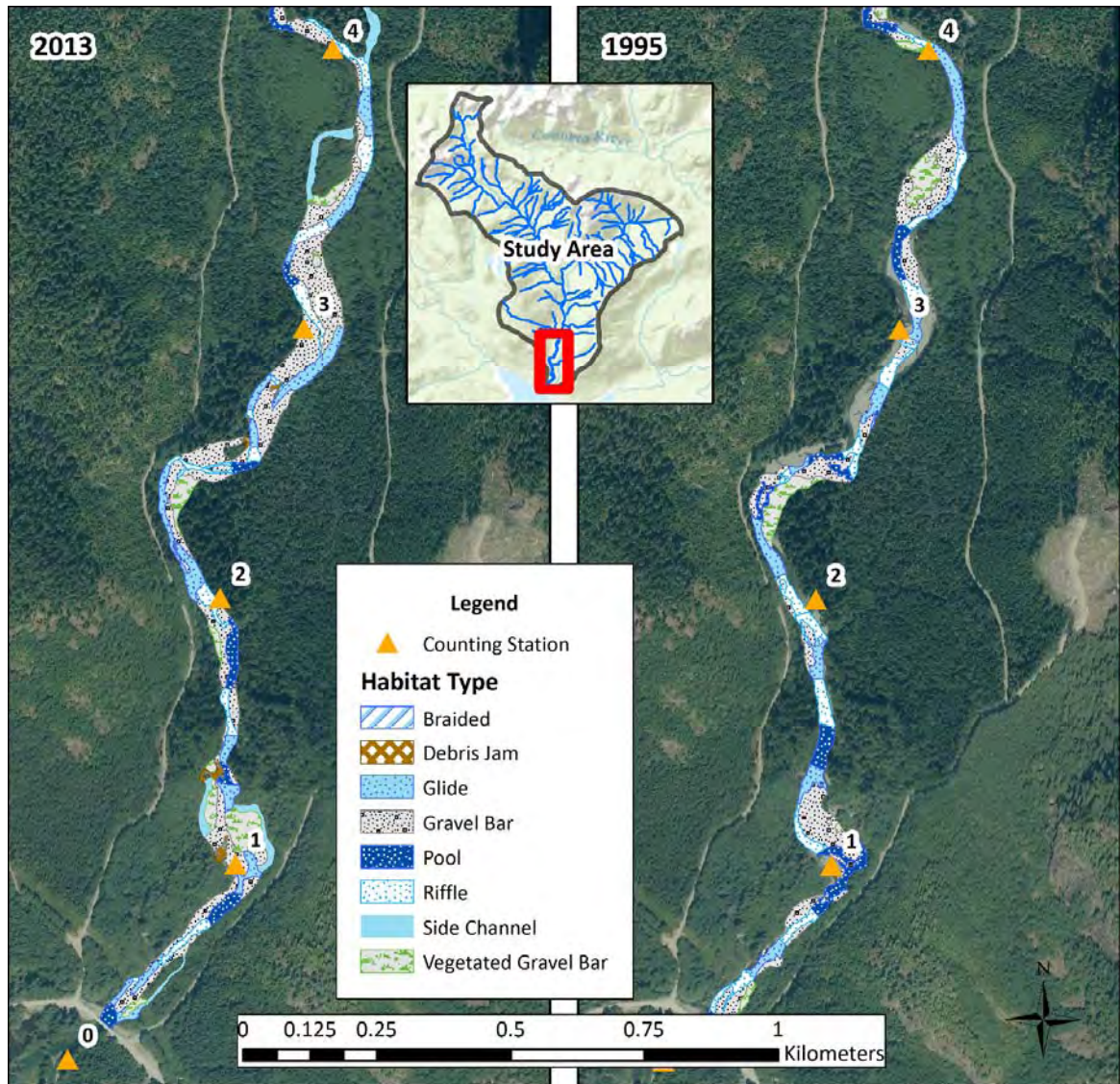


Figure 30. Changes in habitat unit composition between 2013 and 1995 in lower Canton Creek.

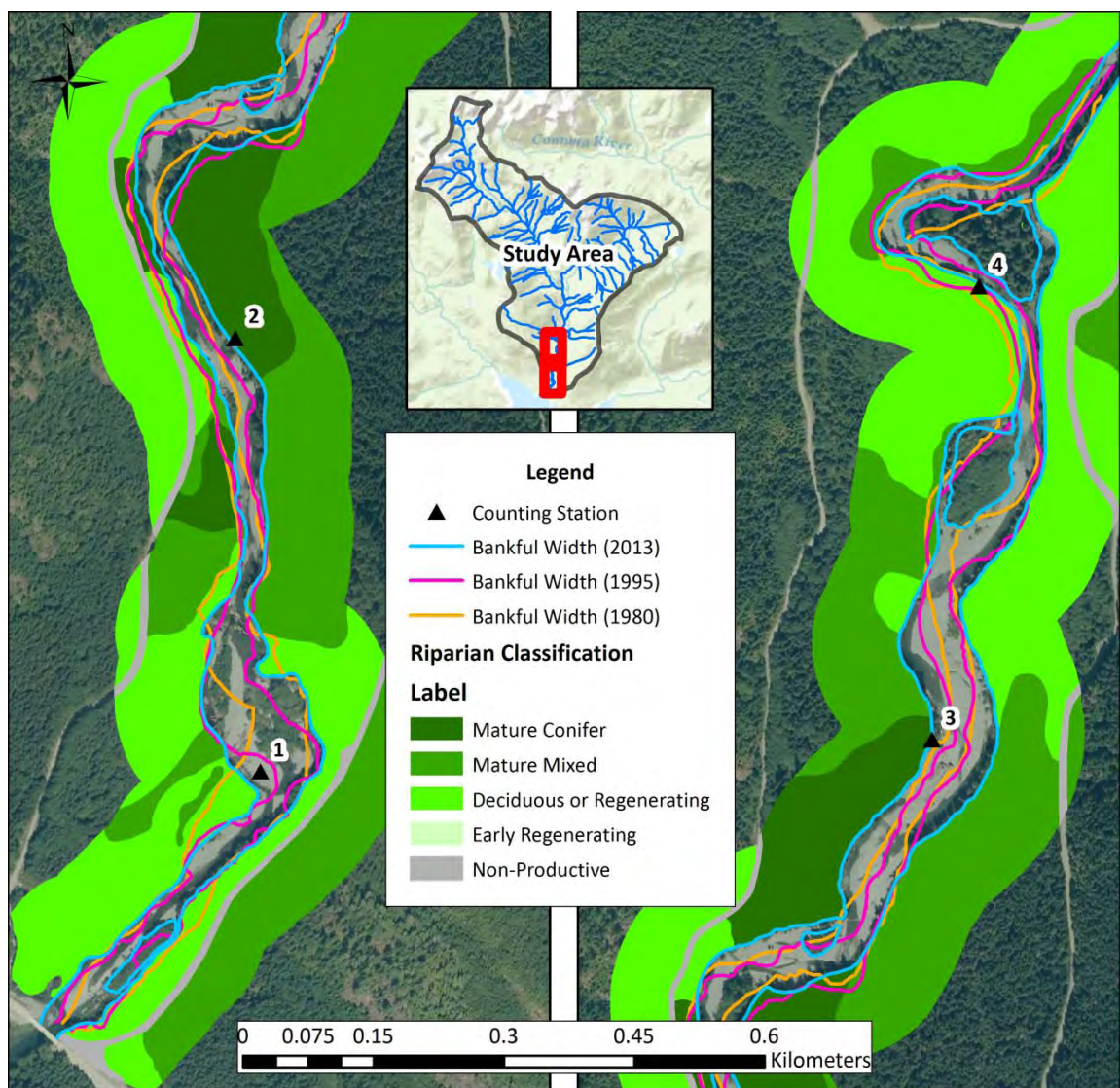
#### 4.13 Stream State Indicator: Channel Stability

A comparison of 1980, 1995, and 2013 imagery between counting stations 0 and 4 demonstrated significant migration of the channel banks in the lower river over time (Figure 31). While channel banks have remained relatively stable between counting stations 0 and 1, significant change has been observed just upstream of counting station 1, where approximately 250m of the river (lineal length) has become over-widened and braided. While the majority of change occurred between 1980 and 1995 some change has still been occurring between 1995 and 2013.

Between counting stations 1 and 2, channel stability appears relatively good, with minor variations in bankful widths possibly attributed to residual errors in air photo interpretation. The presence of mature trees along the left bank indicated future erosion to not be a significant concern in this zone (Figure 31).

Channel banks upstream of counting station 2 demonstrated significantly more migration between 1995 and 2013 when compared with downstream sections. This zone has become considerably wider between 1995 and 2013 along both banks, despite the presence of a mature riparian forest just downstream of counting station 3. Interviews with local experts indicated significant erosion (and subsequent sediment generation) to be occurring at counting station 3 (NSWS, 2015). Changes near counting station 4 included the creation of a flood relief channel along the left bank which has since become the main channel (R. Iles, pers. comm.). Over time, revegetation of this oxbow is anticipated, provided a debris jam does not form at the intake of the new flood channel (Figure 31).





**Figure 31. Observed channel migration in Lower Canton Creek between 1980, 1995, and 2013.**

Based on continued channel widening between counting stations 2 and 4, particularly between 1995 and 2013, the channel stability indicator has been ranked as high risk. Note that a proper study of Canton Creek by a fluvial geomorphologist is recommended to provide a detailed assessment of this indicator.

#### **4.14 Stream State Indicator: Large Woody Debris**

LWD was evaluated in Canton Creek from counting station 0 to the upstream distribution limits of chinook, chum, and sockeye (i.e. just upstream from counting station 7). Note that continuous LWD classification upstream from this point was not possible due to canopy cover and / or shadows obscuring visibility of the river. For the purposes of this analysis, this section was considered one reach. The following table summarizes the results of the LWD classification:

**Table 5. LWD classification in Canton Creek.**

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
Lower Canton	0.468	26	0.440	7	POOR

Based on the results presented above, there is a lack of functional LWD in Canton Creek. The majority of LWD was concentrated between counting stations 2 and 3, and debris jams were most frequent between counting stations 1 and 3. LWD downstream of counting station 2 demonstrated limited function, with the exception of the debris jams. It should be noted that some LWD recruitment potential does exist in the system where adjacent riparian zones remain mature coniferous and / or mature mixed forests.



**Photo 7. Non-functional and functional LWD observed just downstream of Counting Station 3.**

The overall recruitment potential for functional LWD in Canton Creek is low based on its riparian stand classification (i.e. large sections of predominantly deciduous vegetation) (Figure 23). In addition, LWD present in the river system is likely deciduous as well, given this adjacent riparian stand composition. While smaller deciduous LWD still provides some function in the river, coniferous LWD is considered more stable, longer lasting, and more influential over stream flow (Poulin et al, 2000).

Based on the lack of functional LWD in the Canton Creek system and the existing LWD being predominantly deciduous, this habitat indicator was ranked as high risk.

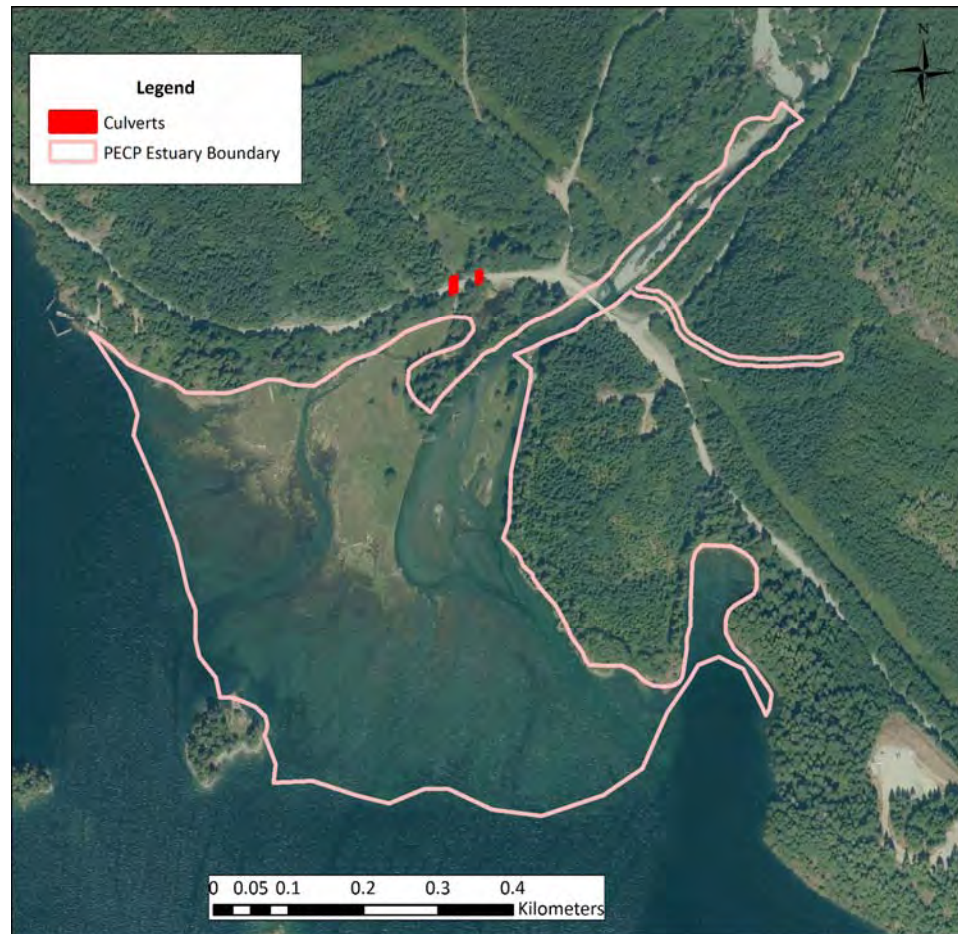
#### ***4.15 Stream State Indicator: Off-Channel Habitats***

Interviews with local experts indicated that limited off-channel habitat exists in Canton Creek, and that no information with respect to the extent and utilization of habitats has been collected. An assessment of off-channel habitats was not possible from the orthophotographs based on heavy canopy cover. As such, the condition and productivity of off-channel habitats in Canton Creek has been identified as a data gap.

#### ***4.16 Estuary State Indicator: Estuary Habitat Disturbance***

The Canton Creek estuary remains relatively undisturbed (NSWS, 2015). There are presently no active crown leases within the estuary, and no infrastructure exists, with the exception of Head Bay Road, which was constructed adjacent to the northern margin of the estuary. While historical imagery suggests this road was not constructed directly on estuarine habitat there are two culverts that are known to be limiting fish passage between the estuary a wetland upstream (M.C. Wright and Associates in-field observations) (Figure 32).





**Figure 32. Known present-day habitat disturbances to the Canton Creek estuary.**

Note that detailed imagery of historical habitat condition was not available. As such, an evaluation of the change in estuarine habitat over time (as an indicator of disturbance) was not possible.

Based on the limited known estuary habitat disturbances in the Canton Creek estuary, and the lack of historical data regarding estuary change over time, this indicator has been ranked as low risk with a partial data gap.

