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

Prepared For:

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LIST OF ACRONYMS / ABBREVIATIONS USED

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

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1.0 INTRODUCTION

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

Implementation of the WSP has been initiated throughout several regions along the west coast of Vancouver Island. The selection of high priority watersheds (Tahsis River, Leiner and Perry Rivers, Conuma River, Canton Creek, and Tsowwin 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 Sucwoa River watershed.

1.1 Objectives

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

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

In addition to the abovementioned objectives, this work is also intended to feed into a future WSP expert-based risk assessment workshop whereby identified limiting factors will be ranked in order of spatial and temporal risk to fish and fish habitat on a watershed basis. This habitat status assessment of the Sucwoa River watershed follows the Tahsis River watershed example (deVisser and Wright, 2015), and has been completed concurrently with five other high priority Nootka Sound watersheds including the Tahsis River, Leiner and Perry Rivers, Canton Creek, Tsowwin River and Conuma River.

1.2 Sucwoa River Watershed

The Sucwoa River watershed is located approximately 100km west of Campbell River and 12km southeast of the Village of Tahsis on the west coast of Vancouver Island (Figure 1). The Sucwoa River drains from Tahsis Mountain, and initially flows northeast into Malaspina Lake at the foot of Malaspina Peak, from which it flows southeast into Head Bay of Tlupana Inlet. The Sucwoa River watershed encompasses a drainage area of approximately 44km^2, and provides approximately 24.5km of fish bearing stream.

1.2.1 Climate, Topography, and Hydrology

The Sucwoa River 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 coastal mountain-heather alpine (undifferentiated and parkland) zones. This area has a mild oceanic climate with high humidity, with the majority of its annual precipitation received as rain. Annual rainfall is approximately 3800mm. Between the months of October and April, high water events are observed frequently (Fisheries and Oceans Canada, 2015).

The Sucwoa River watershed is characterized by a northwest-southeast trending, U-shaped valley, and broad floodplain in the lower watershed; the upper watershed is a mix of confined and unconfined alluvial (Horel, 2008). The east side of the valley has steep slopes and several large upland lakes and ponds (Horel, 2008). The west side of the valley has irregular moderate to steep slopes with several tributary basins (Horel, 2008). The highest peak in the watershed measures 1,100m in elevation, and half of the watershed is situated within the 300-800m elevation range (Hetherington, 1997). Approximately 20% of the watershed is considered to be potentially unstable terrain (Hetherington, 1997).

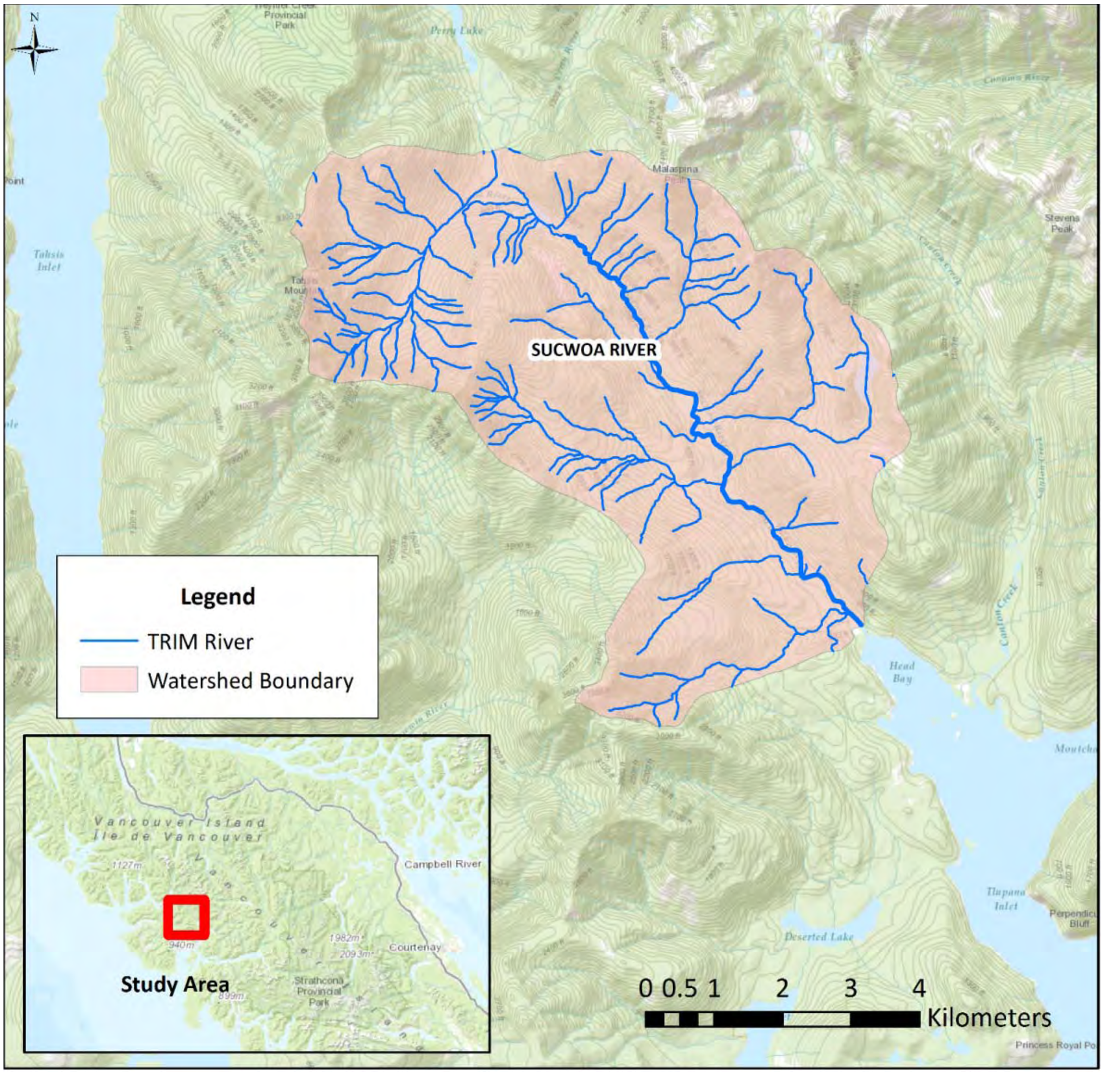

Figure 1. General location of the Sucwoa River watershed.

1.2.2 Watershed Description

The lower 3.4km of the river meanders through a <1% gradient, 100-300m wide alluvial floodplain with riffle-pool morphology. Channel characteristics include a channel width averaging between 20-30m channel width, coarse gravel to small cobble substrate, and gravel bars that are sparsely colonized by alder (Hetherington, 1997). The floodplain channel has widened due to bank disturbance, riparian removal and possible increases in peak flows; minor bank erosion consistent with that of natural processes is also occurring (Hetherington, 1997).

A series of cascades (Reach Break 1) limits all salmon species distribution except coho to a short distance upstream of the Head Bay FSR bridge (immediately upstream of counting station 5) (Figure 2). Chinook, coho and sockeye have been reported sucessfully navigating these cascades and utilize habitats further upstream (Glova and McCart, 1979); however, more recent accounts suggest that only coho are likely to migrate upstream of the cascades (Horel, 2008). Tributary habitat is generally characterized by abrupt changes in gradient or impassable falls present within the first km of channel length, limiting fish distribution to the bottom reach of these tributaries, although four tributaries each provide more than 2km of fish accessible stream length.

The reach from the floodplain upstream to Malaspina Lake is a more confined channel, retaining pool-riffle morphology, with a continued <1% gradient, alluvial banks (<2m high), 15m width and a higher proportion of cobble and small boulder substrate (Hetherington, 1997). Another anadromous barrier exists 6.27km upstream from the river mouth (Reach Break 2) (Figure 2), which is the upper limit of coho distribution (Glova and McCart, 1978). Bedrock becomes exposed with increased boulders near the lake (Hetherington, 1997). In general this upper reach is stable, well-armoured and low to moderately sensitive to disturbance with small amounts of scattered LWD and some debris jams (Hetherington, 1997).

An analysis of watershed indicators in 2008 identified the Sucwoa River watershed to be moderately disturbed or improving but still of concern as a result of unstable channels from riparian logging, based on the regional landslide frequency, total area of the watershed situated in steep terrain (i.e. >60%), occurrence of natural landslides, hillslope connectivity to the mainstem and channel sensitivity (Horel, 2008). This watershed was identified as high risk, with high terrain stability risk, high stream sensitivity rating, moderate stability disturbance rating, and high stream disturbance rating (Horel, 2008). The main deficiency was the length of stream channel with inadequate riparian forests for LWD contribution and bank erosion control, which has resulted in an unstable alluvial channel (caused by pre-code riparian logging). It was estimated that the condition of the watershed would improve in 20 years, however it was noted that there may be potential to accelerate recovery with riparian treatments to encourage conifer growth (Horel, 2008).

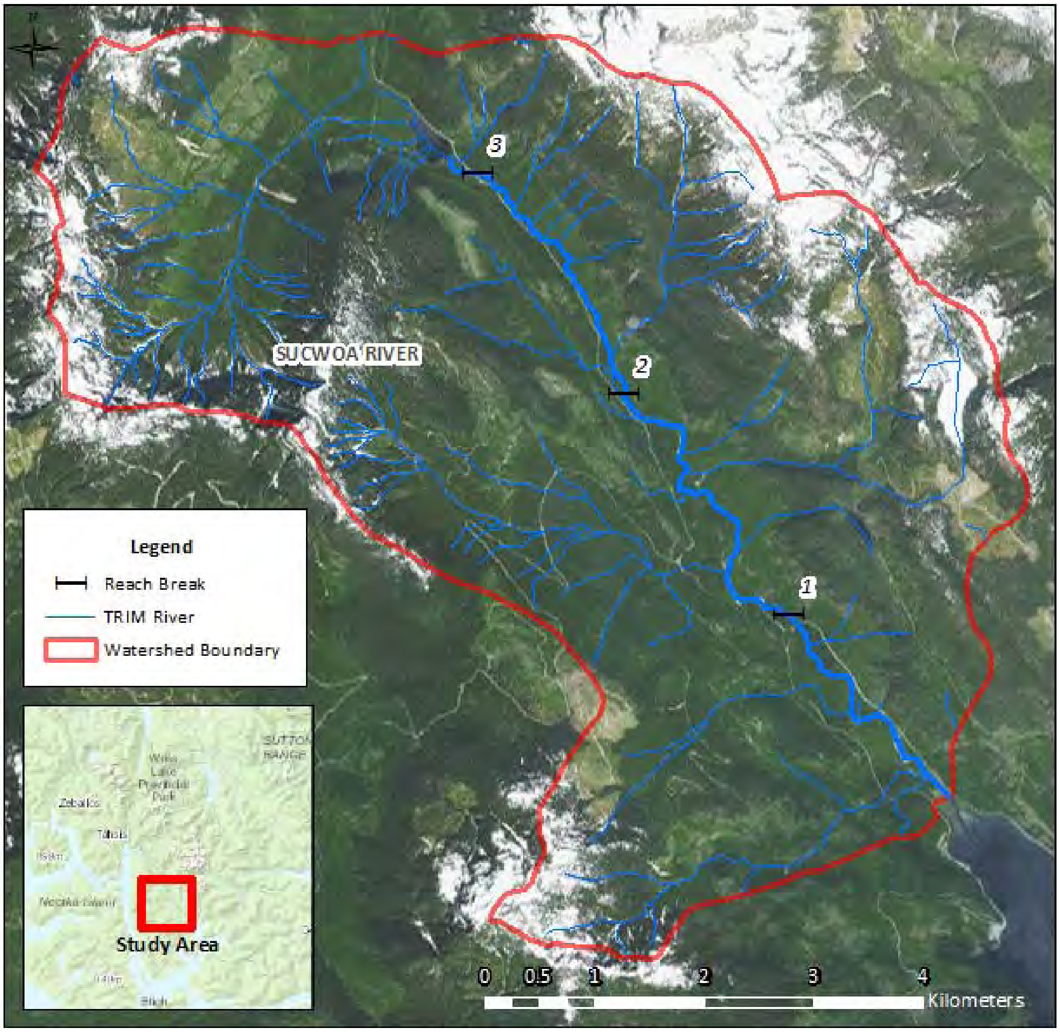

Figure 2. Sucwoa River reach breaks (Witt et. al. ,1980).

The following table describes the average bankful widths (as determined from 2013 orthophotography) for reaches 1 -3 of the Sucwoa River.

Table 1. Reach lengths and average bankful widths for the Sucwoa River.

Reach Number	Reach Length (km)	Average Bankful Width (m)
1	2.84	43.2
2	3.26	30.7
3	2.73	ND

1.2.3 Watershed History

The Sucwoa River resides within the traditional territory of the Mowachaht / Muchalaht First Nation, who have remained 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 hand loggers settling in Tahsis Inlet as early as 1882 (Sellars, 1992).

Forest Harvesting

Logging commenced in the lower Sucwoa watershed in 1958, with much of the floodplain and riparian forest harvested by the 1970s (McGeough, 2010 and Hetherington, 1997). Harvesting in the 1970s continued up the west slope into Stoltze Creek, and in the 1980s and 1990s moved up the east side of the valley (Hetherington, 1997). Extensive siltation in 1972 resulted from logging road development along the entire stream length and bank slippage and re-channeling was observed in 1974 (Brown et. al. 1979).

While very little riparian vegetation was preserved during logging operations with most areas harvested right to the stream bank, many of these areas were re-planted following operations. By 1997, more than 43% of the total watershed area had been logged, and of the total harvested area in the watershed in 2008, approximately 95% was logged prior to implementation of the Forest Practices Code (Horel, 2008).

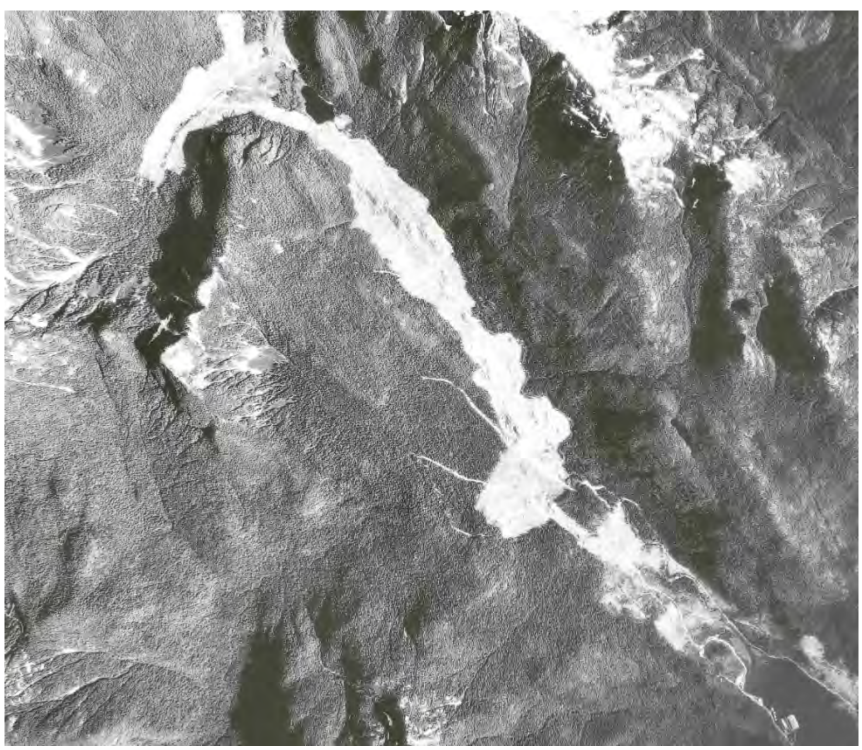

Photo 1. Logging activity in the Sucwoa River watershed in 1954. Note the extensive forest removal along the valley bottom.