#### **4.17 Estuary State Indicator: Permitted Waste Discharges**

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

#### **4.18 Estuary State Indicator: Estuary Chemistry and Contaminants**

Discussions with local experts indicated the Canton Creek estuary remains in a relatively productive condition with no known major historical impacts to the estuary. As such, water



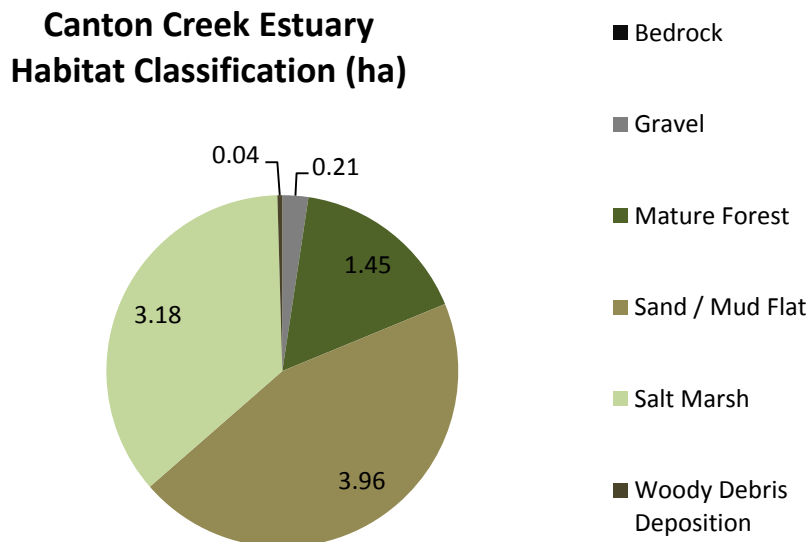
quality was not anticipated to be a concern (NSWS, 2015); however, no data with respect to estuary chemistry and contaminants was available for the Canton Creek estuary. As such, this indicator has been identified as a data gap.

#### **4.19 Estuary State Indicator: Dissolved Oxygen**

No data with respect to estuary dissolved oxygen was available for the Canton Creek estuary. As such, this indicator has been identified as a data gap.

#### **4.20 Estuary State Indicator: Estuarine Habitat Area**

The following figure details habitat composition within the Canton Creek estuary:



**Figure 33. Estuary habitat composition in the Canton Creek estuary.**

As demonstrated in Figure 33, a large component of the Canton Creek estuary is comprised of high value salt marsh habitat (3.18 hectares, or 35.97%). Sand and mud flats comprise 3.96 hectares (or 44.80%) of the area, with the remaining components dominated by mature forest (i.e. marine riparian) and gravel. Figure 34 demonstrates a relatively even distribution of salt marsh habitat across the width of the estuary, with the majority of gravel deposition near Head Bay Road at the northern margin of the estuary.

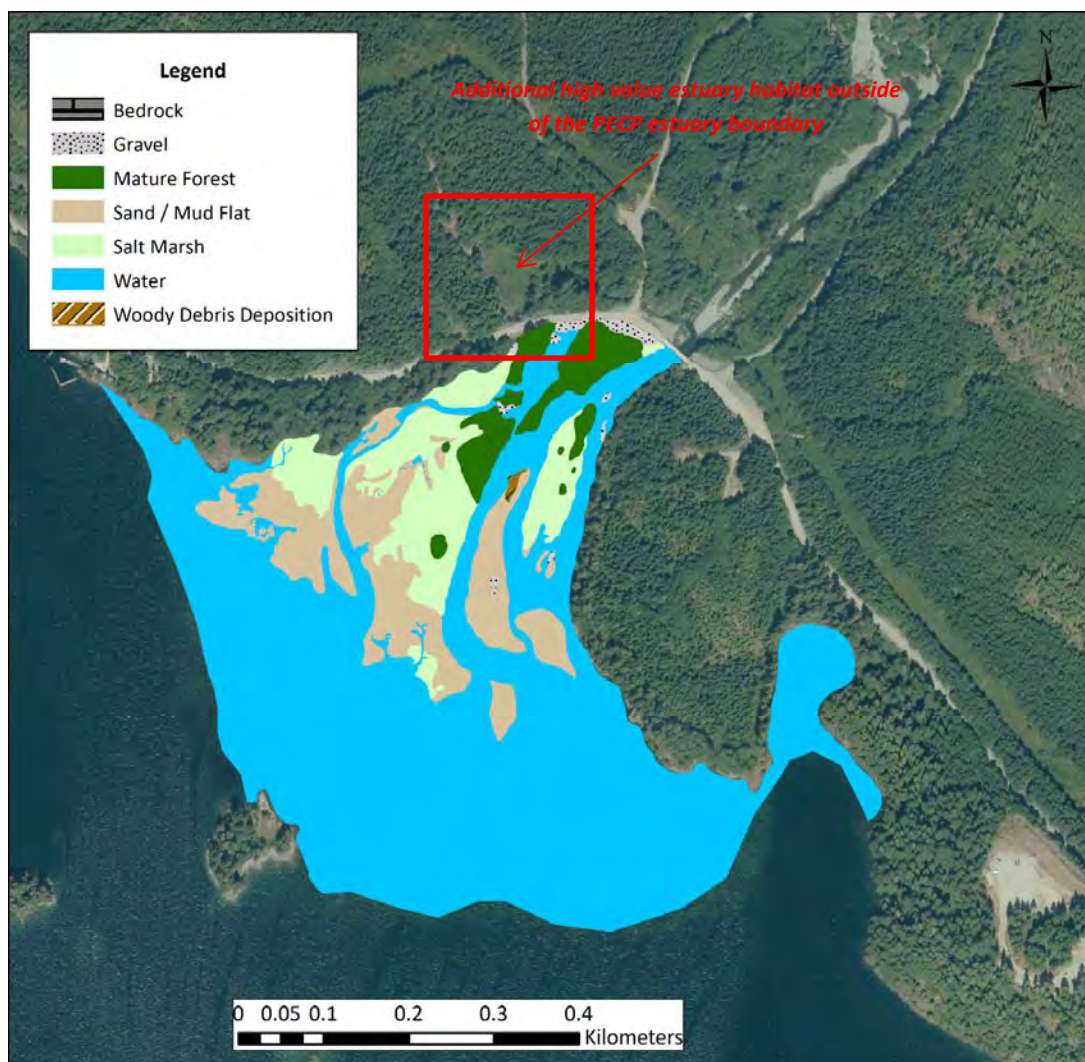


Figure 34. Estuary habitat area in the Canton Creek watershed.

Note that additional high value estuarine habitat (outside of the PECP estuary boundary) is present just north of the Canton Creek estuary (north of Head Bay FSR) (Figure 34). While tributaries draining into this habitat are outside of the Canton Creek watershed there is opportunity for juvenile fish originating from Canton Creek to rear and forage in this zone, as direct connectivity exists at certain tides.

Given the known importance of estuaries as a critical rearing and foraging zone for all species of out-migrating salmonids, and the apparent good health of the Canton Creek estuary, continued protection of this habitat is critical to maintaining fish productivity levels in the watershed. Based on its current state, Canton Creek has been given a low risk rating for estuary habitat area. Interviews with local experts indicated there is a healthy eelgrass bed in the estuary; however, no subtidal habitat condition data was available for review. A partial data gap has been assigned to this indicator to address this lack of subtidal data.

## 5.0 SUMMARY OF HABITAT INDICATORS AND DATA GAPS

Based on the results of the habitat status assessment of the Canton Creek watershed, it is clear that legacy impacts from forest harvesting continue to persist in this watershed, despite evidence of recovery in localized zones. The inherent characteristics of this system (i.e. aggressive hydrology, alluvial nature, presence of steep terrain, and frequent occurrence of natural landslides), combined with ongoing forest harvesting, has resulted in significant aggradation and channel over-widening in the lower river. A subsequent loss in pool habitat has been observed based on this sedimentation. Degraded riparian zones persist along both the left and right banks of the entire mainstem, and are a result of historical forest harvesting practices and ongoing channel instabilities. Very little functional LWD remains in the system; however, some areas do demonstrate LWD recruitment potential based on adjacent mature riparian stands.

Table 6 summarizes the results of ranked assessed habitat indicators and identifies indicator data gaps:

Table 6. Summary of assessed habitat indicators and data gaps.

Indicator	Type	Risk Rating	Data Gaps (Y/N)?	Comments
Total land cover alterations	Stream: Pressure	HIGH	N	Land cover alterations primarily in the form of deciduous-dominated riparian forests adjacent to fish and fish habitat.
Riparian disturbance	Stream: Pressure	HIGH	Y	Deciduous-dominated riparian zones. <b>Data gap for riparian classification of tributaries.</b>
Channel stability	Stream: State	HIGH	Y - Partial	Significant channel migration observed in select locations between 1980 and 2013. Channel over-widening continuing to occur in key locations. Ground truthing of these zones is recommended to complement the orthophotography assessment.
Habitat composition	Stream: State	HIGH	N	Percent pool area remains below suggested benchmarks described in Johnston and Slaney (1996). Loss of pool habitat between 1995 and 2013 observed.
Large woody debris	Stream: State	HIGH	Y - Partial	Pieces of functional LWD per bankful width remains below suggested benchmarks in Johnston and Slaney (1996) for all assessed reaches. Ground truthing of LWD recommended to quantify additional LWD that may not be visible from orthophotographs (i.e. completely submerged LWD in deep pools).
Watershed road development	Stream: Pressure	HIGH	Y - Partial	Indicator exceeds metrics provided in Stalberg et al (2009). However, analysis does not consider condition of roads (i.e. era of construction, deactivation status, etc.); therefore, partial data gap assigned.
Estuary habitat disturbance	Estuary: State	LOW	Y - Partial	Limited known disturbances to the estuary (with the exception of the construction of Head Bay Road, adjacent to the northern margin of the estuary), no active crown leases in



				the area. Lacking temporal comparison data to determine if reduction in habitat areas are resulting from upstream disturbances.
<b>Estuary habitat area</b>	Estuary: State	LOW	Y - Partial	Considerable salt marsh area remaining in the estuary, habitat appears to be in good health. Note: no data available on subtidal habitat condition.
<b>Permitted waste management discharges</b>	Stream: State	LOW	N	No permitted waste management discharges in Canton Creek.
<b>Water extraction</b>	Stream: Pressure	LOW	N	Only extraction presently licenced is near the downstream extent of any migration, spawning and rearing habitats, therefore having little impact on the watershed.
<b>Water temperature: Migration and spawning</b>	Stream: State	LOW	Y - Partial	Recorded water temperatures during spawn surveys from 2006 – 2014 showed no occurrence of temperatures approaching the UOTR for adult salmonids. Note that temporal distribution of data is limited – only point samples taken during swim surveys.
<b>Permitted waste management discharges</b>	Estuary: State	LOW	N	No permitted waste discharges identified in the Canton Creek estuary.
<b>Stream crossing density</b>	Stream: Pressure	Not ranked – data gap	Y	While high number of crossings modeled for this watershed, no confirmation data available with respect to crossing condition and potential impacts. Ground-truthing required to assess status of these crossings.
<b>Water quality</b>	Stream: State	Not ranked – data gap	Y	Water quality data available through the regional geochemical stream surveys only assessed fluoride, uranium, sulphate, and pH. Other key parameters (i.e. DO) not assessed.
<b>Water temperature: Juvenile rearing and</b>	Stream: State	Not ranked – data gap	Y	<b>No water temperature data available outside of the fall swim survey period.</b> This metric important to understand

<b>migration</b>				water temperature's influence on emergence timing and potential egg freezing events during winter low flows.
<b>Stream discharge</b>	Stream: State	Not ranked – data gap	Y	<b>No discharge data available for Canton Creek.</b>
<b>Estuary chemistry and contaminants</b>	Estuary: State	Not ranked – data gap	Y	<b>No water quality data available for the estuary.</b>
<b>Estuary dissolved oxygen</b>	Estuary: State	Not ranked – data gap	Y	<b>No DO data available for the estuary.</b>
<b>Accessible stream length</b>	Stream: State	N/A	Y - Partial	Requires temporal comparison of change over time to determine indicator risk. Confirmation of accessible stream length recommended through field mapping of tributary and side channel habitat.
<b>Key spawning areas (length)</b>	Stream: State	N/A	Y - Partial	Requires temporal comparison of change over time to determine indicator risk. Ground truthing of upper and lower limits of spawning zones via GPS recommended to accurately quantify and monitor this indicator.

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.

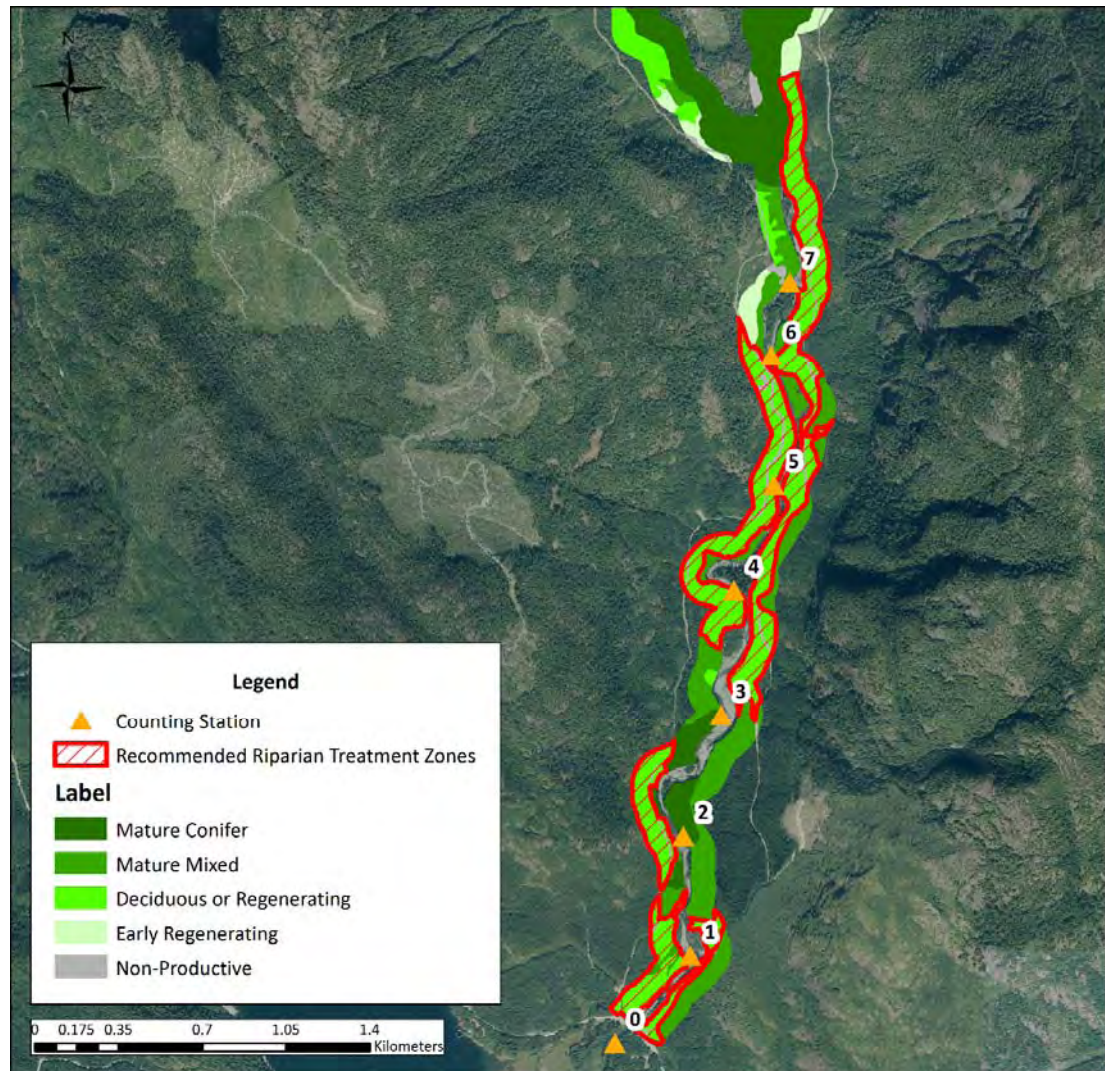
In many cases data gaps prevented a full assessment of state and pressure indicators. Based on the results of this habitat status assessment, recommendations can be broken down as follows: recommended restoration projects, data gaps to be addressed, and best functioning habitats requiring protection.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

## **5.1    *Recommended Restoration Projects***

Given the known issues of degraded riparian zones, channel instabilities, over-widening and aggradation, fish access issues into wetlands above the estuary, and previous prescriptions for groundwater channels, the following sections describe recommended restoration projects for the Canton Creek watershed.