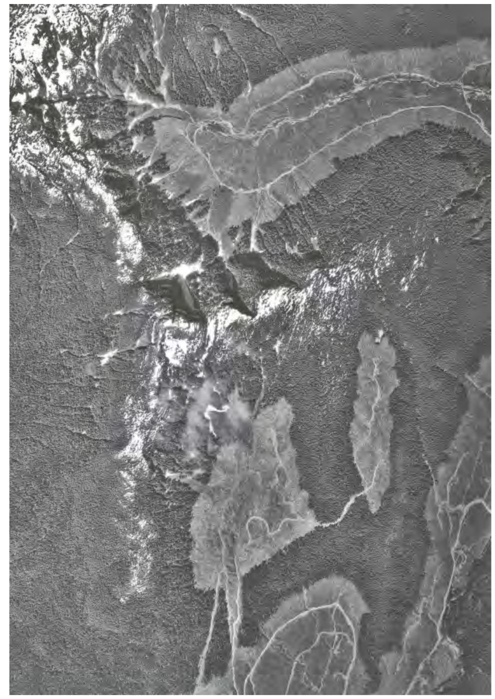

Photo 2. Continued logging activity in the Sucwoa River watershed in 1977. Lower watershed shown left and upper watershed right. Clearcuts extended further up the west valley slope and up to the sub-alpine headwaters.

Photo 3. Sucwoa River estuary in 1977. Note the booming ground and industrial land use along the west shore.

Mineral Extraction

Two historical magenetite occurrences, the Glengarry and Rob Roy showings, were identified within the southwestern boundary of the Sucwoa River watershed. These showings were originally staked in 1902 and in 1959 exporatory drilling occurred. Mining of the Glengarry showing commenced in 1959 by Hualpai Enterprises Ltd., with 125,000 tons of ore and waste extracted, and a total of 25,000 tons of magnetite concentrate produced and shipped from Head Bay by boat (Figure 3). Production ceased in 1960 when Hualpai Enterprises Ltd. went into receivership (Shearer, 2013).

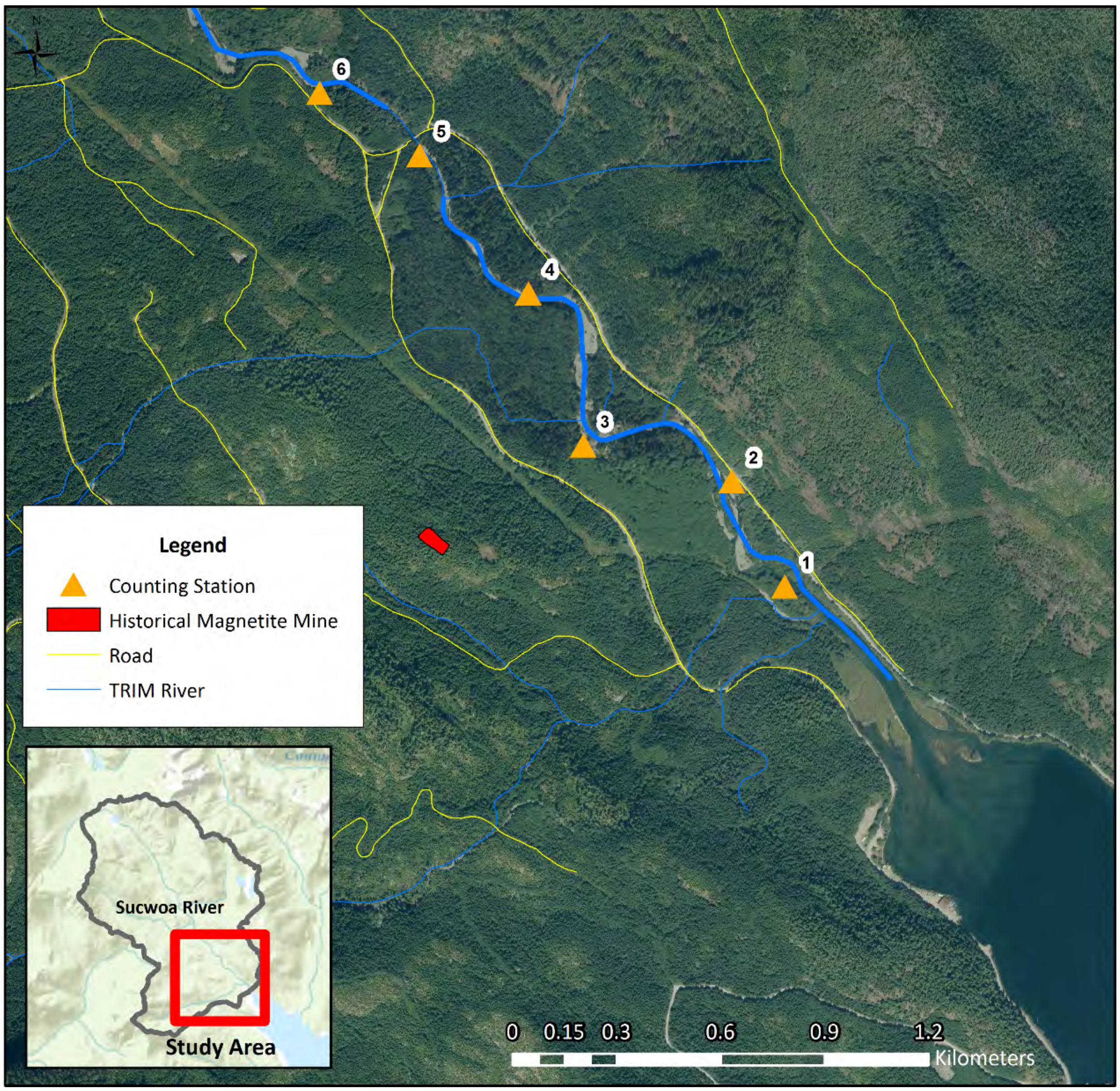

Figure 3. Historical magnetite mine in the Sucwoa River watershed.

In 2007, limited geological mapping and soil sampling of the magnetite showings occurred, with results warranting further evaluation as there is limited magnetite production in British Columbia. An airphoto interpretation assessment and historical review of this showing in 2013 recommended initiation of an early stage exploration (Shearer, 2013).

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 2. 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 Sucwoa River watershed occurred following a comprehensive literature review and spatial data gathering and analyses. In addition to the indicators describe in Table 2, 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 1:20,000 scale watershed boundaries.

2.3 Interviews

In addition to the information compiled during the literature review and spatial data gathering, interviews with the Nootka Sound Watershed Society and other experts in the area were conducted to incorporate local knowledge of the Sucwoa River. 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 Sucwoa River watershed were calculated by analyzing WFP's forest age layer for each watershed. This layer categorized all forested areas within a watershed using the following classification scheme: younger than 40 years, 41 to 120 years, and older than 120 years. Forested areas classified as older than 120 years were considered un-altered. Non-forested areas were described as non-productive. For polygons classified as non-productive by WFP, data was overlaid on high resolution 2012 – 2013 orthophotographs to differentiate the type of non-productive land present. These lands were further classified as follows: non-productive (alpine), non-productive (avalanche chute), non-productive (barren surface), non-productive (fresh water), and non-productive (urban). Classification into these non-productive categories was used to determine the area of natural (i.e. unaltered) non-productive land cover versus the area of altered non-productive land cover.

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

2.4.2 Watershed Road Development

Indicator Type: Pressure

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

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

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

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

2.4.3 Water Extraction

Indicator Type: Pressure

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

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

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

2.4.4 Riparian Disturbance

Indicator Type: Pressure

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

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

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

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

Once classified, the riparian composition was summarized for the fish-bearing component of the mainstem to determine the relative riparian disturbance pressure for anadromous 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 Sucwoa River watershed. Results were mapped in ArcGIS using the coordinates provided in the database, and all authorization information was retained as fields in the attributes table.

2.4.6 Water Quality

Indicator Type: State

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

Sucwoa River, water quality data was obtained from the Ministry of Energy and Mines regional geochemical stream survey data. This data was limited to the sampling of uranium, fluoride and pH across six sampling sites and one sampling year (2007).

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 Sucwoa River watershed during the juvenile rearing and migration period and has been identified as a data gap.

2.4.8 Water Temperature: Migration and Spawning

Indicator Type: State

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

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

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

2.4.9 Stream Discharge

Indicator Type: State

The carrying capacity of streams and their seasonal suitability for use by different salmonid species and life-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 the Sucwoa River 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 Nootka Sound Watershed Society and the Tahsis Enhancement Society (2014). Compiled data was digitized as a line feature in ArcGIS to determine the linear length of fish distribution.

2.4.11 Key Spawning Areas (Length)

Indicator Type: State

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

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

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

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

2.5.3 Channel Stability

Indicator Type: State

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

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

2.5.4 Large Woody Debris

Indicator Type: State

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

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

Visible LWD was classified using the following categories:

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

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

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

2.5.5 Off-Channel Habitats

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

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

2.6 Selected Estuary Habitat Indicators

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

2.6.1 Estuary Habitat Disturbance

Indicator Type: Pressure

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

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

2.6.2 Permitted Waste Management Discharges

Indicator Type: Pressure

Permitted waste management discharges within the estuarine habitat have the potential to impact salmonid through the reduction of water quality (i.e. dissolved oxygen) and an increase in suspended solids (Aitkin, 1998). This indicator was evaluated based on the presence / absence of permitted waste management discharges within the Sucwoa River 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 Sucwoa River estuary was available, and has therefore been identified as a data gap.

2.6.4 Estuary Dissolved Oxygen

Indicator Type: State

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

2.6.5 Estuarine Habitat Area

Indicator Type: State

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

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

3.0 WILD PACIFIC SALMON OF THE SUCWOA RIVER WATERSHED

Five species of anadromous salmon – chinook (*Oncorhynchus tshawytscha),* coho (*O. kisutch),* chum (*O. keta),* pink (O. *gorbuscha)* and sockeye (*O. nerka*) – are supported by the Sucwoa River watershed. Winter steelhead, resident cutthroat and rainbow trout have also been observed in the watershed (McGeough, 2010 and Hetherington, 1997). 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 typically arrive in in the Sucwoa River in late September and begin spawning in early October. Peak spawning typically occurs in early October with the end of the run in mid-October. Although recent observations only document chinook distribution in the mainstem up to the cascade between counting stations 5 and 6 (Figure 4), they have been known to migrate further upstream (Glova and McCart, 1978). Due to the lack of information on chinook distribution upstream of the cascade, this is considered a data gap warranting further investigation.

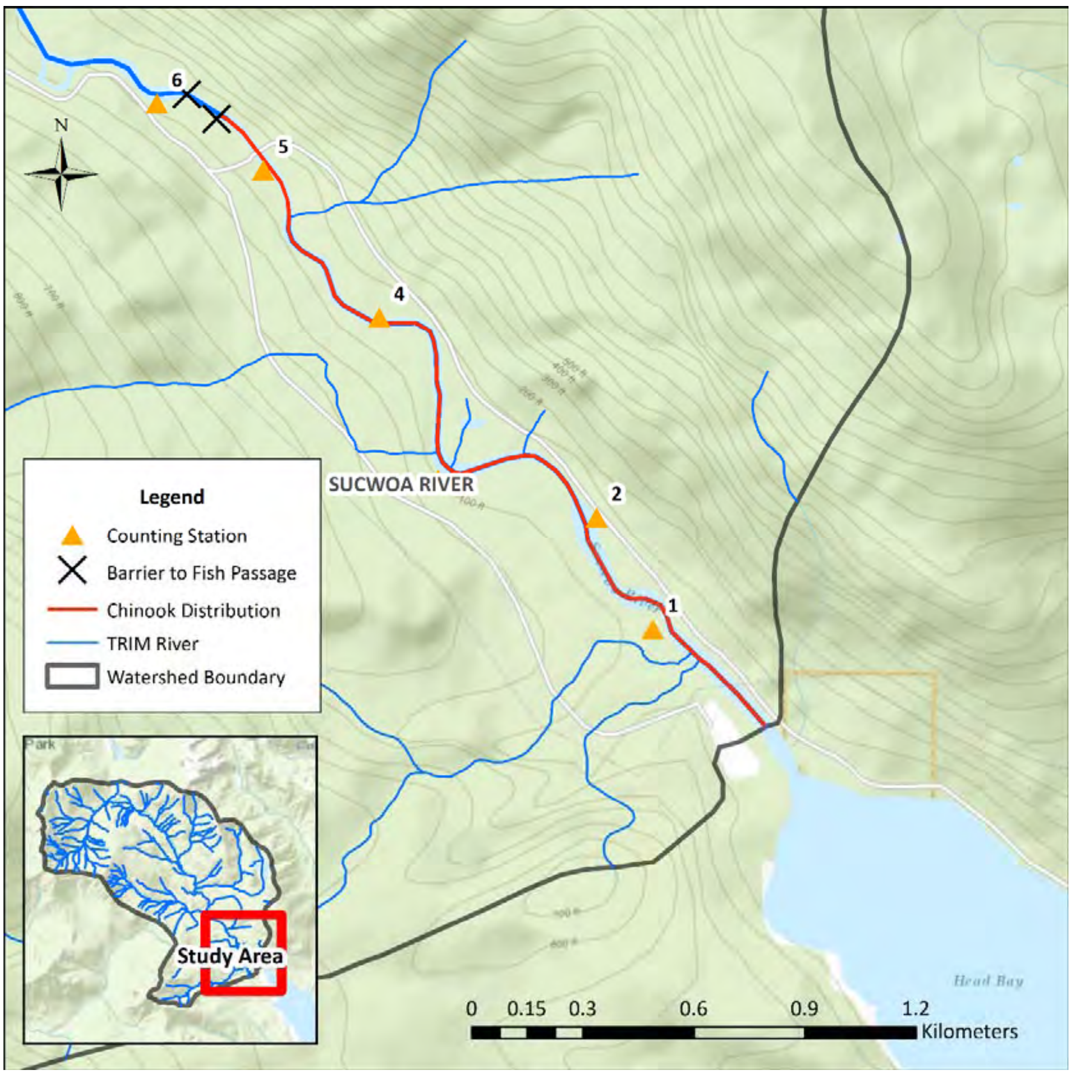

Figure 4. Known chinook distribution in the Sucwoa River watershed.

During upstream migration to the spawning grounds, adult chinook take advantage of several key holding pools, notably between counting sections 1 - 2 and 3 – 4. Excellent holding habitat known locally as "Larry's tree" is located between counting stations 1 and 2. The section at counting stations 5 is important for chinook spawning, with the pool under the bridge, and large boulders and white water at the base of the cascade providing excellent cover (Fisheries and Oceans Canada, 2015).

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 the Sucwoa River, known spawning grounds have been identified in key riffles and pool tail-outs between counting sections 3-4 and 4-5 (Figure 5).

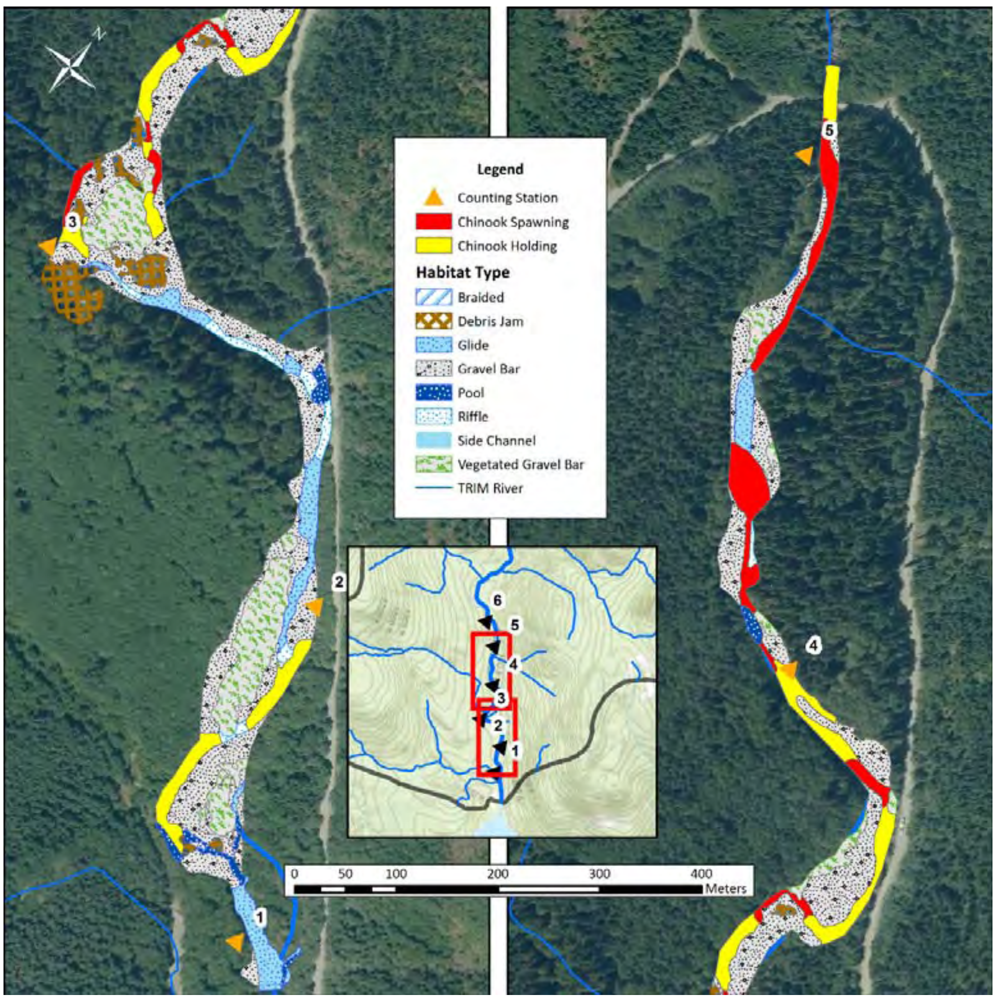

Figure 5. Known adult chinook holding and spawning habitat in the Sucwoa River.

Fry emergence is partially dependent on water temperature and can vary from year to year (i.e. the lower the water temperature, the longer the incubation period required). Following emergence, fry typically migrate downstream immediately. Migration usually occurs between April and June for ocean-type chinook (note that the specific migration timing for the Sucwoa River system is unknown). During downstream migration, fry typically target reduced flows at the river edges (Diewert, 2007). Given this requirement migration habitat for chinook fry has been inferred for the Sucwoa River based on characteristics observed from the orthophotographs (Figure 6).

Ocean-type chinook are most dependent upon estuaries to complete their life cycle (Aitkin, 1998). Estuaries are an environmental transition zone that provides opportunities for feeding and growth and refuge from predators. Upon reaching the estuary, juveniles rear in this zone for up to several months, where rapid growth (dependant on food resources available in the estuary) typically occurs (Diewert, 2007). There was no information found documenting the timing of peak outmigration to the estuary, or the residence time of juveniles in the estuarine and marine foreshore zones.

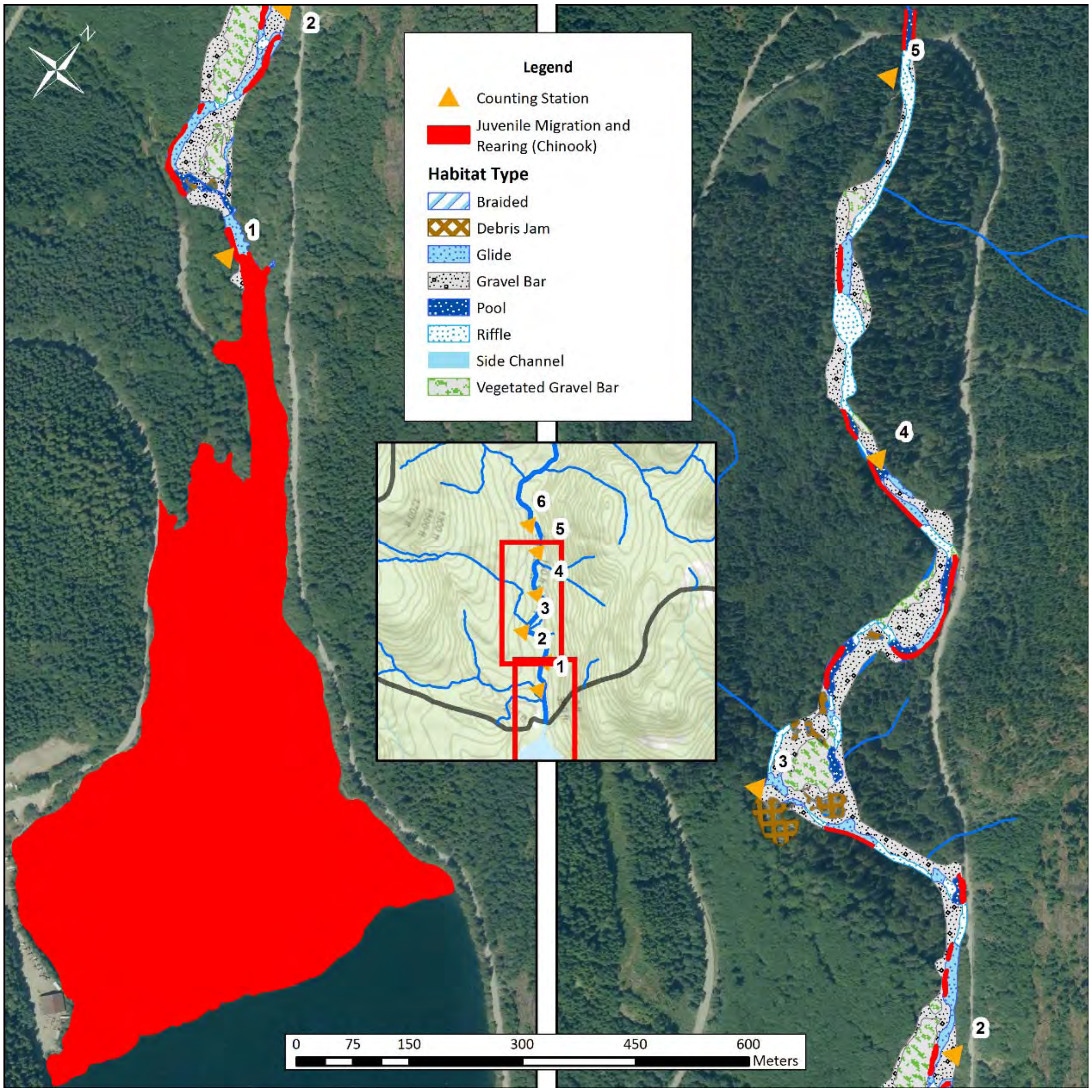

Figure 6. Known and inferred juvenile chinook migration and rearing habitat in the Sucwoa River.

3.1.2 Escapement

The Sucwoa River has historically been a consistent producer of chinook salmon with average annual escapements of approximately 400 fish between 1958-1978 . Historical escapements up to 1,500 fish were recorded in the mid-1960s, dropping back to counts between 20 and 300 until 1995 where numbers again increased to 1,100 adults. Recent escapement estimates range between 26 to 295 fish (Figure 7).

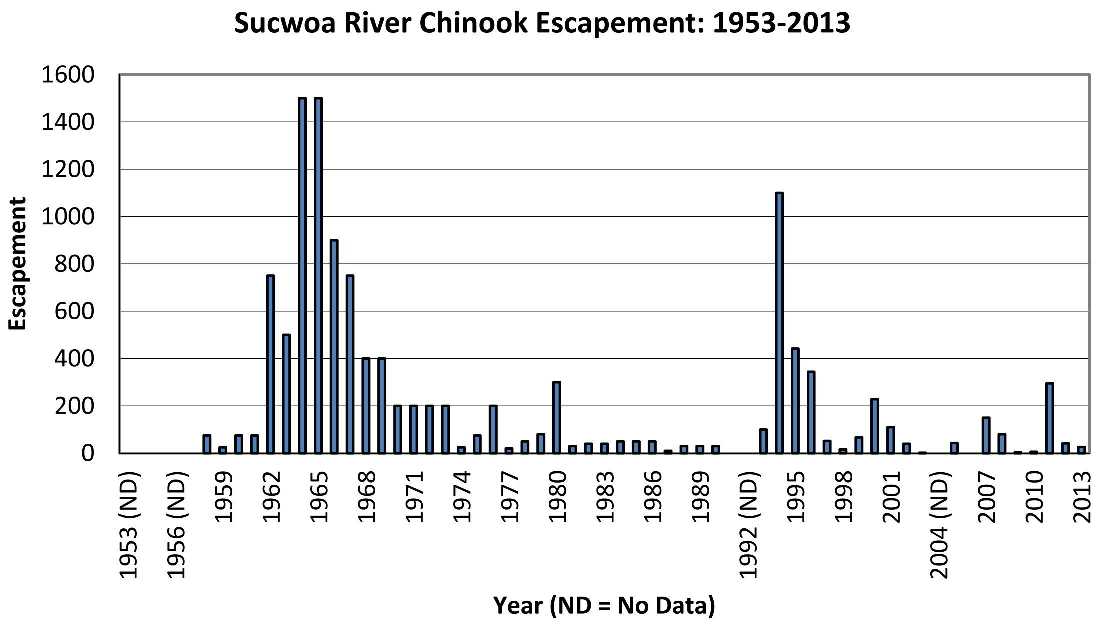

Figure 7. Chinook escapement in the Sucwoa River between 1953 and 2013 (compiled from DFO's NuSEDs database).

3.2 Coho Salmon

3.2.1 Biology, Distribution, and Known Habitats

Coho salmon typically arrive in the Sucwoa River in mid-September and begin spawning in late October. Peak spawning typically occurs in mid-November, with the end of the run observed in late November (Fisheries and Oceans Canada, 2015). Distribution has been observed in the mainstem up to an anadromous barrier falls located approximately 6.4km upstream from the river mouth. Additionally, coho distribution extends into a number of tributaries, the majority providing less than 1km of accessible stream length, but four tributaries provide over 2km of access, one of which is over 4km long with an accessible 180m^2 headwater lake (Figure 8).

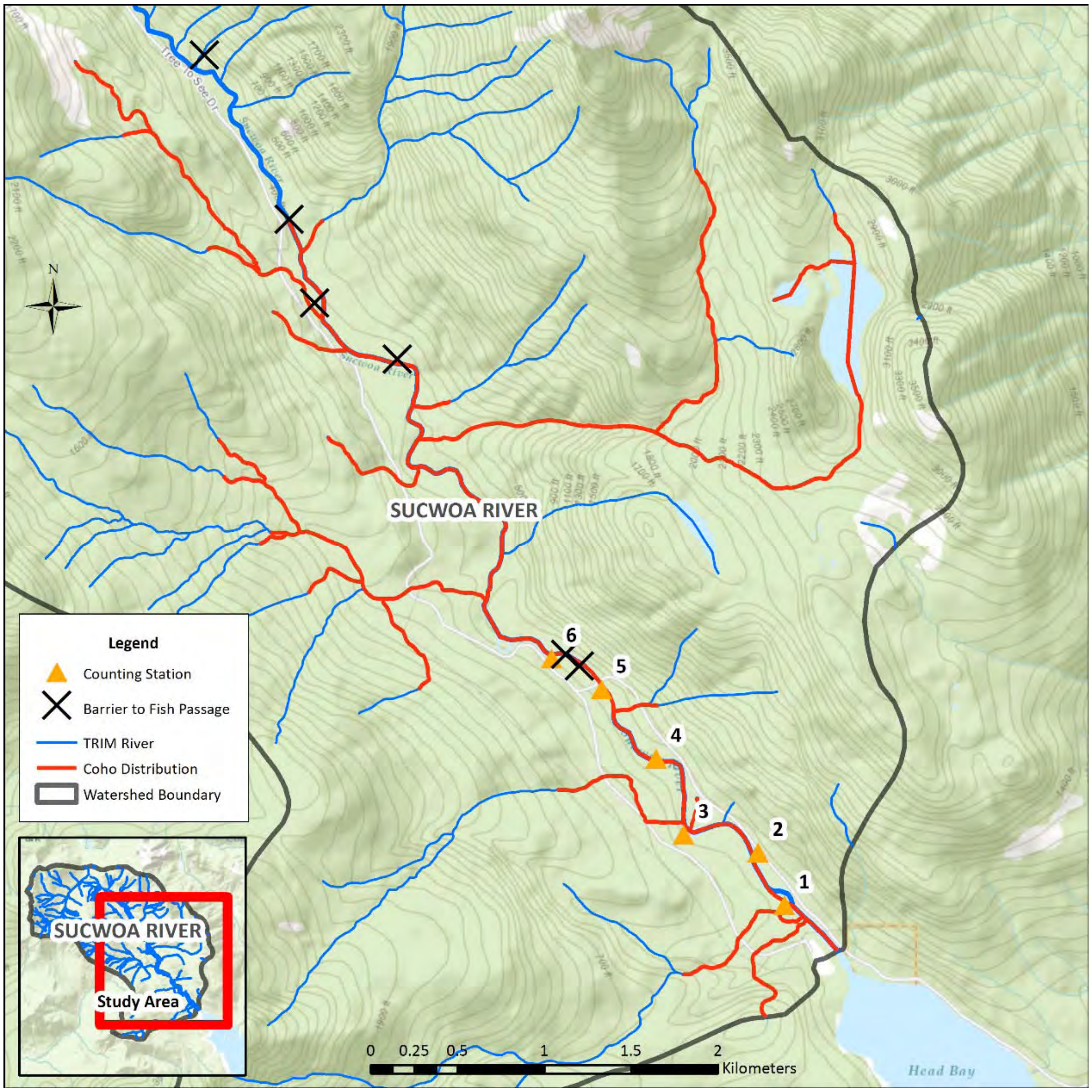

Figure 8. Known and inferred coho distribution in the Sucwoa River watershed.