### **5.1.1        Riparian Treatments**

Specific zones recommended for riparian treatments include the deciduous-dominated right bank between counting stations 0 and 2, the left bank between counting stations 0 and 1, both banks between counting stations 3 and 6, and the left bank between counting station 6 and just upstream of counting station 7 (Figure 35). The total area of these recommended areas is approximately 51.5 hectares. Note that additional riparian treatment opportunities exist upstream of this zone (i.e. East Canton Creek); however, riparian restoration lower down in the watershed would target more critical habitats for all species observed in this river.



**Figure 35. Recommended riparian treatment zones for Canton Creek.**

Common riparian treatments utilized in degraded riparian zones that could be applied in Canton Creek include the following (Poulin, 2005):

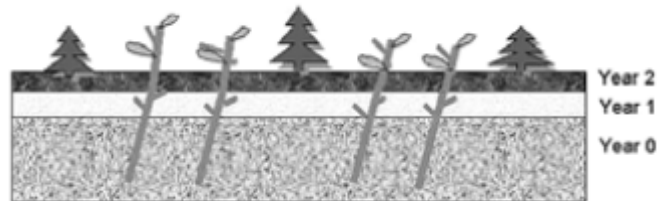
- Conifer release: treatment removes competing over story or brush by felling, girdling, or brushing.
- Uniform thin: a thinning treatment that spaces conifer generally uniformly throughout a stand. The treatment maximizes the number of large diameter conifers per unit area.
- Variable thin: allows for wide variability in conifer spacing. Mimics distribution of conifers on moist and wet sites where competition is generally most-severe.
- Planting: planting on best available microsites, implies cluster planting.



Based on the potential riparian treatment sites identified above, development of riparian prescriptions by a Registered Professional Forester (RPF) is recommended to move forward with addressing this high risk habitat indicator.

### **5.1.2 Live Gravel Bar Staking**

Live staking of gravel bars using willow (*Salix spp.*) and other plant species such as red-osier dogwood (*Osier stolonifera*) and black cottonwood (*Populus trichocarpa*) can be used to treat river channels that have become aggraded and braided. In live staking, cuttings (stakes) from the selected species are planted at high density into the gravel bars. Placing of these stakes is intended to trap woody debris and encourage local sediment deposition while live stakes continue to grow and protrude above the gravel bar. Over time, elevation of gravel bars is anticipated, while the accumulation of fines and organics will promote the establishment of additional riparian vegetation (Figure 36). Eventually streamflow will become more confined to the main channel and normal bankful widths will be achieved (Cuthbert and Redden, 2005).



**Figure 36. Live gravel bar staking resulting in eventual re-vegetation of gravel bars.**

In Canton Creek, several gravel bars have been identified as candidates for live staking between counting stations 2 and 4 (Figure 37). Prior to gravel bar staking, field ground-truthing of these gravel bars is required to assess if natural re-vegetation is already occurring in these zones and to evaluate channel stability. An evaluation of channel stability by a fluvial geo-morphologist is highly recommended to assess the suitability of candidate sites (and identify additional candidate sites).



Figure 37. Candidate sites for live gravel bar staking in Canton Creek.

### 5.1.3 Groundwater Channel Construction

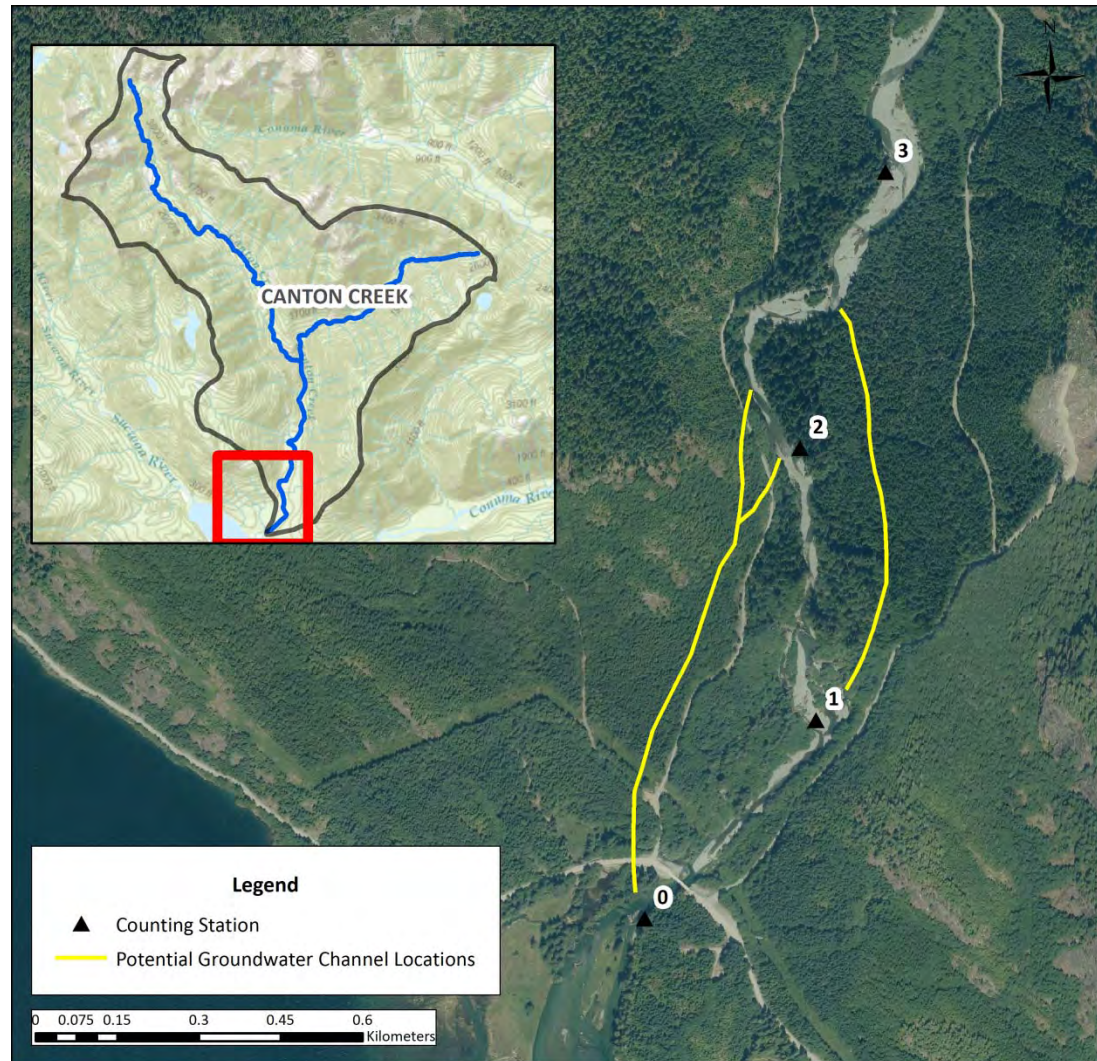
In the early 2000s, high quality groundwater channel opportunities were located along the left and right banks of lower Canton Creek, with potential to provide critical spawning and rearing habitats for both chum and coho salmon (Figure 38) (Fisheries and Oceans Canada, 2007). Ten shallow test wells were installed in 2004, and in 2007, a proposal was submitted to construction additional test wells to facilitate with prescription design. No further work was completed with respect to these side channels.

Considering the work that has already gone into the development of these channels, and the known values to fish that groundwater channels provide, resurrection of the Canton



Creek groundwater channels is recommended. Discussions with Fisheries and Oceans Canada (Resource Restoration Department) should be initiated to evaluate the existing test pit data and determine next steps for prescription development.

Note that the groundwater channel along the left bank (between counting stations 2 and 1) partially coincides with the historic chum spawning back channel constructed in the 1970s. As such, opportunity may exist to restore this channel to a higher functioning condition.



**Figure 38. Potential groundwater location channels in Lower Canton Creek (derived from Fisheries and Oceans Canada's proposal [2007]).**

#### 5.1.4 Head Bay FSR Culvert Replacement

In 2012, an assessment of two culverts along Head Bay FSR was conducted to determine if these crossings were restricting fish access between the estuary and an upstream wetland (Figure 39) (Photo 8, Photo 9, and Photo 10). Results of this assessment identified both of these crossings to be restricting fish passage (M.C. Wright and Associates, unpublished field data).



Figure 39. Location of culverts restricting fish access along Head Bay FSR.





**Photo 8. High value salt marsh habitat upstream of the Head Bay FSR culverts.**



**Photo 9. Estuarine habitat downstream of the Head Bay FSR culverts.**



**Photo 10. Head Bay FSR culvert restricting fish passage.**

Considering the known fish values of estuarine and wetland habitats for juvenile salmonid rearing habitat, facilitating access between the Canton Creek estuary and this wetland upstream would provide benefit to all species of juvenile salmon in Canton Creek. Further investigations into replacing these crossings are highly recommended. It should be noted that considering these crossings are on a forest service road, replacement work may be eligible for funding through the Ministry of Forests, Lands, and Natural Resource Operation's fish passage program (<https://www.for.gov.bc.ca/hfp/fish/fishpassage.html>).

#### **5.1.5 LWD Placement**

Previous studies have identified that the in-stream placement of LWD can increase the habitat capacity and subsequent productivity levels of chinook salmon (Polivka et al, 2014). Given Canton Creek has been scored as high risk for the LWD indicator, focus is recommended towards identifying locations for in-stream LWD placement. Note that ground-truthing will be required to select sites that are both deficient in LWD and are situated adjacent to riparian zones with future LWD recruitment potential.



## 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 7. Data gaps and recommended studies for habitat indicators in Canton Creek.**

Data Gap	Priority	Recommendation
Intergravel flows and DO levels	High	Direct field efforts to collect this intergravel flow and DO data at known spawning grounds. Collect GPS coordinates of upstream and downstream extents of known spawning grounds.
Channel stability	High	Ground-truth key eroding sections and have channel stability assessed by a fluvial geo-morphologist.
Status of off-channel habitats, including wetlands, tributaries, and accessible stream length of these tributaries	High	Conduct a field mapping study of off-channel habitats. Collect water quality data simultaneously. Use field data of tributary locations to classify riparian vegetation using 2013 high resolution orthophotographs.
Status of modeled stream crossings in the watershed	High	Secure funding to conduct a culvert assessment of modeled crossings in the watershed.
Coho holding and spawning habitat above counting station 7	Moderate	Conduct a snorkel survey throughout the known coho distribution (and upstream of current survey area) during coho spawning to identify critical spawning and holding habitats.
Riparian classification of tributaries	Moderate	Utilize off-channel mapping data to classify riparian vegetation using the most recently orthophotography available.
Large woody debris	Moderate	Ground-truth LWD for functionality and assess submerged LWD not visible from orthophotographs.
Stream discharge	Moderate	Install a hydromet station on Canton Creek to measure continuous discharge and temperature information.
Water temperature	Moderate	
Key spawning areas (length)	Moderate	Collect GPS coordinates of extents of spawning grounds during AUC swim surveys.
Instream water quality	Low	Collect opportunistic water quality data throughout the watershed. Note no major issues with water quality anticipated in the system based on interviews with local experts.
Subtidal estuarine habitat	Low	Conduct a detailed subtidal habitat study of the estuary,

condition		including quantifying and mapping subtidal habitat types and impacts, and analyzing water quality and sediment samples for contaminants. This study could occur in conjunction with field work required to develop prescription for potential intertidal habitat reclamation.
Estuary chemistry and contaminants	Low	
Estuary dissolved oxygen	Low	



### ***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 40 summarizes all of the known functioning 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.

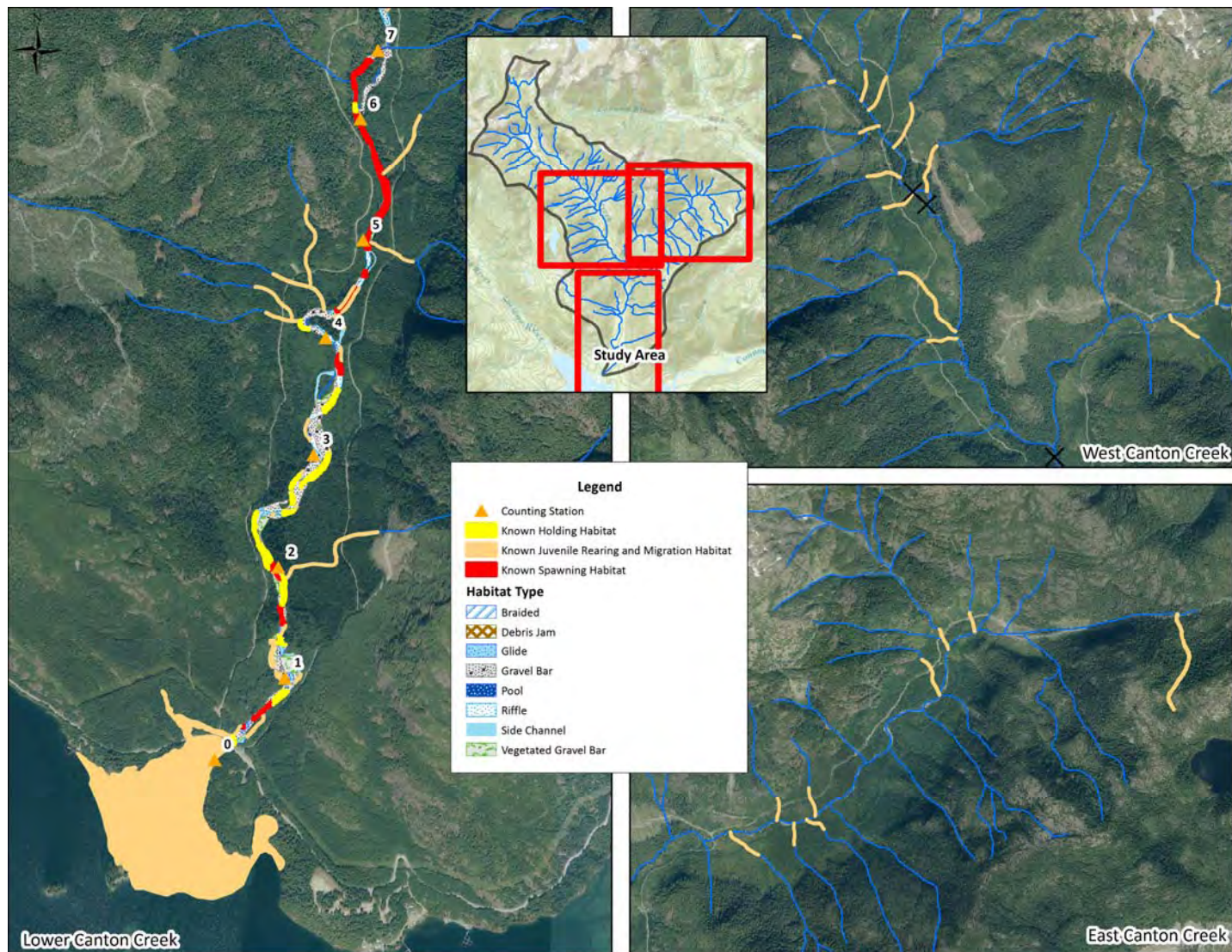


Figure 40. Known functioning habitats requiring protection in the Canton Creek watershed.