Key holding pools used by coho have been identified in counting sections 1-2, 3-4 and at counting station 5 (Figure 9). Excellent holding habitat known locally as "Larry's tree" is located between counting stations 1 and 2. Coho utilize the pool at the bridge (counting station 5) for holding briefly before migrating to the upper river (Fisheries and Oceans Canada, 2015). Coho spawning habitat is very diverse, and can range from large river systems to small headwater streams and / or tributaries (Diewert, 2007). Key spawning areas are known in counting sections 3-4 and 4-5 (Figure 9); however, upstream of the cascade in counting section 5-6, the location of key coho spawning habitat was identified as a data gap requiring further investigation. It is likely that spawning occurs in the accessible tributaries, as well as the mainstem above counting station 6.

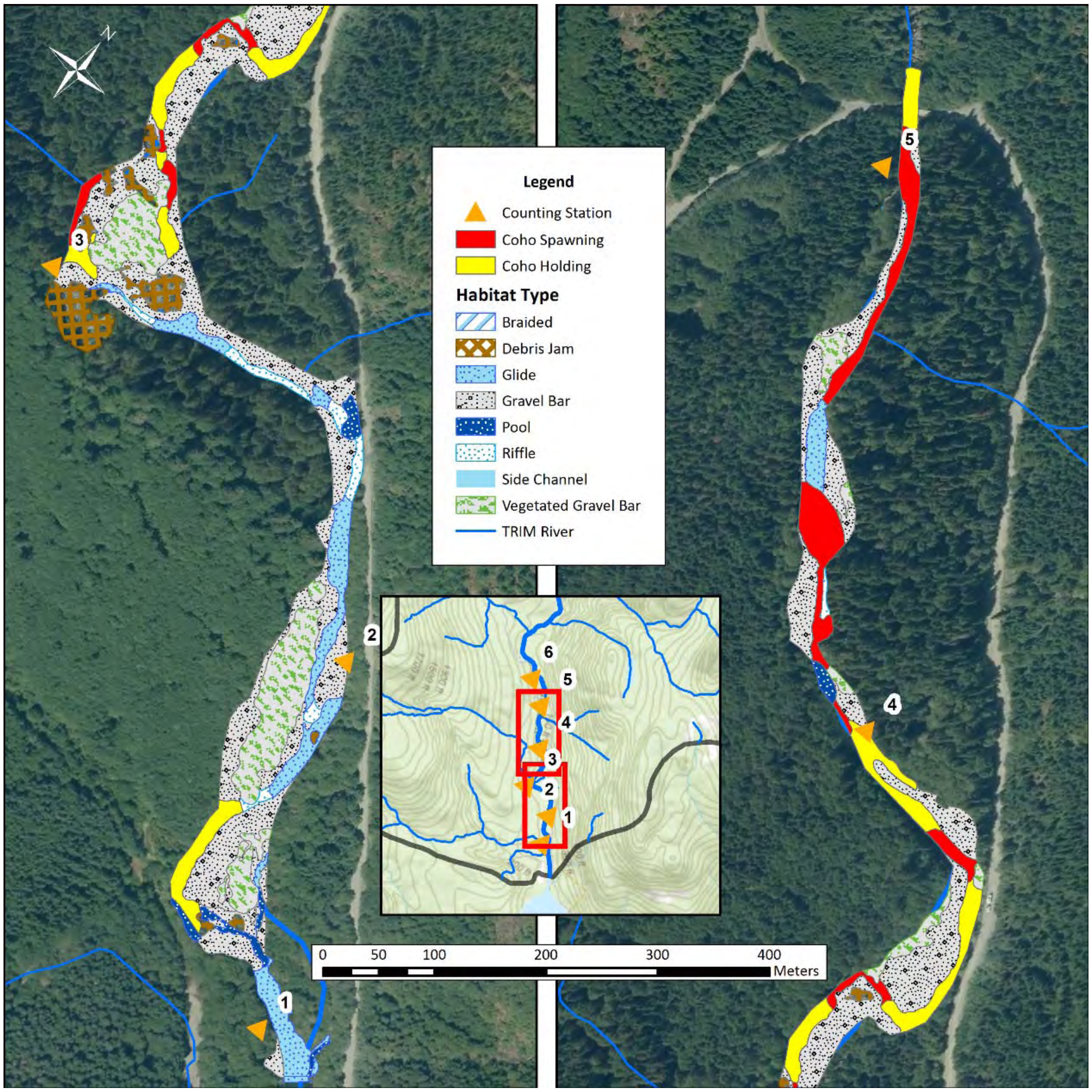

Figure 9. Known adult coho holding and spawning habitat in the Sucwoa River.

Fry emergence is partially dependent on water temperature and can vary from year to year (i.e. the lower the water temperature, the longer the incubation period required), although it typically occurs between March and late June (Diewerts 2007). Although no studies on fry development and outmigration in the Sucwoa River were available at the time of writing, it is likely that coho fry remain in fresh water for one to two years before migrating as smolts (Diewert, 2007).

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). In the Sucwoa River, important overwintering and rearing habitat is likely available in the tributaries and side channels (Figure 10 and Figure 11), although juvenile coho distribution is currently a data gap. Habitats depicted in Figures 9 and 10 have been inferred from both known life history requirements and the location of LWD accumulations in the Sucwoa River.

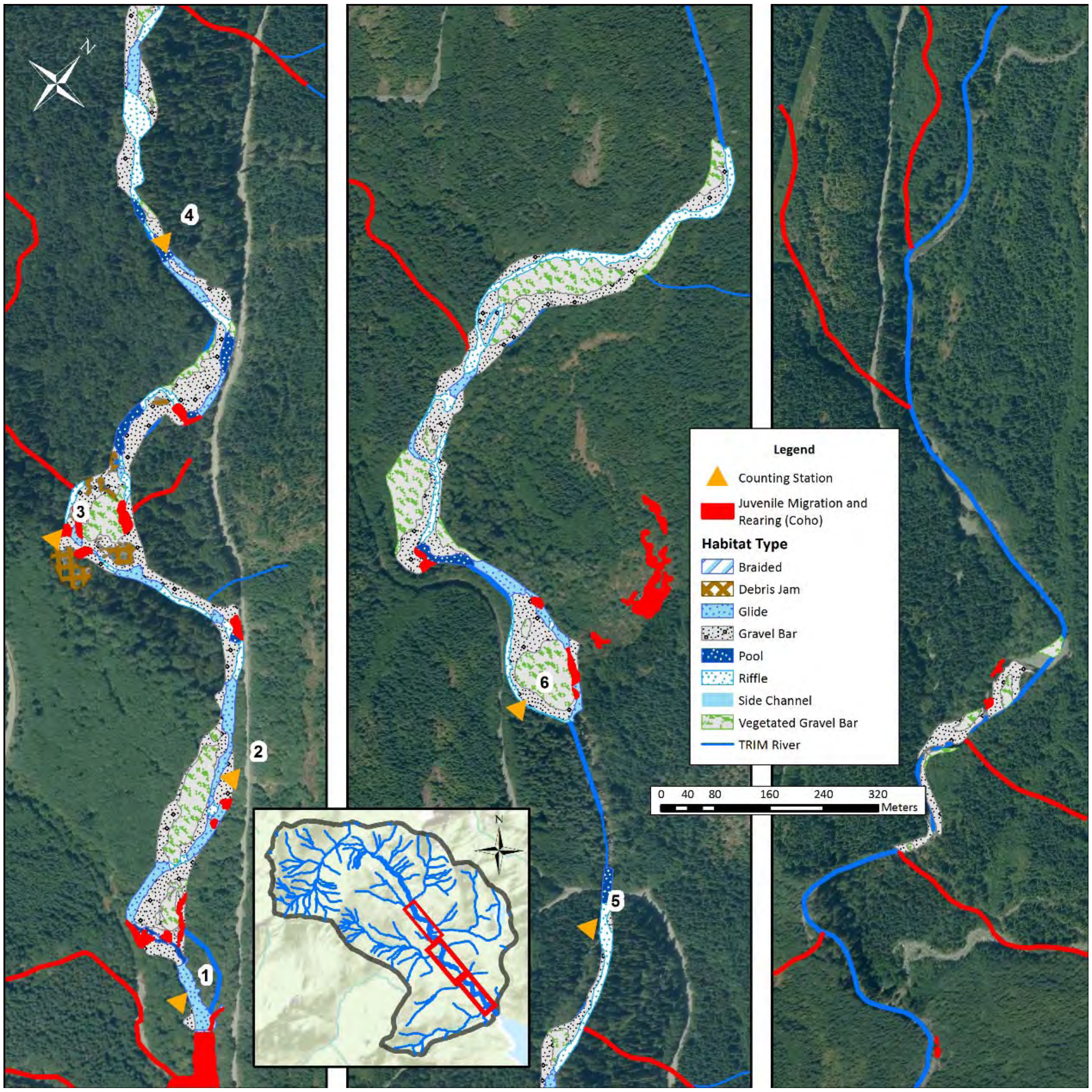

Figure 10. Known and inferred juvenile coho migration and rearing habitat in the Sucwoa River mainstem.

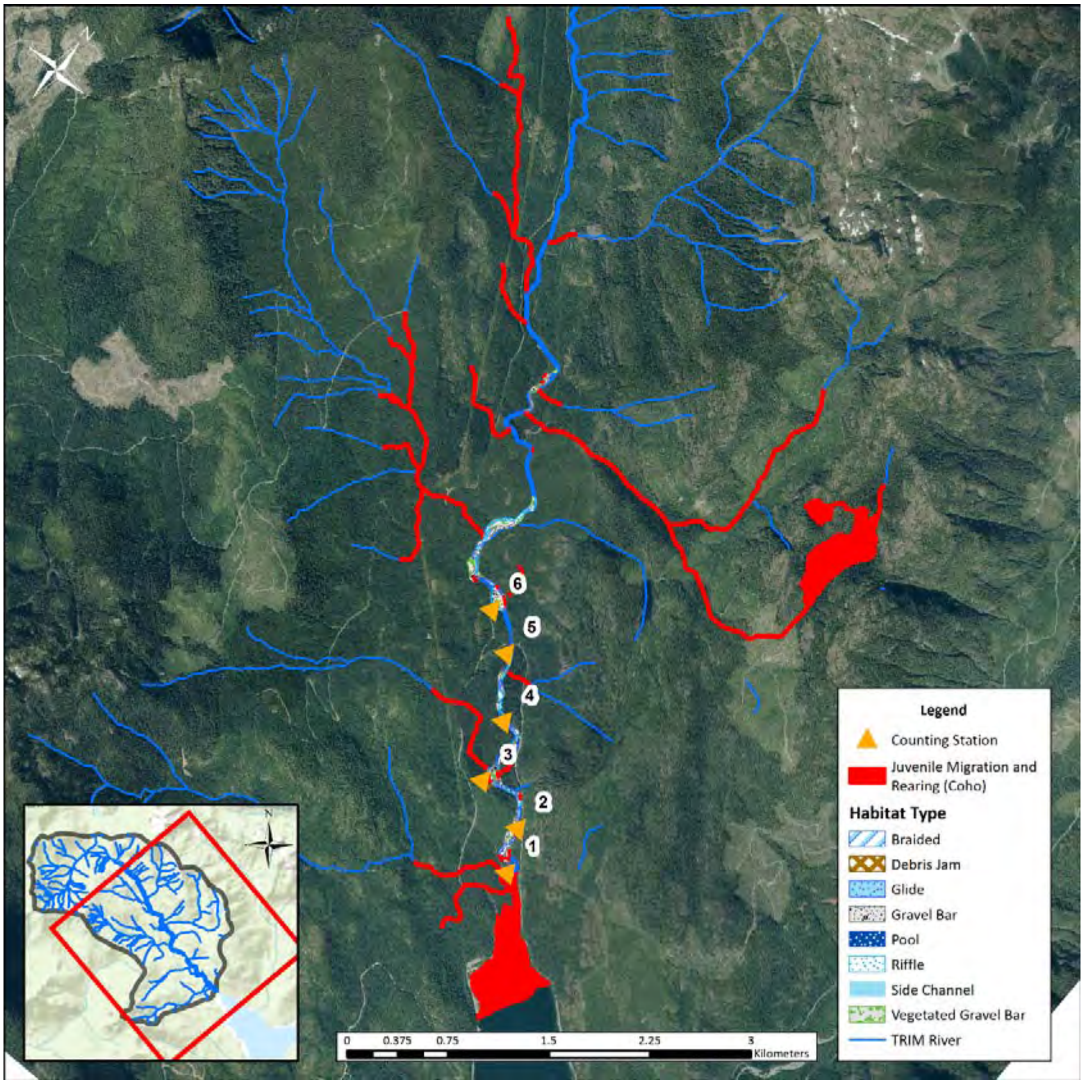

Figure 11. Known and inferred juvenile coho migration and rearing habitat in the Sucwoa River watershed.

3.2.2 Escapement

The Sucwoa River has historically been a consistent producer of coho salmon (Fisheries and Oceans Canada, 2015), with the exception of low escapement years from 1955 to 1961, 1981 to 1985, and 1990 to 1997 (Figure 12). During the early to mid-1990s, poor ocean survival resulted in a decrease in the abundance of coho on the WCVI, which was reflected in escapements to the Sucwoa River within this time frame. Historical records show maximum escapements to have reached 3,500 fish in 1962. An escapement estimate of 2,386 was recorded for 2000. Data was only available for four years over the past decade (2007 and 2009 to 2011), with the lowest estimate at 146 in 2007 and the highest run calculation of 461 fish in 2011 (Based on DFO's NuSEDS database). Based on the known distribution of coho beyond the survey area, escapement estimates presented in Figure 12 should be considered as underestimates.