## 6.0 CONCLUSION

The Canton Creek watershed remains highly degraded from historical logging practices removing riparian vegetation to the stream banks. The inherent characteristics of this system (i.e. aggressive hydrology, alluvial nature, presence of steep terrain, and frequent occurrence of natural landslides), combined with ongoing forest harvesting, has resulted in significant aggradation and channel over-widening in the lower river. While this watershed is known to be improving (Horel, 2008), high risk indicators still exist, and restoration opportunities are present that will help accelerate watershed recovery over time.

The habitat status assessment for the Canton Creek watershed has identified high risk habitat indicators to be high total land cover alterations adjacent to fish habitat, riparian disturbances, channel bank stability (i.e. over-widening), habitat composition (i.e. aggradation and infilling of pools), and presence of LWD (note that watershed road development also scored as high risk; however, data gaps exist with this metric). Important data gaps to note include instream water quality, continuous discharge and temperature data, intergravel flows and DO in key spawning grounds, and quantification of off-channel and wetland habitat condition.

Both riparian, instream, and off-channel restoration opportunities exist in this system. Potential riparian treatments have been identified throughout counting stations 0 and 7. Several key gravel bars between counting stations 2 and 4 would benefit from live staking to promote re-vegetation, and construction of the groundwater channel opportunities identified in 2007 would provide valuable off-channel spawning and rearing habitats (Fisheries and Oceans Canada, 2007). Replacement of two culverts on Head Bay FSR would improve fish passage between the estuary and an upstream wetland (and therefore provide additional critical rearing and foraging habitat for juvenile salmonids), and the placement of instream LWD at select locations would provide additional cover and holding habitat for both adult and juvenile salmonids.

While high priority restoration initiatives have been identified for this watershed, important data gaps that require further understanding exist as well. More information with respect to water quality, discharge, intergravel flows, and off-channel habitats is necessary to obtain a more comprehensive understanding of limiting factors in the Canton Creek watershed.

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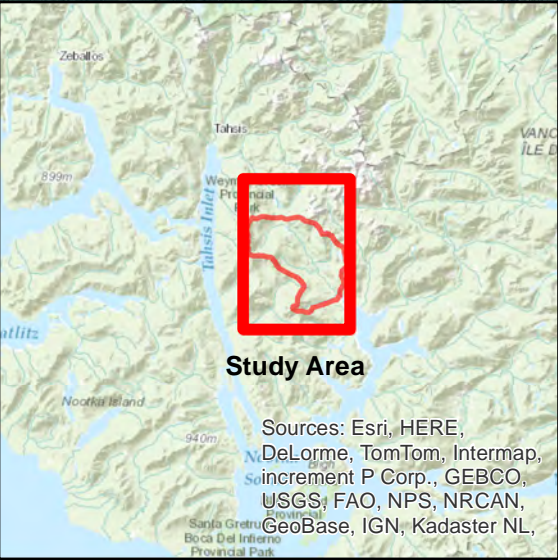
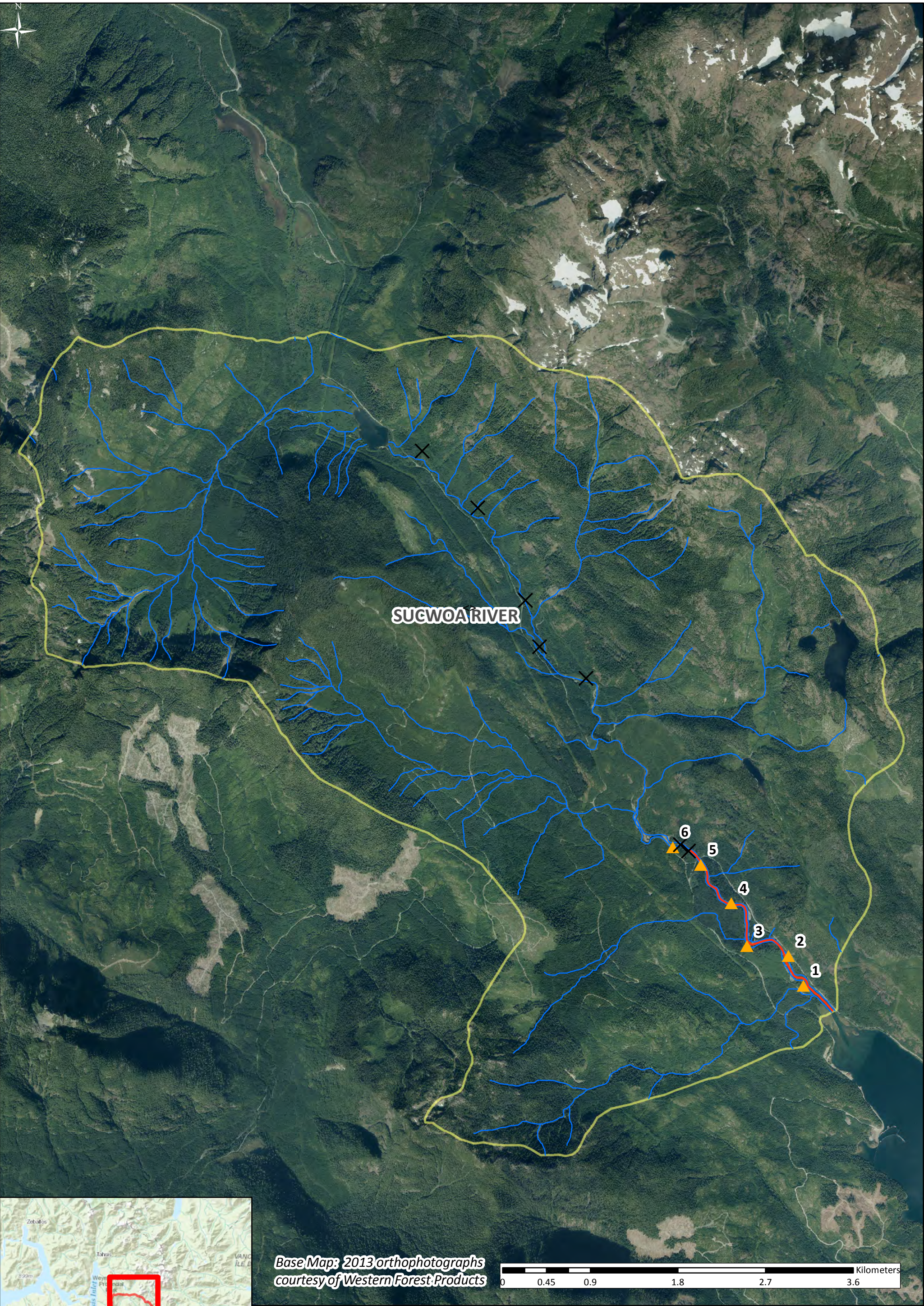
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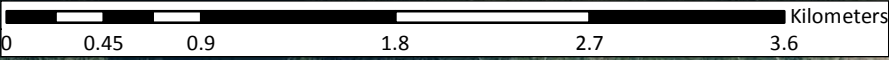
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## APPENDIX 1: CANTON CREEK WATERSHED MAP ATLAS





Base Map: 2013 orthophotographs  
courtesy of Western Forest Products



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 9, 2015



Nootka Sound Watershed Society



M. C. Wright and Associates Ltd.  
Biological Consultants

NC ompas  
Software Development

MAP 1

Sucwoa River Watershed  
Known Chinook Distribution





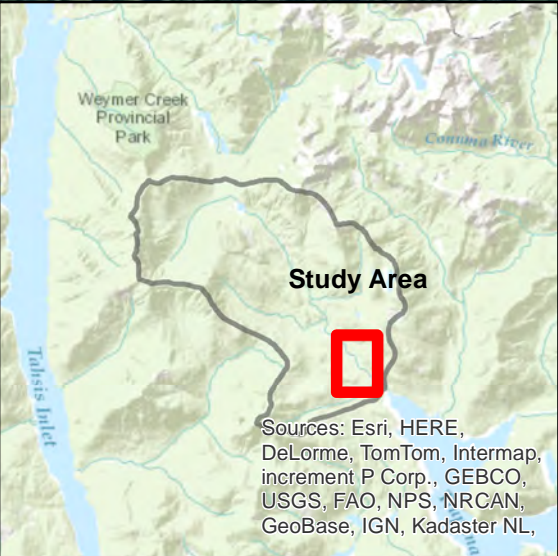
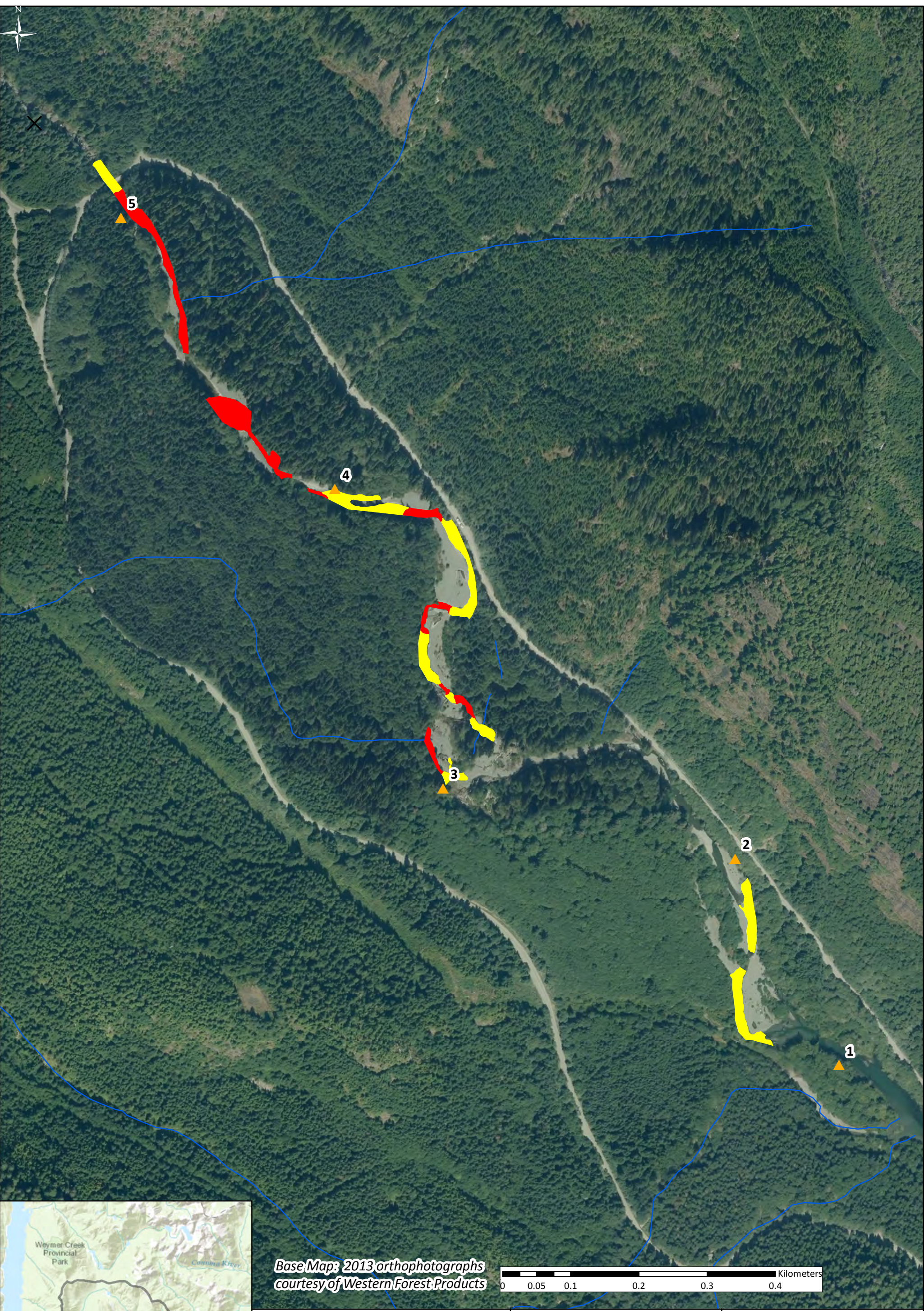