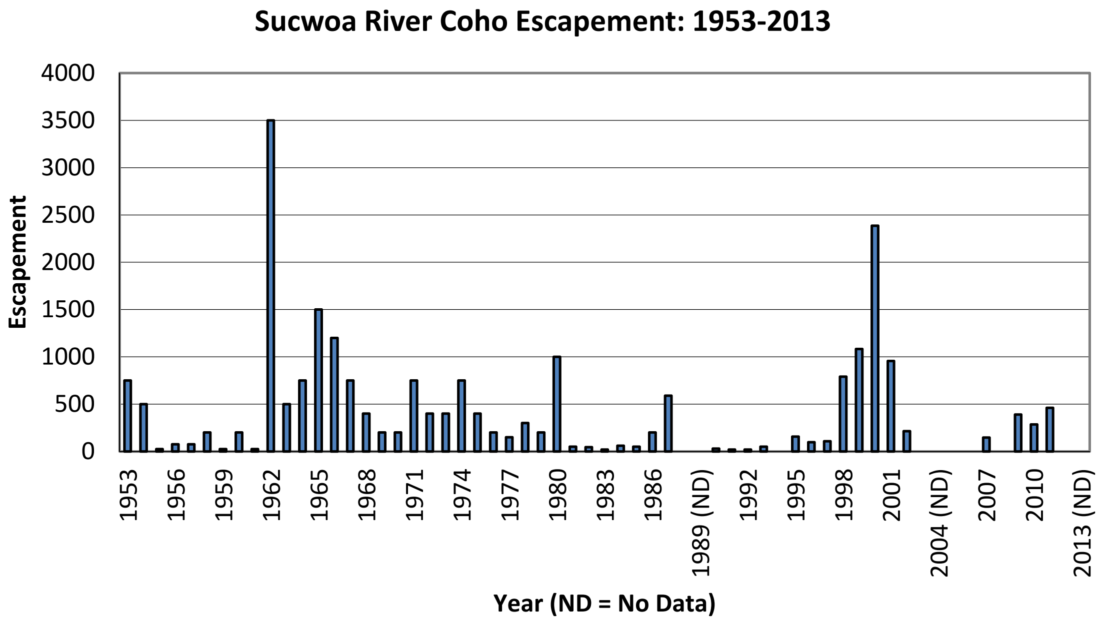

Figure 12. Coho escapement in the Sucwoa River between 1953 and 2013 (compiled from DFO's NuSEDs database).

3.3 Sockeye Salmon

3.3.1 Biology, Distribution, and Known Habitats

Sockeye arrive in the Sucwoa River in mid-August and begin spawning in late October. Peak spawning is observed in early November, and spawning is typically over by mid-November (Fisheries and Oceans Canada, 2015). Distribution is known up to the barrier between counting stations 5 and 6 (Figure 13). Excellent holding habitat known locally as "Larry's tree" is located between counting stations 1 and 2. The pool at the bridge (counting station 5) is important for sockeye, which arrive there early and hold in the pool all fall before spawning downstream. (Fisheries and Oceans Canada, 2015)

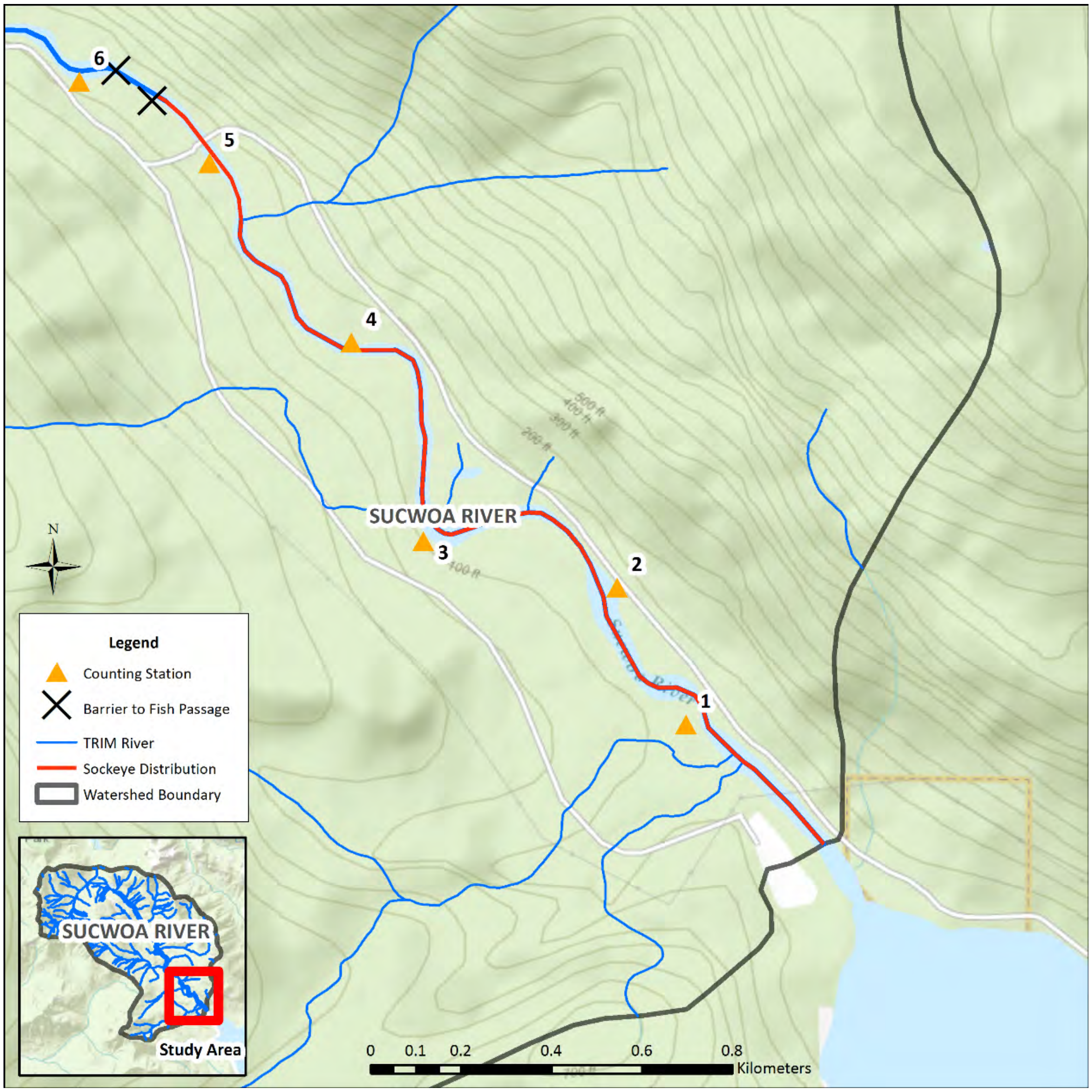

Figure 13. Known sockeye distribution in the Sucwoa River watershed.

During upstream migration of both the early and later returning fish, key holding pools are utilized between counting stations 1 and 2, between counting stations 3 and 4, and at counting station 5. Spawning areas were identified as key riffles between counting stations 1 and 2 and stations 3 and 4 (Figure 14) (Fisheries and Oceans Canada, 2015).

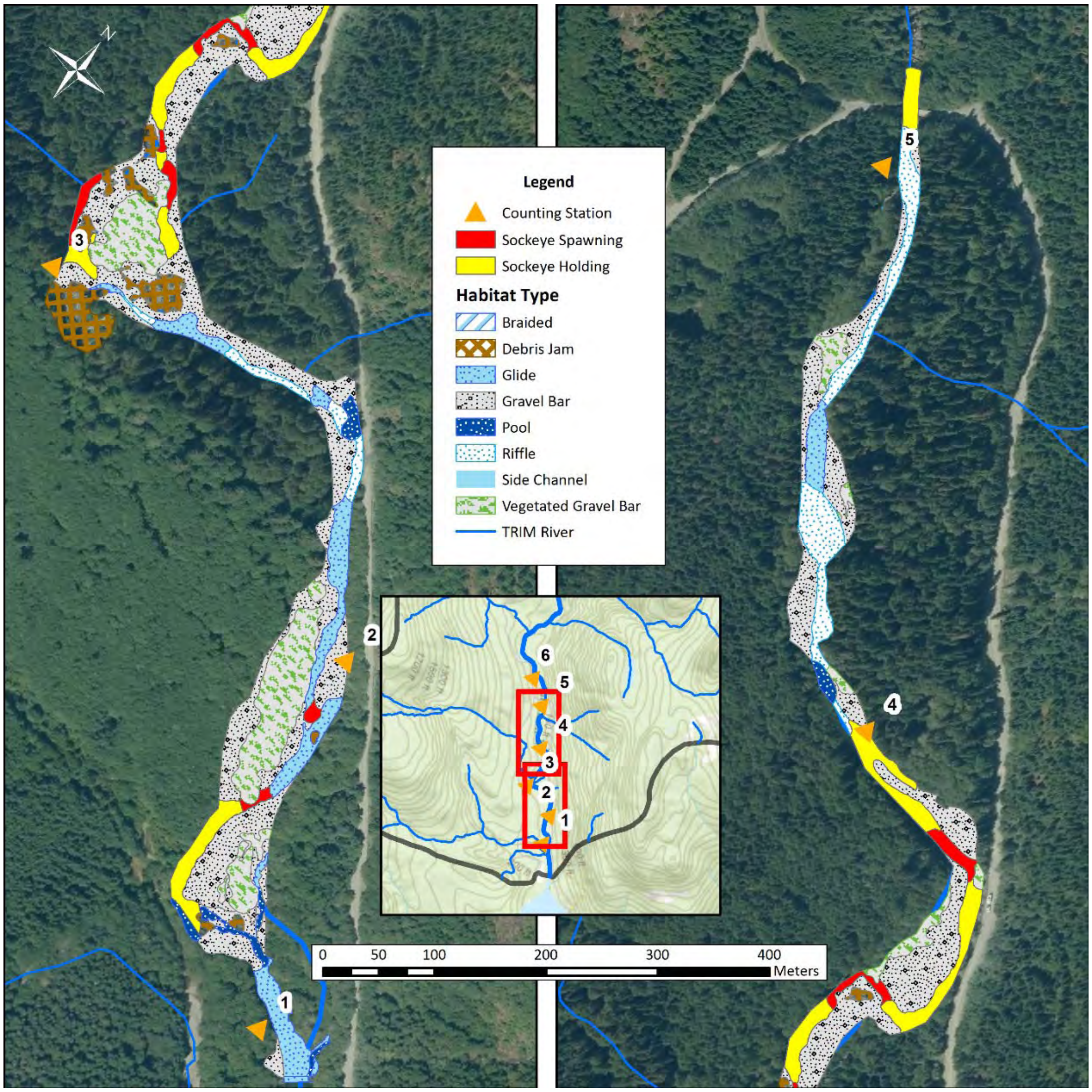

Figure 14. Known adult sockeye holding and spawning habitat in the Sucwoa River.

Sockeye in the Sucwoa River have a sea-type life history type, meaning that following emergence, they spend only a few months rearing in the river before migrating to the estuary (Aitkin, 1998). Little data exists on freshwater rearing habitats for the Sucwoa River; however, literature suggests these fish reside in lower river reaches prior to migration into the estuary. Juveniles typically rear in the estuary for several months (Diewert, 2007). Specific distributions of both the freshwater and estuarine rearing and migration stages of this population have been identified as a data gap.

3.3.2 Escapement

The Sucwoa River has a historically small population of sockeye, generally below 200 fish. Four exceptions included the return of 500 fish in 1993, 1357 fish in 1997, 663 fish in 1999, and 336 fish in 2011 (Figure 15). Escapement data prior to 1976 is very sparse, and as such the status of the sockeye population prior to widespread riparian logging in the watershed is unknown.

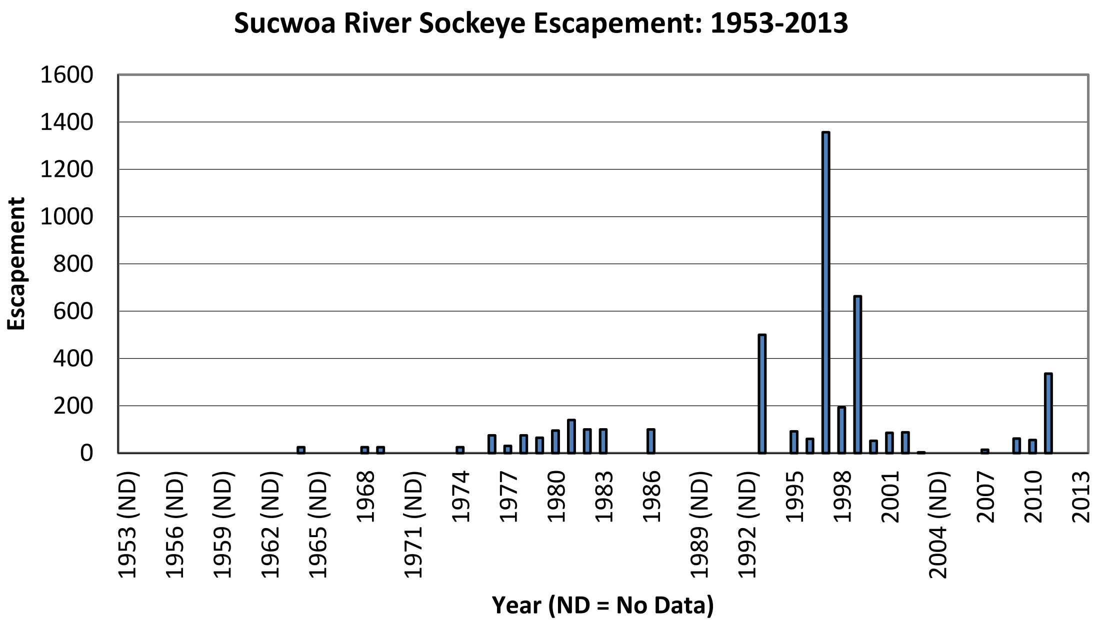

Figure 15. Sockeye escapement in the Sucwoa River between 1953 and 2013 (compiled from DFO's NuSEDs database).

3.4 Chum Salmon

3.4.1 Biology, Distribution, and Known Habitats

Spawning begins in the second half of September with peak spawning in mid-October and the run typically over by late October (Glova and McCart, 1979). This system is enhanced by the Conuma hatchery (Dobson et al, 2009). Despite enhancement efforts, chum numbers have not increased in recent years. Chum distribution in the Sucwoa River is limited to the habitat below the barrier between counting stations 5 and 6 (Figure 16). "Tributary A," the main tributary located at the mouth of the mainstem has been known to be heavily utilized by spawning chum with minor spawning at the mouth of "Tributary B" (Glova and McCart, 1979).

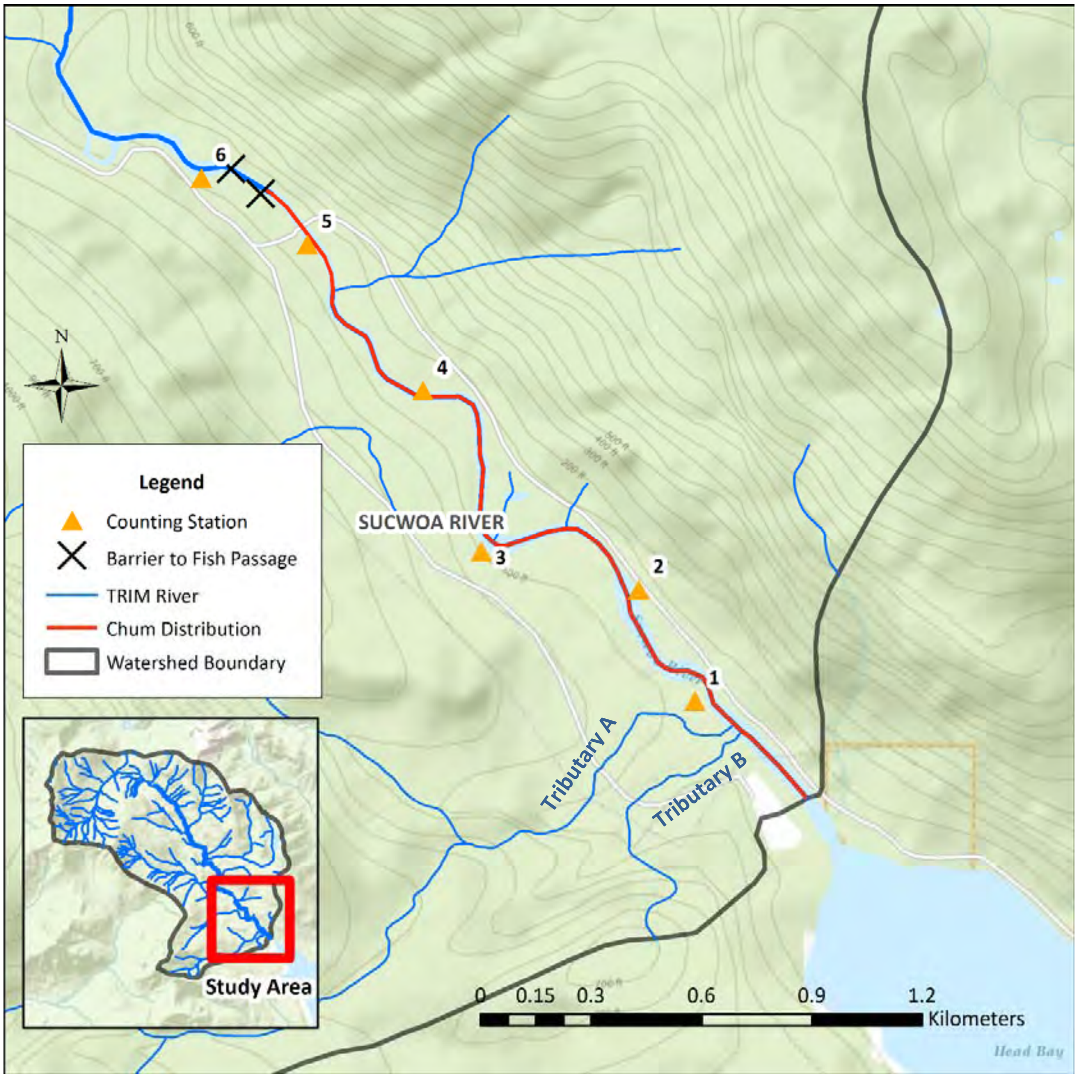

Figure 16. Known chum distribution in the Sucwoa River watershed.

During upstream migration to the spawning grounds, chum salmon utilize key holding pools between counting stations 0 – 1 and 1 – 2. From the river mouth up to 500m upstream is particularly important holding and spawning habitat for chum salmon, and there is excellent holding habitat for all species known locally as "Larry's tree", located between counting stations 1 and 2 (Fisheries and Oceans Canada, 2015) (Figure 17). Apart from the lower section (downstream from counting station 1), chum spawning occurs in key riffles and glides up to counting station 4, with most of the spawning activity occurring between counting stations 2 and 4.

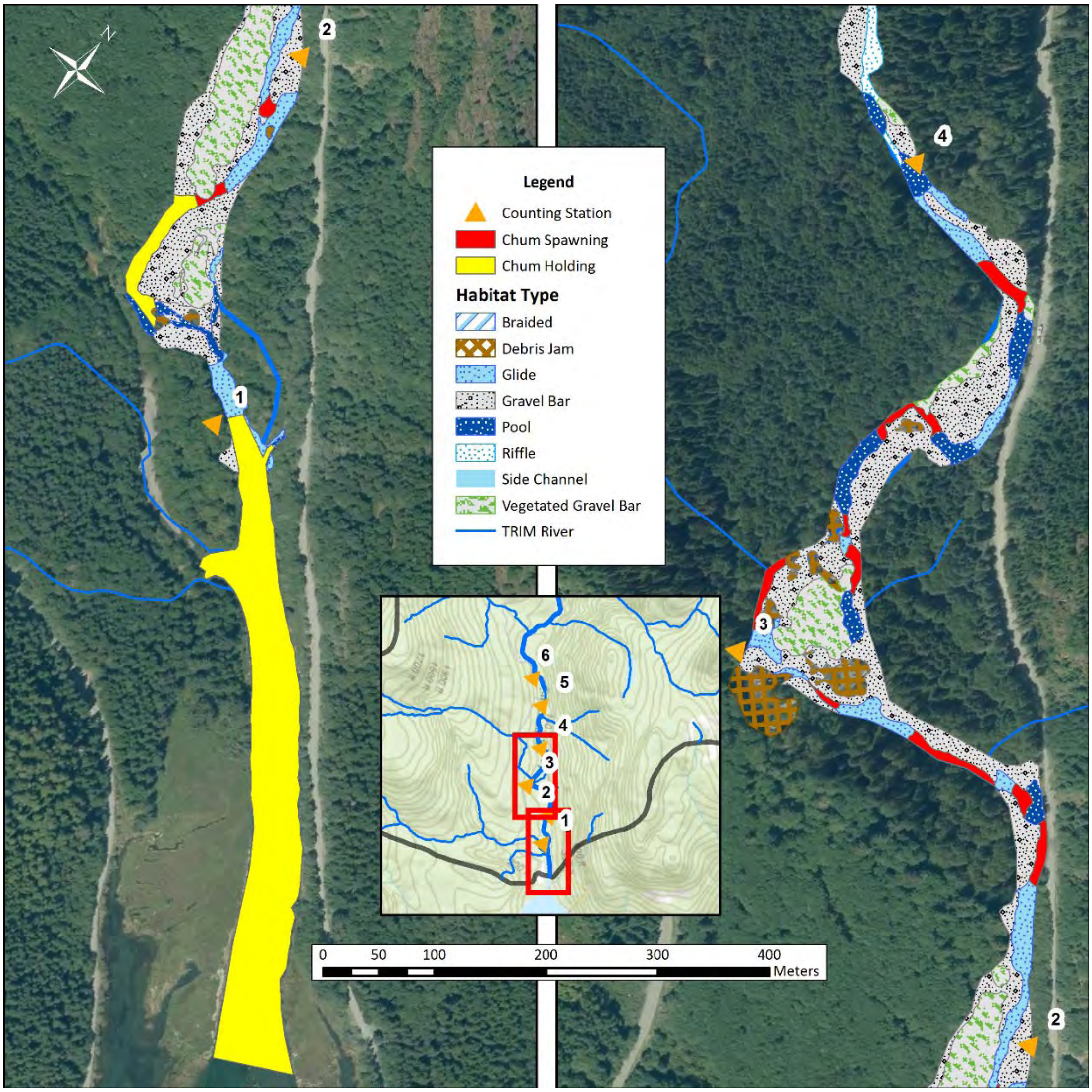

Figure 17. Known adult chum holding and spawning habitat in the Sucwoa River.

Like other species in the Sucwoa 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 (Diewert, 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 (Diewert, 2007). Given this important life history requirement, the Sucwoa River estuary has been classified as known juvenile migration and rearing habitat (Figure 18).

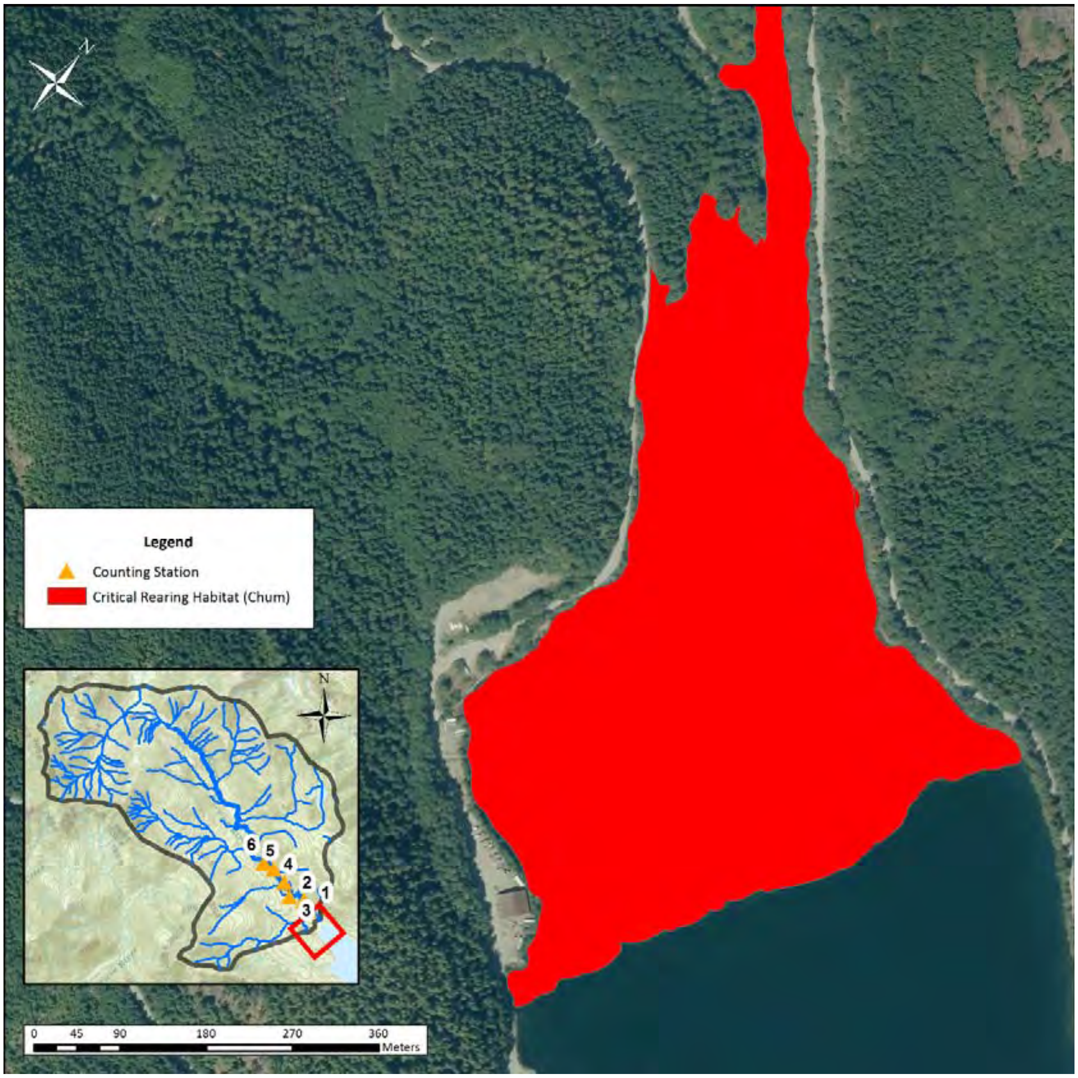

Figure 18. Known juvenile chum rearing habitat in the Sucwoa River estuary.

3.4.2 Escapement

Chum returns up until the early 2000s appear to have remained relatively stable with high escapements as compared to other fish species in the watershed (average of 2800 fish, with numerous years >10,000) (Figure 19). Peak escapement during the last decade was 2,475 fish in 2009 (Fisheries and Oceans Canada, 2015). The estimates of escapements for chum should be considered underestimates since tributary habitat known to support chum is not sureveyed. Chum salmon have experienced falling returns coast-wide over the past five years (Fisheries and Oceans Canada, 2015 and M. Wright, pers. comm.).

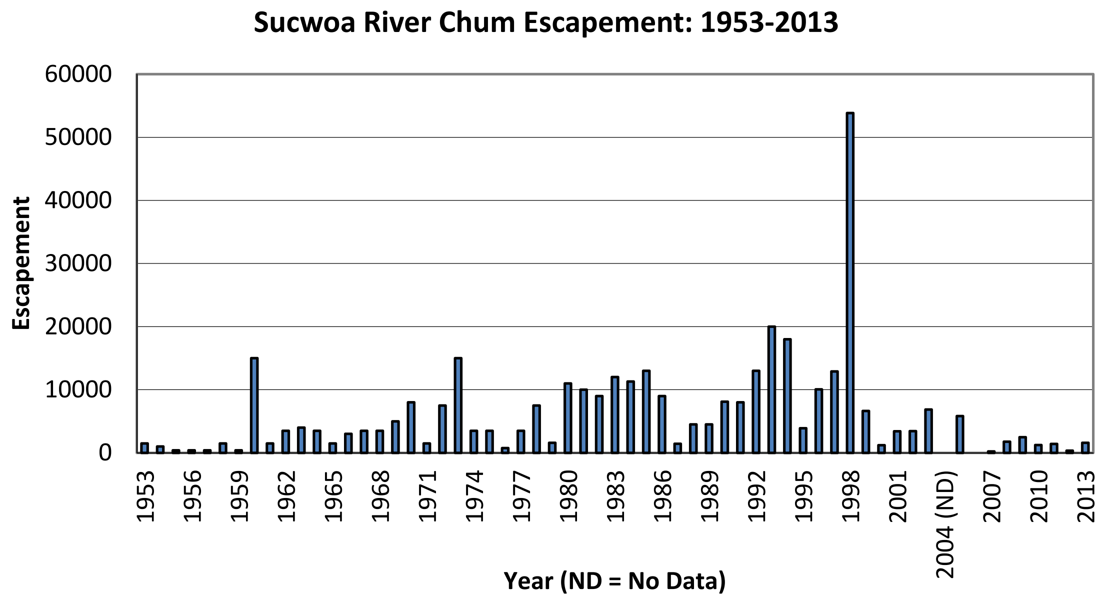

Figure 19. Chum escapement in the Sucwoa River between 1953 and 2013 (compiled from DFO's NuSEDs database).

3.5 Pink Salmon

Although known to be in the system, FISS data contained no known distribution for pink salmon. Low numbers and consequent unknown run timing have been reported for this species (Fisheries and Oceans Canada, 2015). Historical average annual pink salmon escapements in the Sucwoa River for 12 run assessment years between 1956 and 1980 were 700 fish with a peak escapement in 1972 of 3,500 fish; since 1980, the highest escapement was in 1997 at 31 fish () (Based on DFO's NuSEDS database). Considering the virtually non-existent returns in recent years (), this system is no longer considered to support pink salmon and is not considered in further discussions in this report.