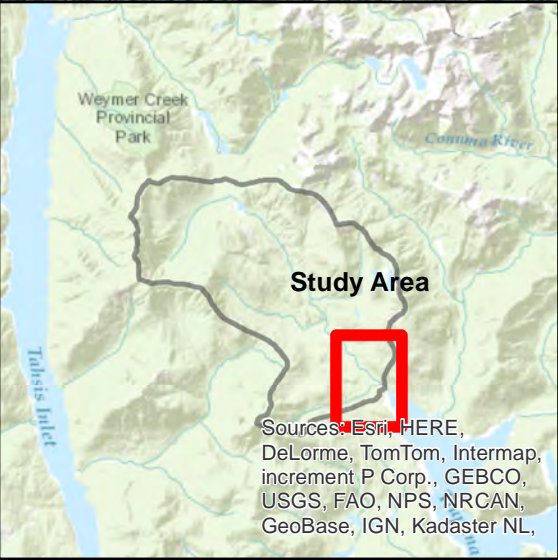
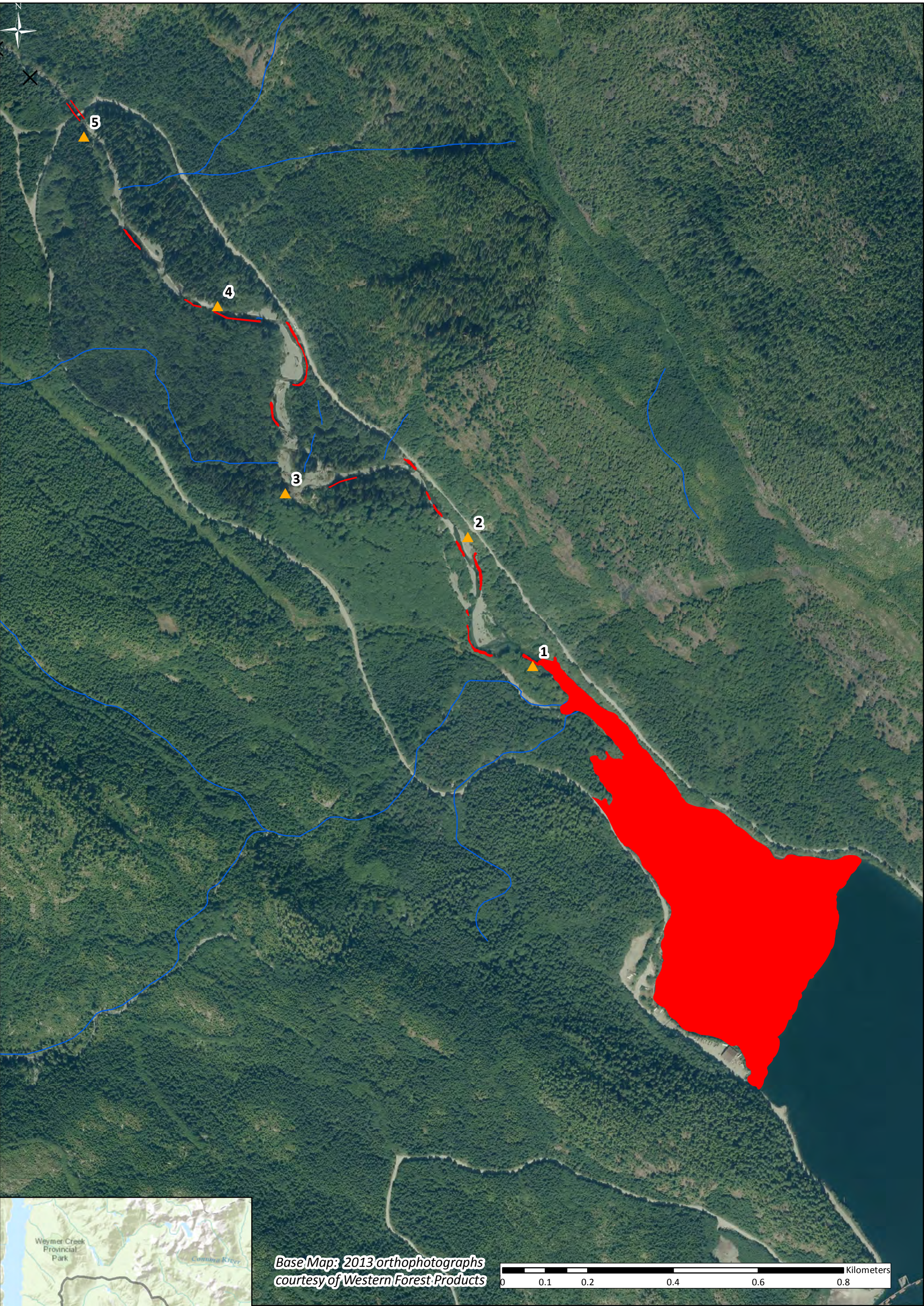


Base Map: 2013 orthophotographs  
courtesy of Western Forest Products



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Base Map: 2013 orthophotographs  
courtesy of Western Forest Products



- Legend**
- ✕ Barrier to Fish Passage
  - ▲ Counting Station
  - Known and Inferred Juvenile Rearing
  - TRIM River

Prepared For: Nootka Sound Watershed Society

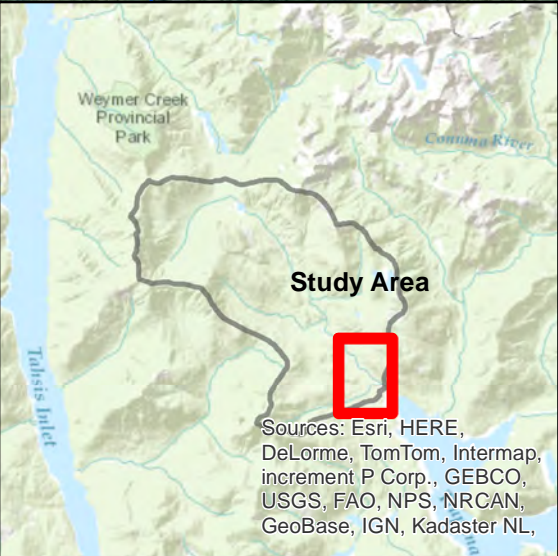
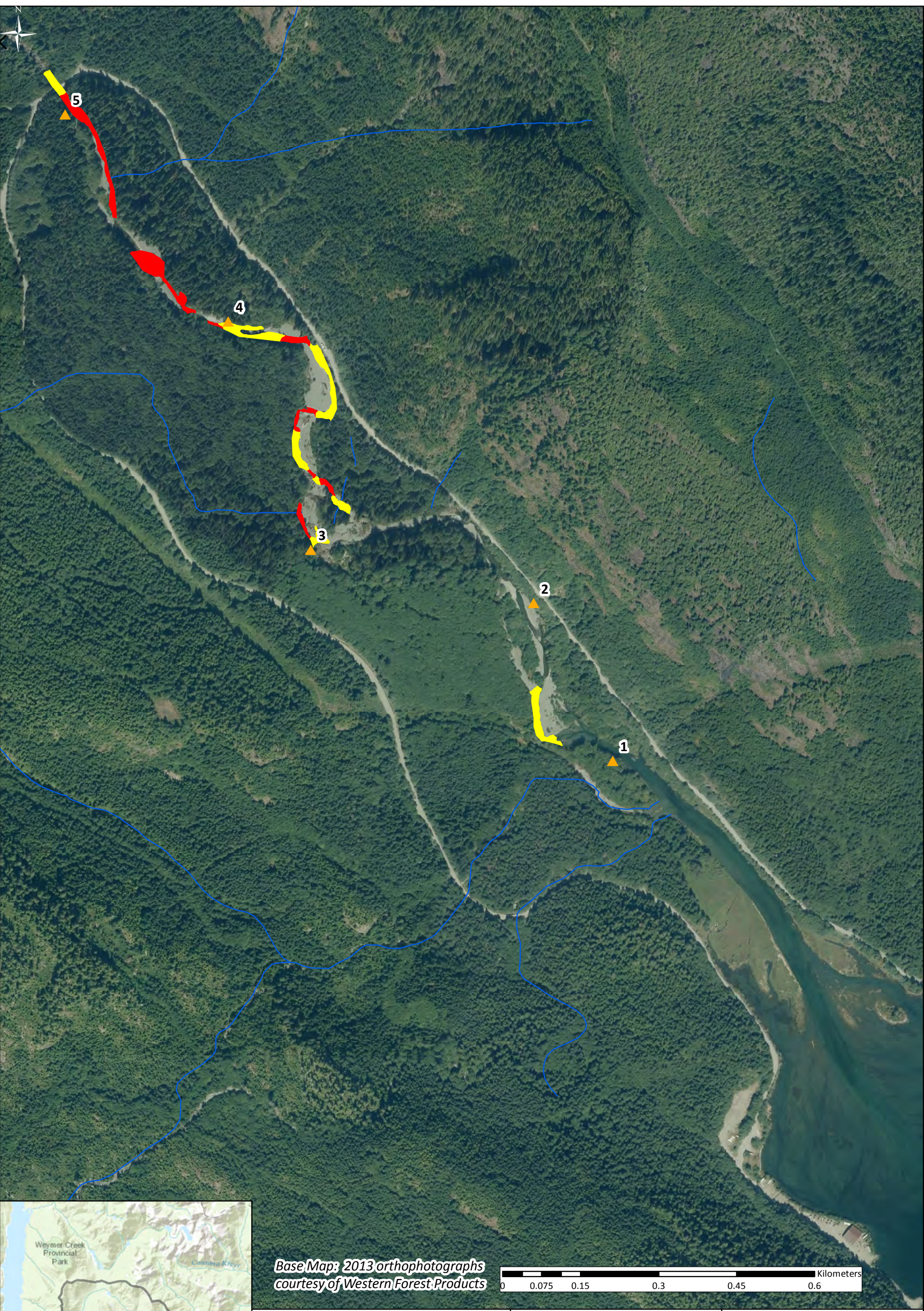
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June 9, 2015



**MAP 6**




**Sucwoa River Watershed  
Known and Inferred Chinook  
Habitat: Juvenile Rearing**



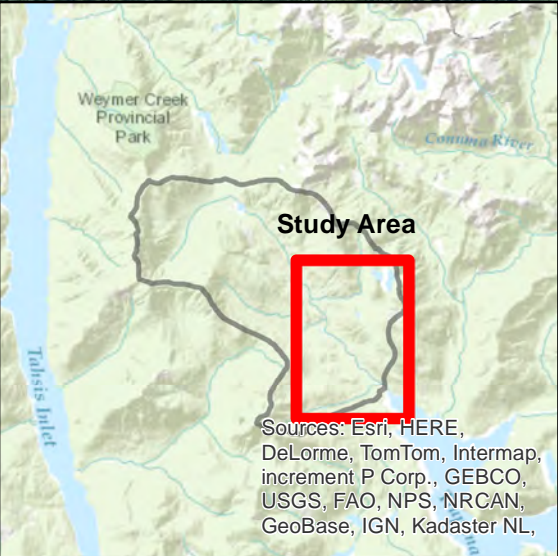
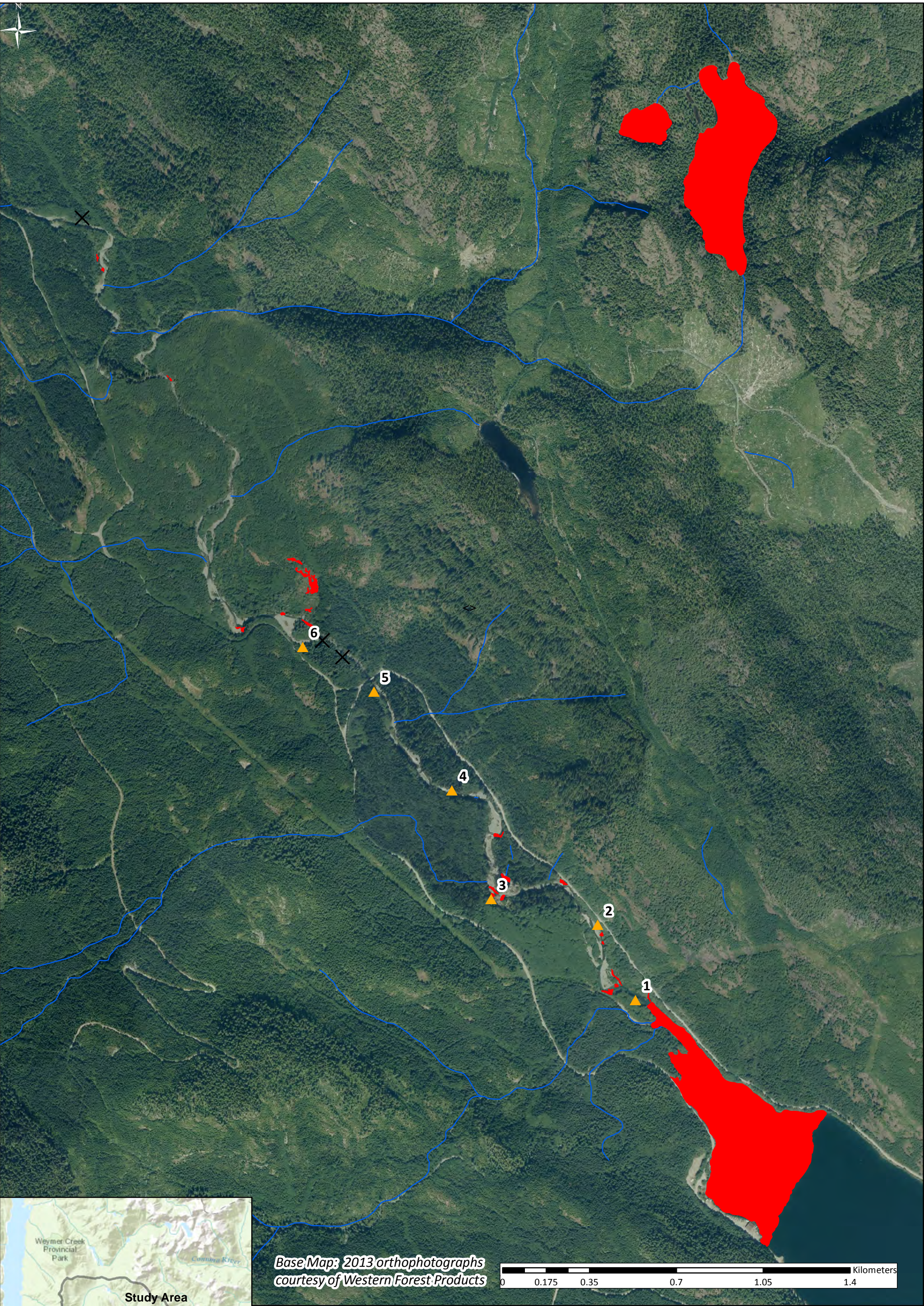


Base Map: 2013 orthophotographs  
courtesy of Western Forest Products



<p><b>Legend</b></p> <ul style="list-style-type: none"><li>✕ Barrier to Fish Passage</li><li>▲ Counting Station</li><li>Known Holding Habitat (Coho)</li><li>Known Spawning Habitat (Coho)</li><li>TRIM River</li></ul>	<p>Prepared For: Nootka Sound Watershed Society</p> <p>Prepared By: M.C. Wright and Associates Ltd. June 9, 2015</p> <div></div>	<p><b>MAP 7</b></p> <p><b>Sucwoa River Watershed Known Coho Habitat: Adult Holding and Spawning</b></p>
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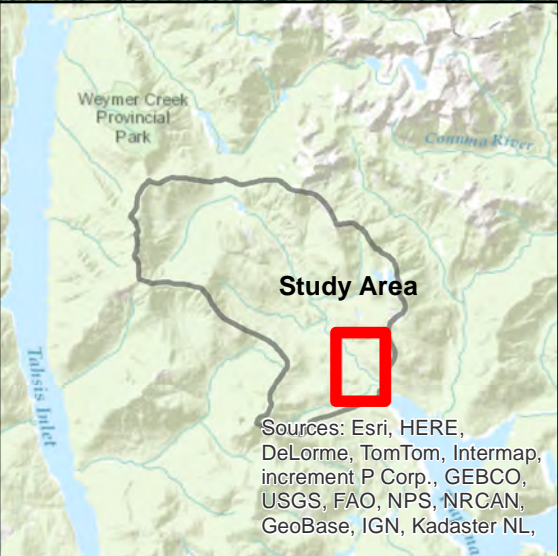
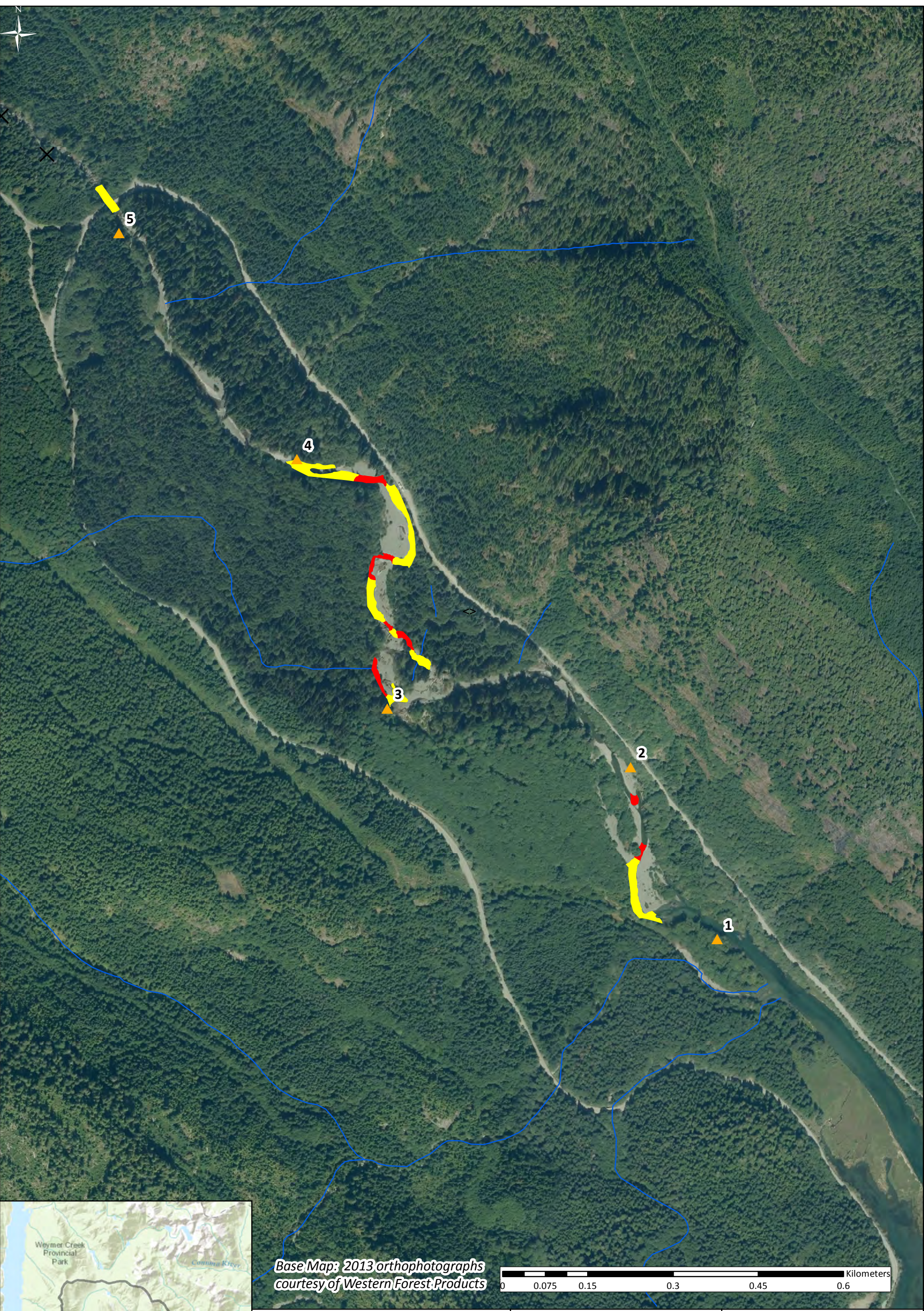


*Base Map: 2013 orthophotographs  
courtesy of Western Forest Products*






<b>Legend</b> <div><div>✕</div>Barrier to Fish Passage</div> <div><div>▲</div>Counting Station</div> <div><div>■</div>Known and Inferred Key Rearing Habitat</div> <div><div>—</div>TRIM River</div>		<b>Prepared For:</b> Nootka Sound Watershed Society <b>Prepared By:</b> M.C. Wright and Associates Ltd. June 9, 2015 <div><div></div><div></div><div></div></div>	<b>MAP 8</b> <b>Sucwoa River Watershed Known and Inferred Coho Habitat: Juvenile Rearing</b>
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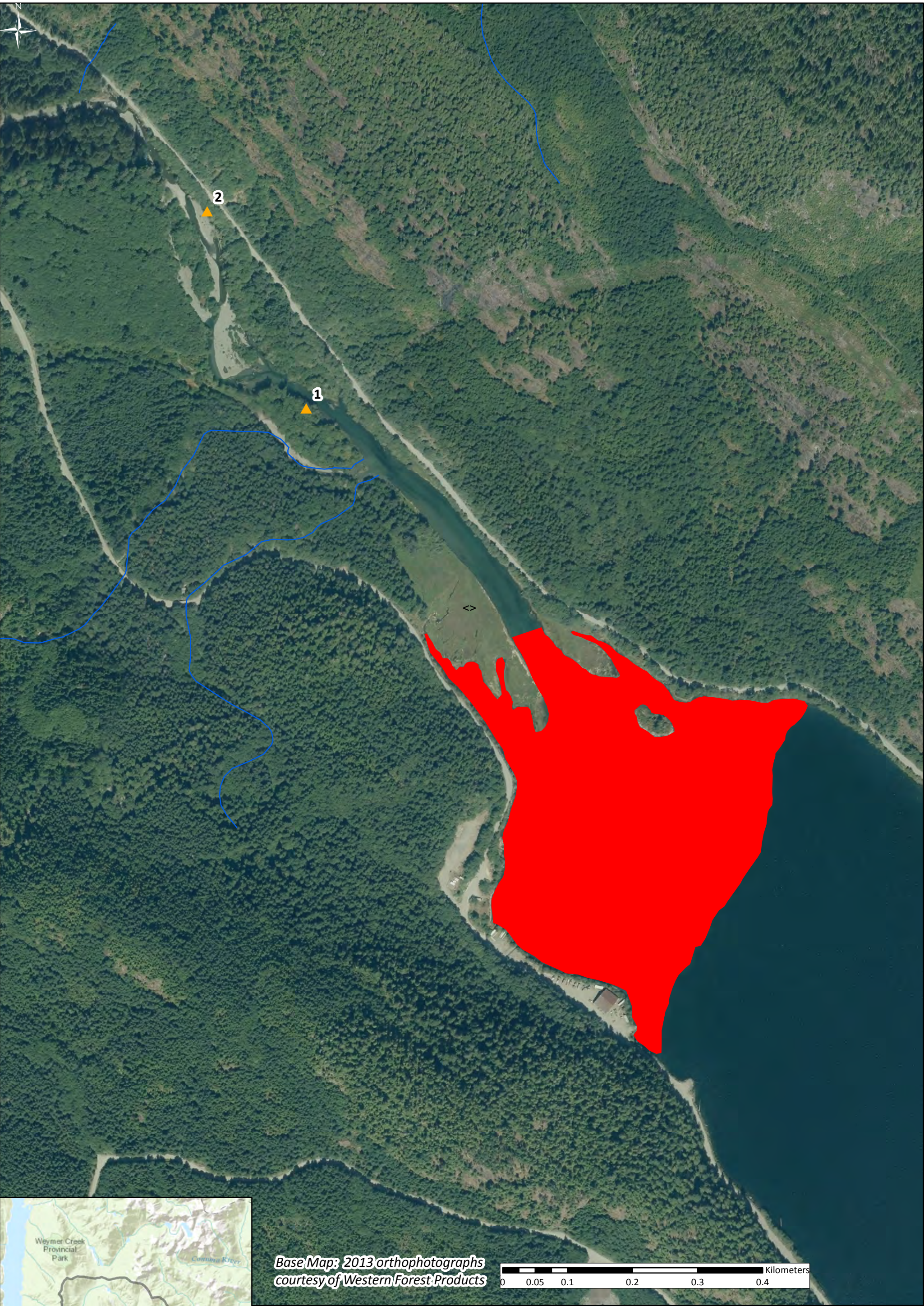


Base Map: 2013 orthophotographs  
courtesy of Western Forest Products



<p><b>Legend</b></p> <p>✕ Barrier to Fish Passage</p> <p>▲ Counting Station</p> <p>Known Holding Habitat (Sockeye)</p> <p>Known Spawning Habitat (Sockeye)</p> <p>— TRIM River</p>	<p><b>Prepared For:</b> Nootka Sound Watershed Society</p> <p><b>Prepared By:</b> M.C. Wright and Associates Ltd. June 9, 2015</p> <div><p>Nootka Sound Watershed Society</p><p>M. C. Wright and Associates Ltd. Biological Consultants</p><p>NCompas Software Development</p></div>	<p><b>MAP 9</b></p> <p><b>Sucwoa River Watershed Known Sockeye Habitat: Adult Holding and Spawning</b></p>
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Base Map: 2013 orthophotographs  
courtesy of Western Forest Products



Legend

- ✕ Barrier to Fish Passage
- ▲ Counting Station
- Key Rearing Habitat
- TRIM River

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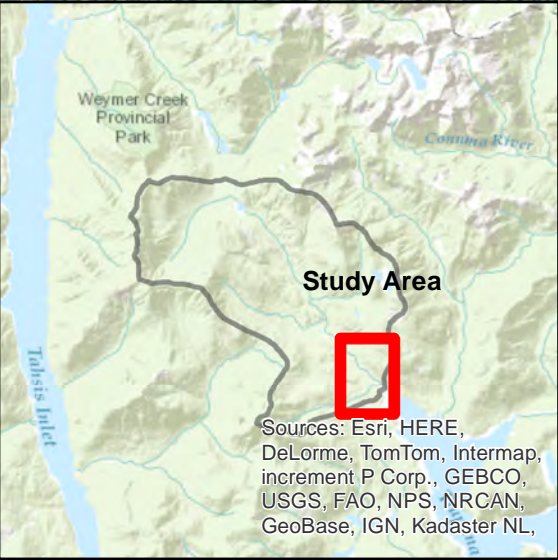
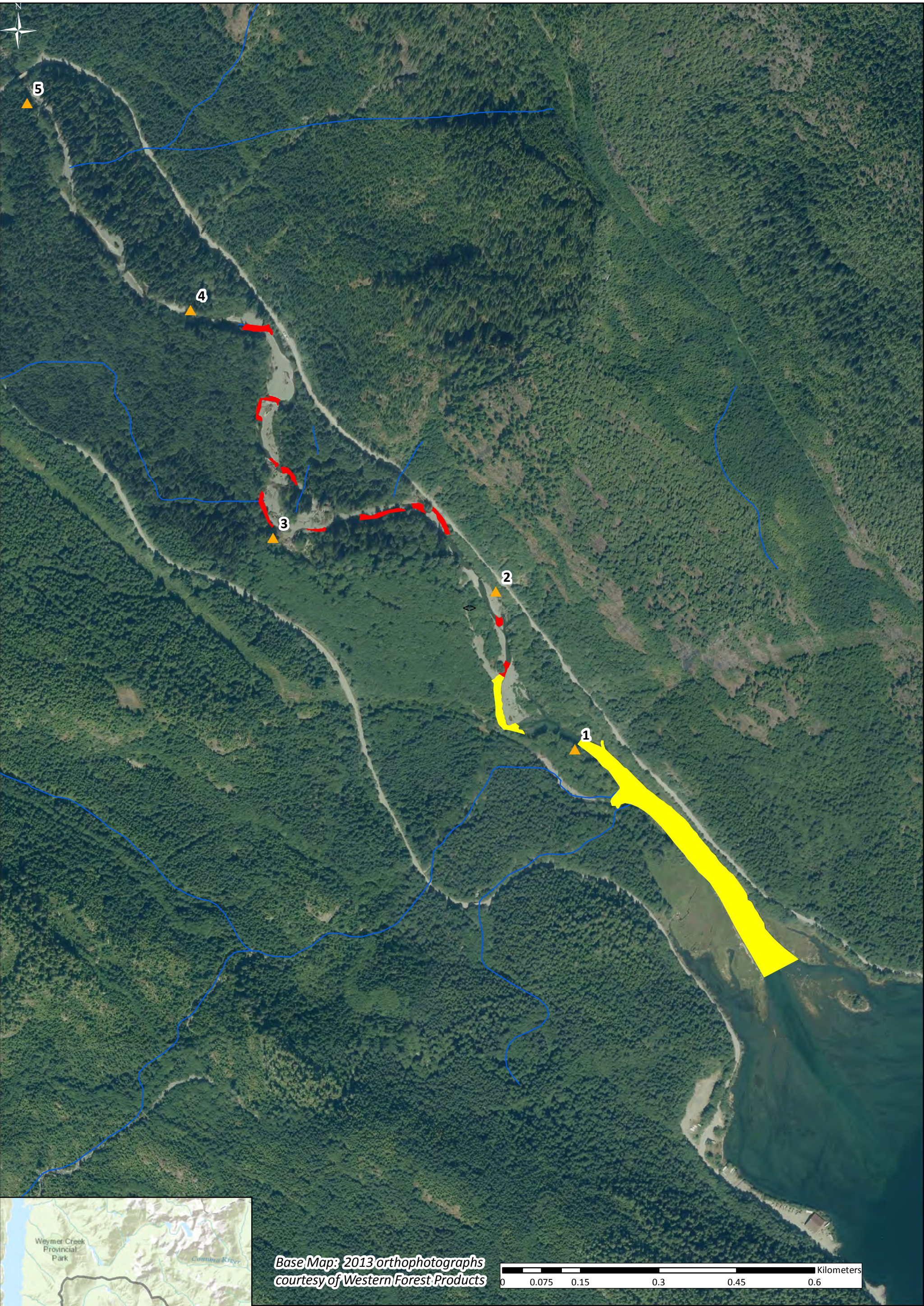
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MAP 10