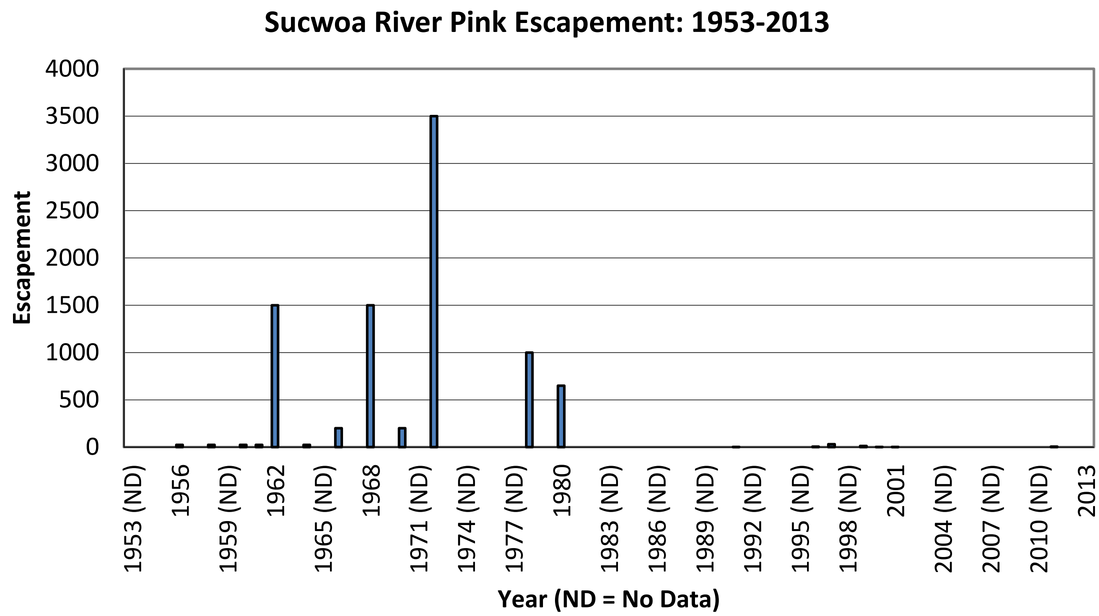

Figure 20. Pink salmon escapement in the Sucwoa River between 1953 and 2013 (from DFO's NuSEDS database).

4.0 HABITAT INDICATOR ASSESSMENT RESULTS

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

4.1 Stream Pressure Indicator: Total Land Cover Alterations

Total land cover alteration within the Sucwoa River watershed is summarized in :

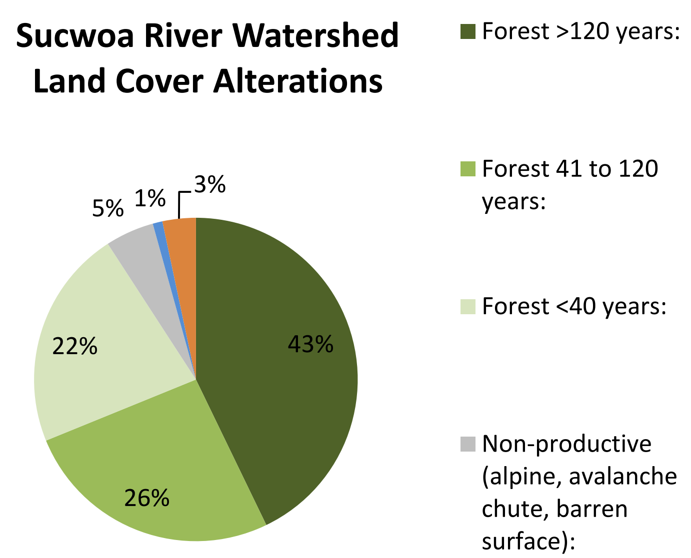

Figure 21. Total land cover alterations for the Sucwoa River watershed.

Based on this figure, approximately 49% of the total area of the Sucwoa River watershed remains unaltered, with mature forests (i.e. >120 years) comprising the majority of this area, and non-productive alpine, avalanche chutes, barren surface and fresh water areas constituting the remainder. Approximately 3% of the watershed has been altered as roads, and approximately 48% 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 half of the watershed remains unaltered, altered areas are generally situated in areas adjacent to and / or within known salmonid habitats (i.e. riparian zone of the mainstem and tributaries) (Figure 22). Considering the proximity of these alterations to known salmonid habitats, the Sucwoa watershed has been classified as high risk for total land cover alterations.

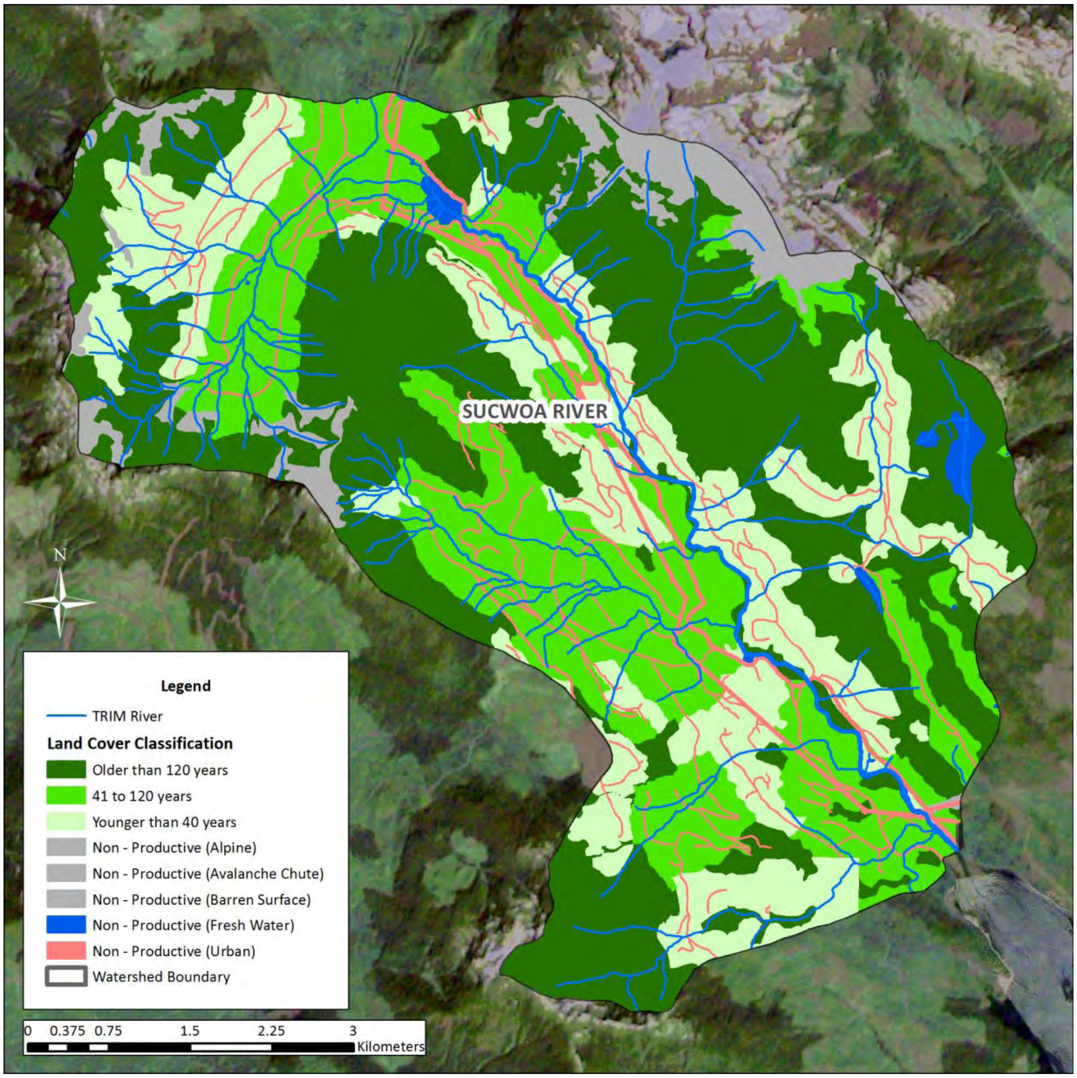

Figure 22. Total land cover alterations in the Sucwoa River watershed.

4.2 Stream Pressure Indicator: Watershed Road Development

Watershed road development for the Sucwoa River watershed was calculated at 2.3km/km^2, which was well above the suggested benchmark of 0.4km/km^2 (Stalberg et al, 2009). The Head Bay FSR road was built in 1970 and closely parallels the river for much of its length, crossing approximately 1.5km from the mouth (Glova and McCart, 1978). Road development was considered to be a high surface erosion hazard in the watershed due to the density and proximity to streams (Hetherington, 1997). Additionally, road development in combination with forest harvesting may have resulted in increased peak flows with the potential to result in bank erosion in the lower reach (Hetherington, 1997).

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).

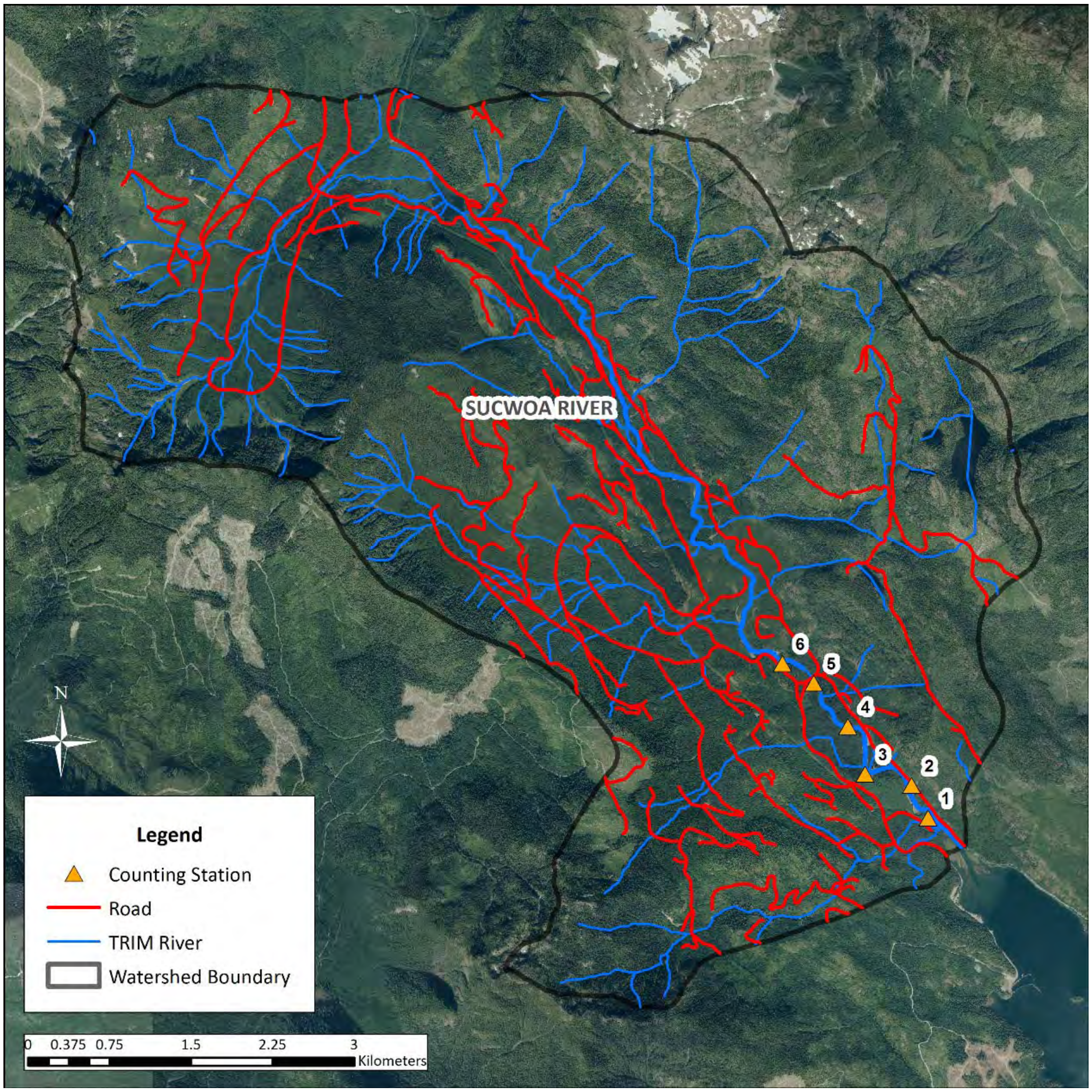

Figure 23. Sucwoa River watershed road density.

4.3 Stream Pressure Indicator: Water Extraction

The Sucwoa River watershed presently has one current water license (Figure 24). It is for the purpose of brake cooling, and is allocated the volume of 6.8m^3 per day. No appropriate benchmarks exist to evaluate the impact of the lower end of water extraction volumes (Stalberg et al, 2009). Given that there is only one water license and that the allocation is relatively low volume, this is considered to pose low risk to salmon in the Sucwoa River watershed.

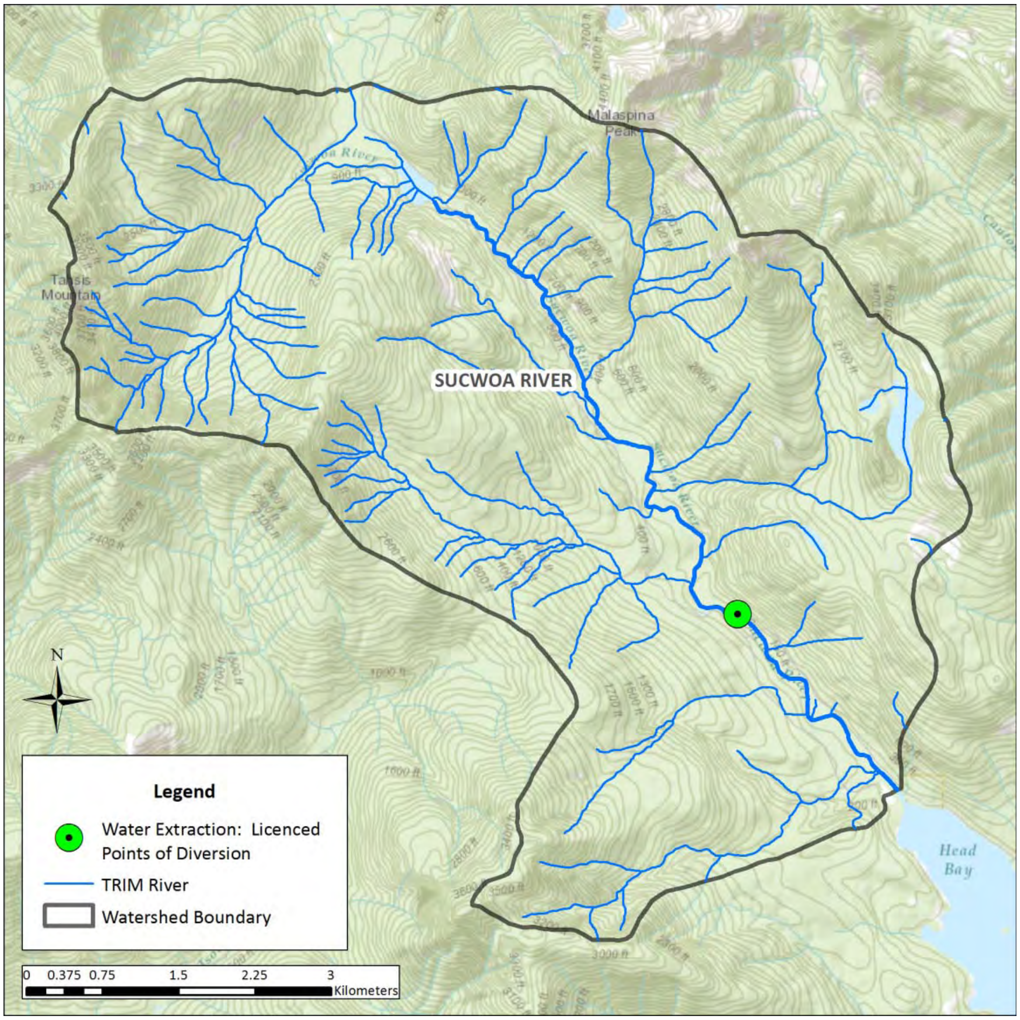

Figure 24. Licenced water points of diversion for the Sucwoa River watershed.