Sucwoa River Watershed  
Known Sockeye Habitat:  
Juvenile Rearing





Base Map: 2013 orthophotographs  
courtesy of Western Forest Products



**Legend**

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

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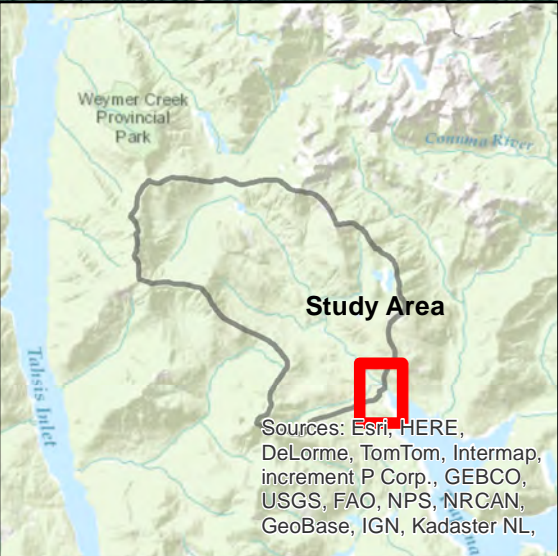
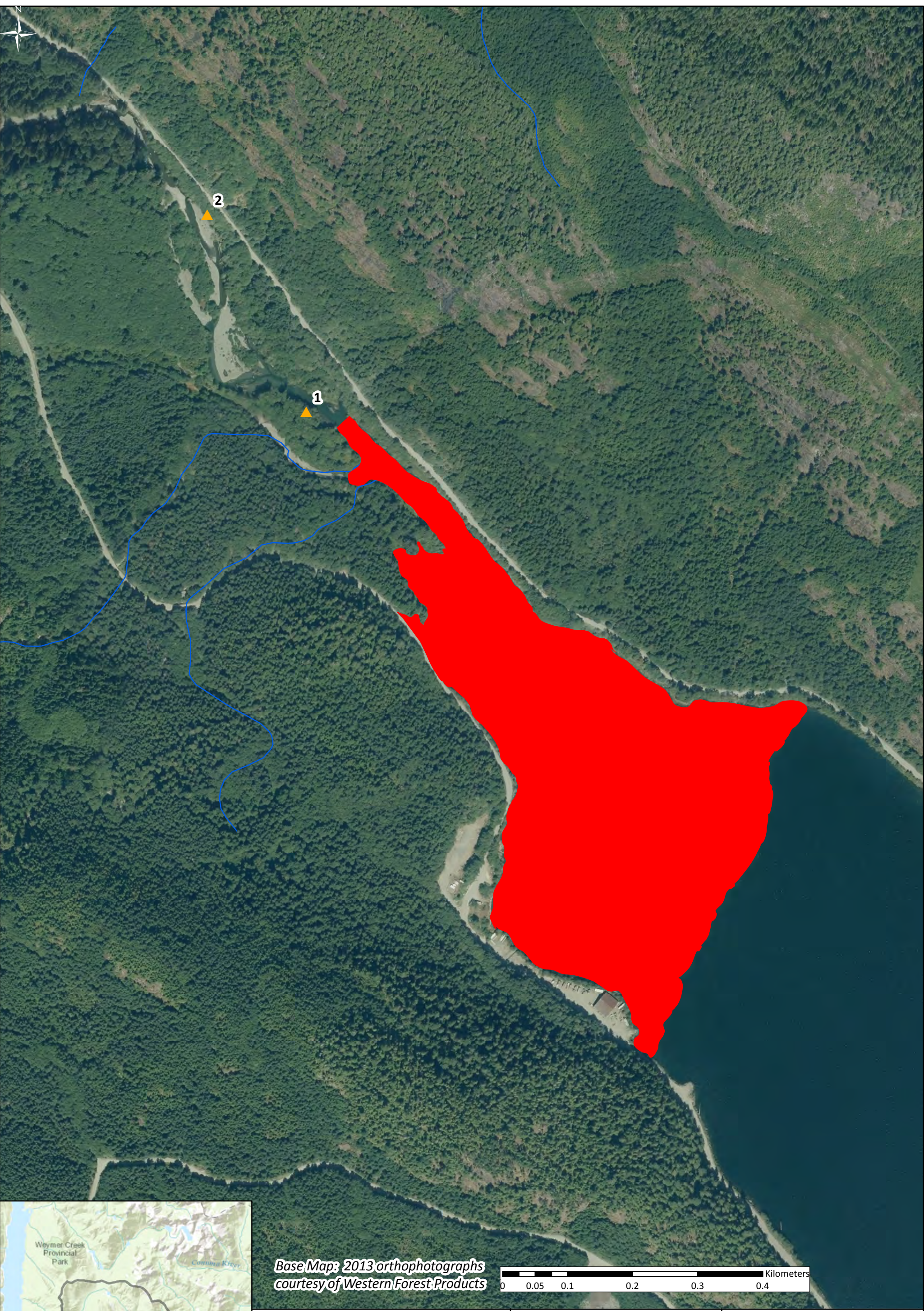
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**MAP 11**

**Sucwoa River Watershed  
Known Chum Habitat:  
Adult Holding and Spawning**





*Base Map: 2013 orthophotographs  
courtesy of Western Forest Products*



**Legend**

- ✕ Barrier to Fish Passage
- ▲ Counting Station
- Known Rearing Habitat
- TRIM River

**Prepared For:** Nootka Sound Watershed Society

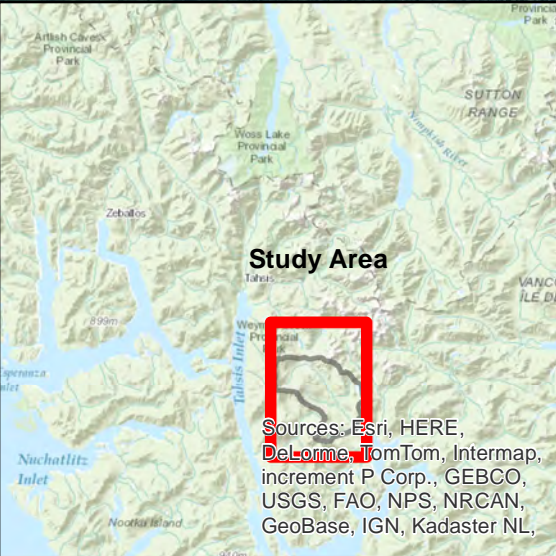
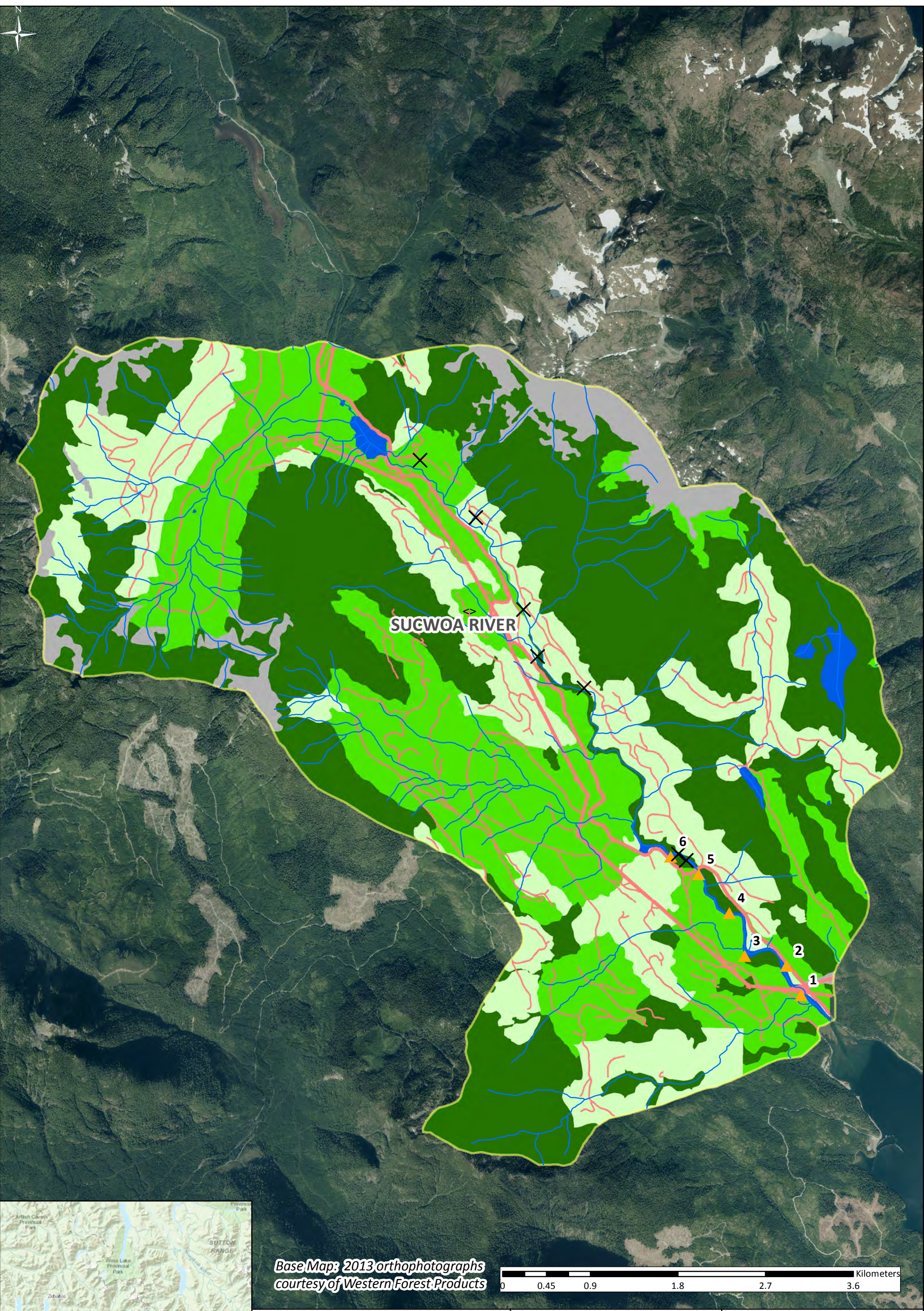
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June 9, 2015



**MAP 12**

**Sucwoa River Watershed  
Known Chum Habitat:  
Juvenile Rearing**





Base Map: 2013 orthophotographs  
courtesy of Western Forest Products



Legend	
	Barrier to Fish Passage
	Counting Station
	TRIM River
	Watershed Boundary
	Older than 120 years
	41 to 120 years
	Younger than 40 years
	Non - Productive (Alpine)
	Non - Productive (Avalanche Chute)
	Non - Productive (Barren Surface)
	Non - Productive (Fresh Water)
	Non - Productive (Urban)

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Prepared By: M.C. Wright and Associates Ltd.  
June 9, 2015

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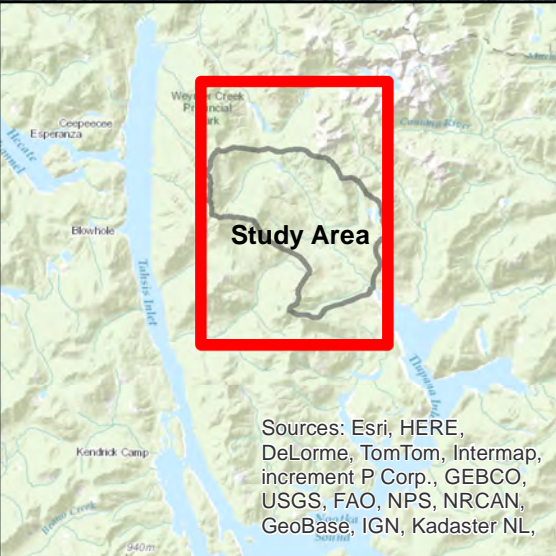
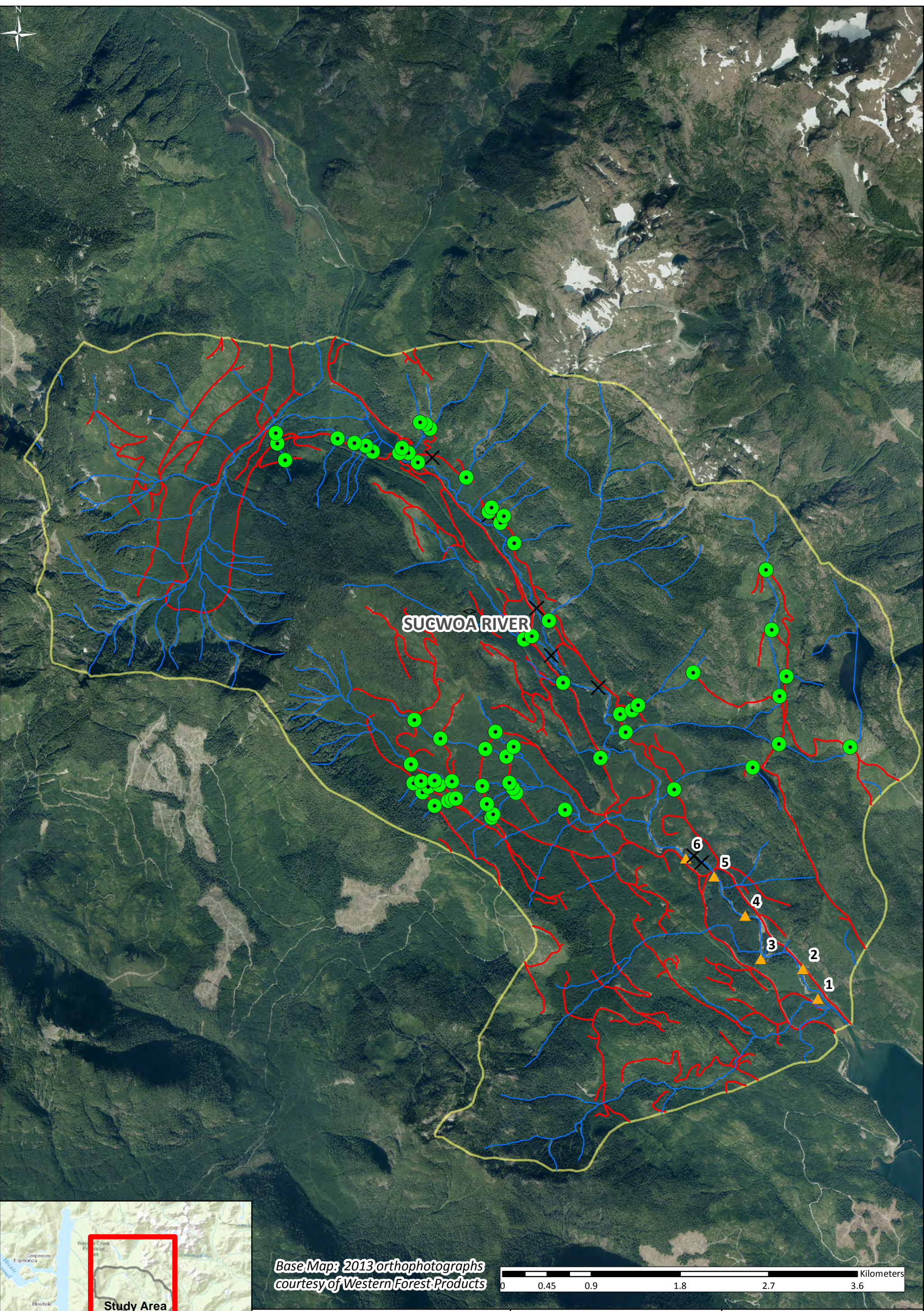
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Biological Consultants

NCompas  
Software Development

MAP 13

Sucwoa River Watershed  
Total Land  
Cover Alterations





Base Map: 2013 orthophotographs  
courtesy of Western Forest Products



Legend

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

Prepared For: Nootka Sound Watershed Society

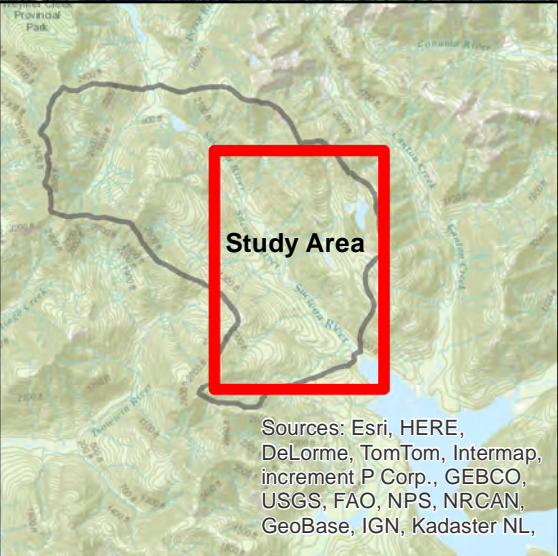
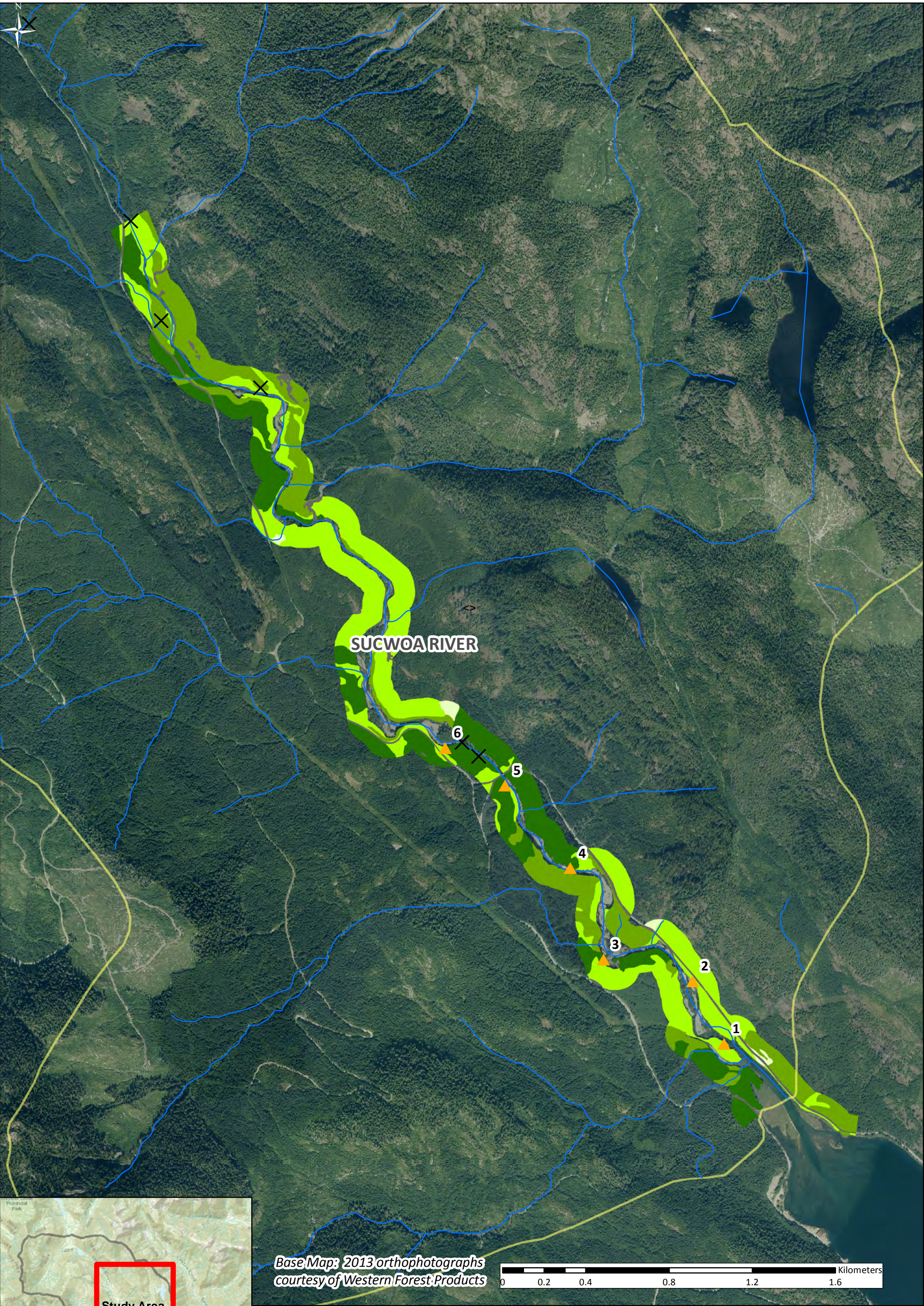
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June 9, 2015



MAP 14

Sucwoa 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

**Prepared For:** Nootka Sound Watershed Society

**Prepared By:** M.C. Wright and Associates Ltd.  
June 9, 2015

Nootka Sound Watershed Society

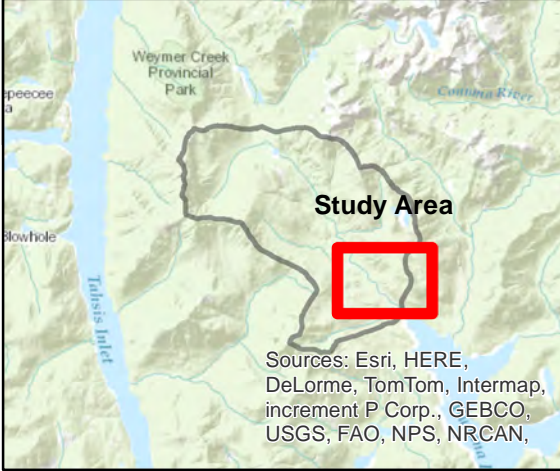
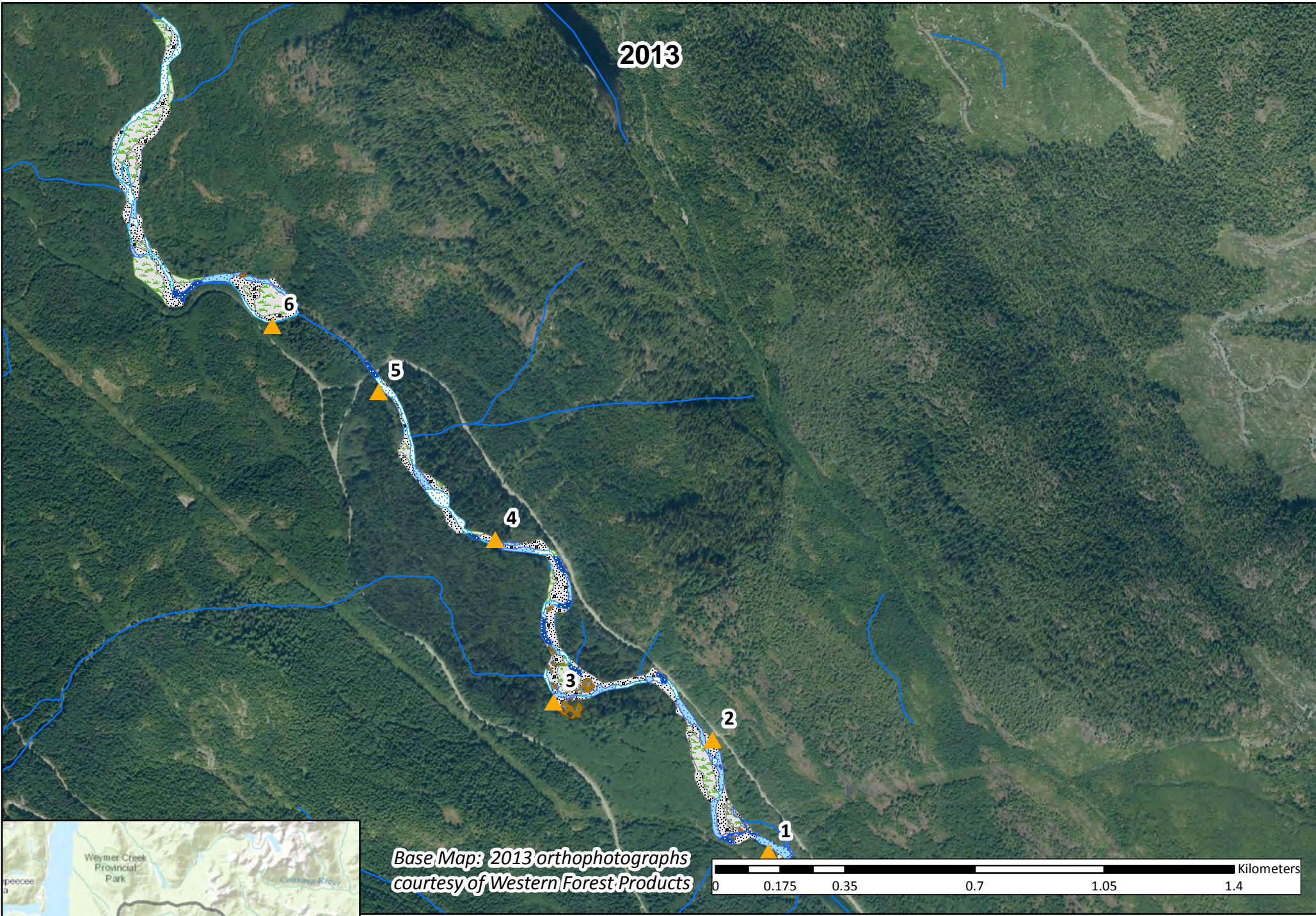
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**MAP 15**

**Sucwoa River Watershed  
Riparian Disturbance**





Base Map: 2013 orthophotographs  
courtesy of Western Forest Products

Legend

- |                           |                  |
|---------------------------|------------------|
| <b>Habitat Type</b>       | Counting Station |
| Braided                   | TRIM River       |
| Debris Jam                |                  |
| Glide                     |                  |
| Gravel Bar                |                  |
| Pool                      |                  |
| Riffle                    |                  |
| Secondary or Side Channel |                  |
| Vegetated Gravel Bar      |                  |

Prepared For: Nootka Sound Watershed Society

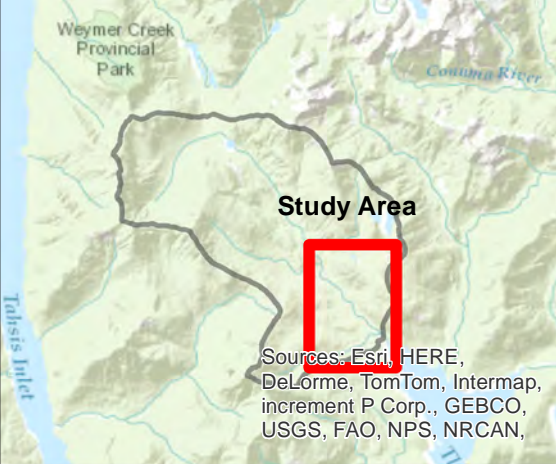
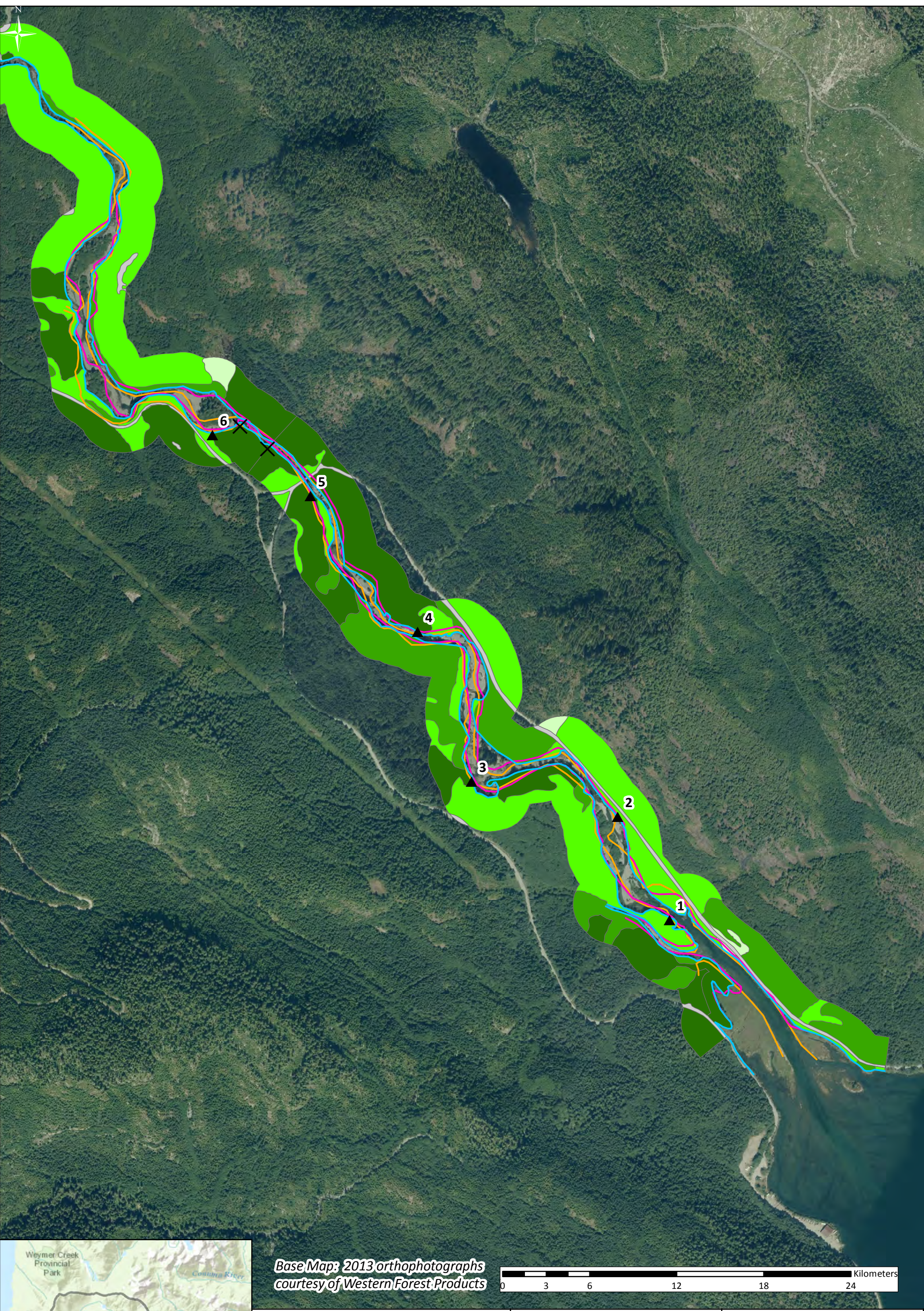
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June 9, 2015



MAP 16

Sucwoa River Watershed  
Habitat Composition  
1995 vs. 2013





Base Map: 2013 orthophotographs  
courtesy of Western Forest Products



<b>Legend</b>		<b>Prepared For:</b> Nootka Sound Watershed Society	<b>MAP 17</b>
Bankful Width (2013)	Riparian Classification: Deciduous or Regenerating	<b>Prepared By:</b> M.C. Wright and Associates Ltd. June 9, 2015	
Bankful Width (1995)	Early Regenerating	  	<b>Sucwoa River Watershed Channel Bank Stability 1980 to 2013</b>
Bankful Width (1980)	Mature Conifer		
Counting Station	Mature Mixed		
	Non-Productive		
	Bedrock		