4.4 Stream Pressure Indicator: Riparian Disturbance

Significant lengths of the alluvial mainstem are over widened and aggraded as a result of riparian logging in the pre-code era (Horel, 2008). Based on the findings of Horel (2008) a study was initiated to identify and prescribe restoration treatments that would enhance riparian function within Sucwoa River watershed (McGeough, 2010). Impacts observed in 2010 included: impacted channel banks, weak diversity of fish habitat, unstable substrates, high sediment levels, and weak LWD provision. Some old remnant riparian forest stands were observed along the lower reach of the Sucwoa River; however, extensive red alder colonization was noted impeding riparian forest recovery such that full recovery to a functional condition was expected to take decades. Evidence of unstable channel banks, active down-cutting on floodplain channels and impaired LWD complexing existed within the channel (McGeough, 2010).

Based on an analysis of 2013 orthophotographs, the calculated riparian disturbance in the Sucwoa River was significant with the mainstem of the Sucwoa River dominated by a primarily deciduous and / or regenerating stand (Figure 25). Exceptions to this composition were in counting sections 0-1, 4-5 and 5-6, where a high component of mature and mature mixed riparian forest exists (Figure 26). The most significant riparian disturbances extended between counting stations 1 and 4, and approximately 1.7km upstream of counting station 6. It should be noted that the persistence of these deciduous zones given no significant harvesting has occurred in the watershed since 1995, which indicates channel instabilities are preventing the reestablishment of old growth vegetation.

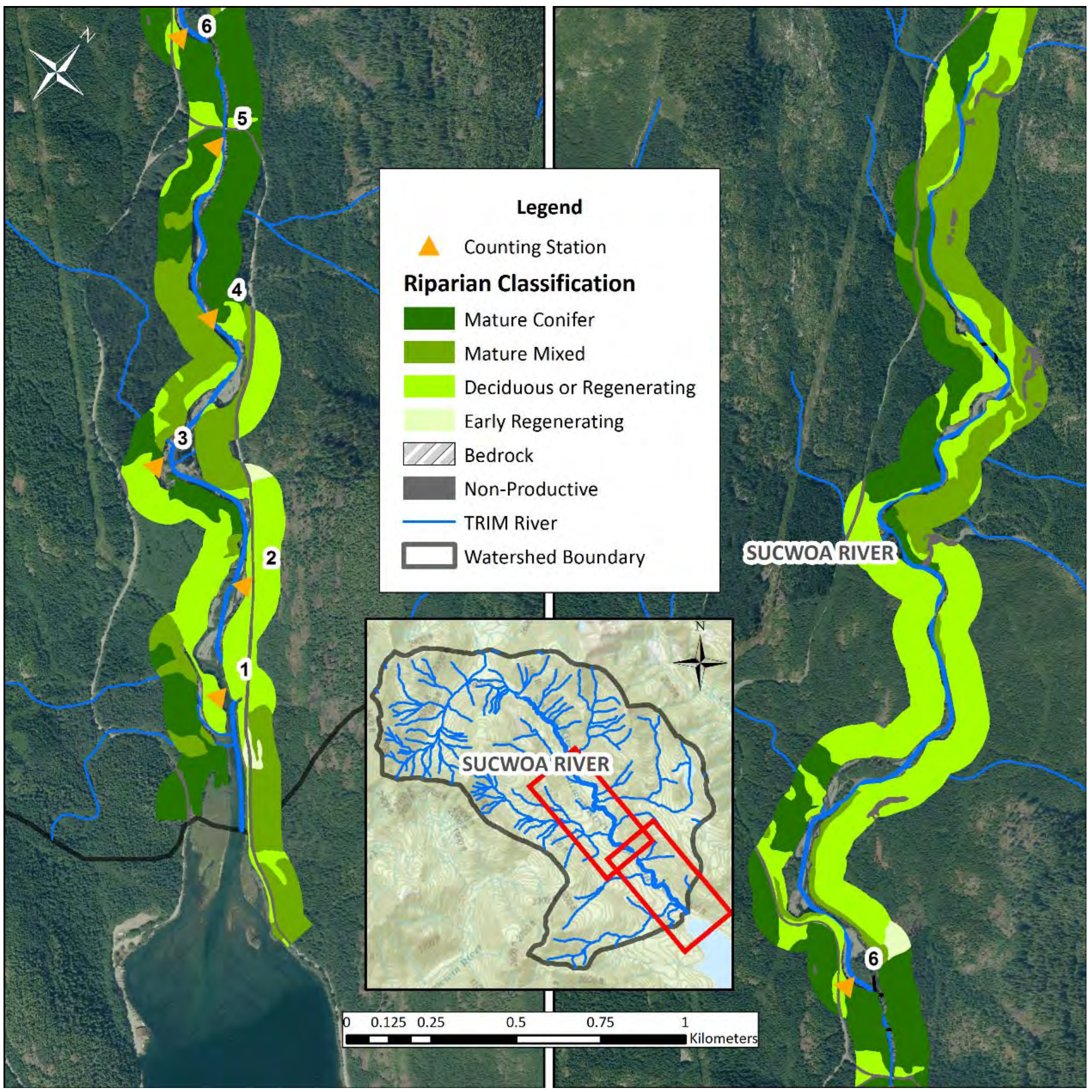

Figure 25. Riparian disturbance in the Sucwoa River watershed.

Throughout the anadromous reach, spawning and rearing habitats continue to be affected by a compromised riparian stand consisting of approximately 41% deciduous and / or regenerating forest (Figure 27). The component of early regenerating riparian stands was small (<1.0%). 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. If nothing is done, 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.

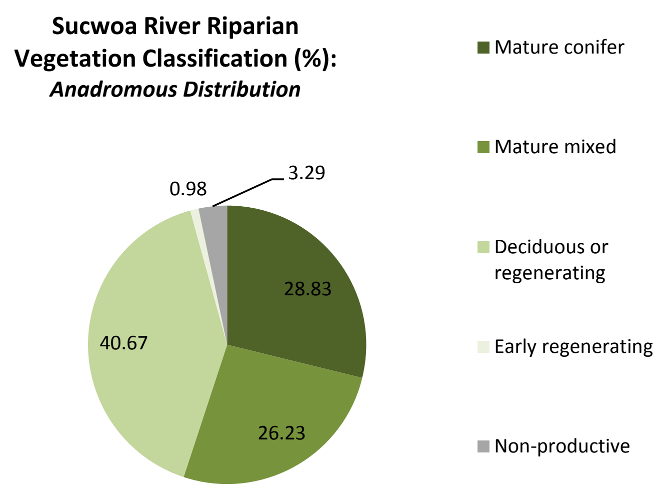

Figure 26. Riparian vegetation composition for the anadromous reaches of the Sucwoa River watershed.

An analysis of riparian condition for tributaries to the Sucwoa River was not completed. As such, this has been identified as a data gap for coho, considering this species is the heaviest utilizer of these types of habitats.

The riparian management prescription completed by McGeough (2010) will stimulate recovery of riparian function. Funding should be secured to implement the prescribed treatments.

4.5 Stream Pressure Indicator: Permitted Waste Management Discharges

No permitted waste management discharges were identified in the Sucwoa River watershed.

4.6 Stream State Indicator: Water Quality

Data collected in 2007 at the five regional geochemical stream survey monitoring sites in the Sucwoa River watershed (Figure 27) showed that of the water parameters that were sampled (uranium, fluoride and pH), all were compliant with the Canadian Water Quality Guidelines for the Protection of Aquatic Life (Canadian Council of Ministers of the Environment, 2014). Reported pH values at these sites were between 6.1 and 7.7 (BC Ministry of Energy and Mines, 2015).

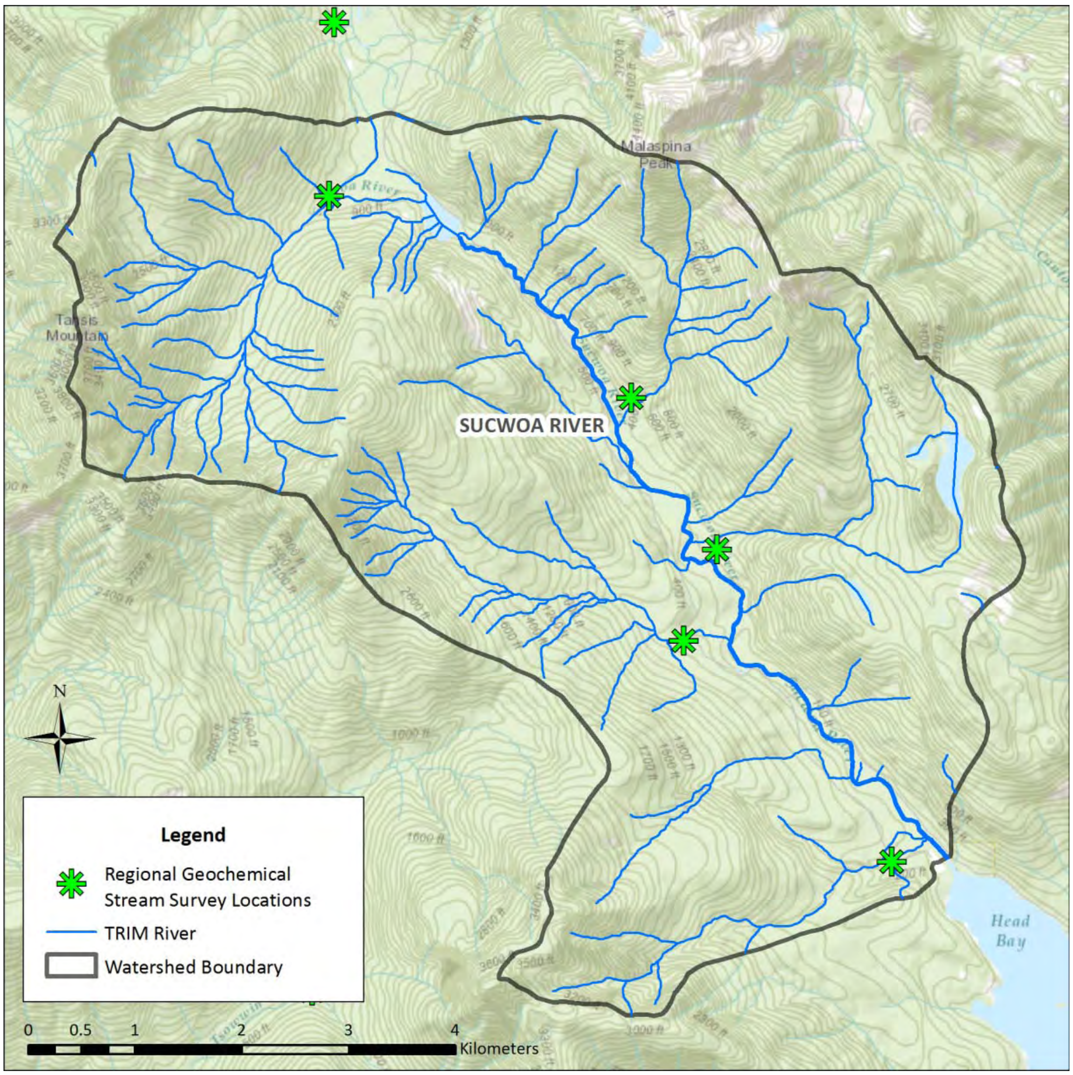

Figure 27. Regional geochemical stream survey locations in the Sucwoa River watershed.

Note that the available water quality data for the Sucwoa River watershed was both spatially and temporally limited to the 2007 regional geochemical stream survey at six locations. No dissolved oxygen data was available for either the Sucwoa River or its tributaries. While no exceedances were identified with the available data, the spatial and temporal distribution of this data, and the number of sampling parameters, were not robust enough to determine any influence water quality may have on fish production in the watershed. 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); however, no supporting data exists (NSWS, 2015). As such, the water quality habitat indicator has been identified as a data gap.

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

Compilation of SIL data during the spawning period on the Sucwoa River demonstrated water temperatures to have remained below the UOTR (between 15°C and 20°C) for all species between 2007 and 2012 (Table 3). Interviews with the NSWS and local experts indicated this parameter to not likely be impacting adult migration and spawning in this system (NSWS, 2015). 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 (no water temperature measurements were available for July or August when it would be more likely for the temperature to exceed the UOTR).

Table 3. Water temperature data from 2007 to 2012 for the Sucwoa River during adult migration and spawning.

SUCWOA RIVER						
Year	***Date***	***Temperature (°C)***	***Species Present***			
			SK	***CO***	***CH***	***CM***
2007	Oct. 14	9	X	X	X	X
2009	Oct. 10	10	X	X	X	X
	Oct. 22	9	X	X		X
	Nov. 8	8	X	X		X
2010	Sept. 20	9	X	X	X	X
	Oct. 14	9	X	X	X	X
2011	Sept. 11	12.5	X	X		X
	Sept. 29	10	X	X	X	X
	Oct. 9	10	X	X	X	X
	Oct. 31	7	X	X		X
	Nov. 13	6	X	X		X
2012	Sept. 27	10	X		X	X
	Oct. 11	9			X	X

4.8 Stream State Indicator: Discharge

Interviews with the NSWS and local experts indicated that higher discharges during rain events in recent years has resulted in significant bedload movement (NSWS, 2015); however, no discharge data exists for this system. As such, this parameter has been identified as a data gap.

4.9 Stream State Indicator: Accessible Stream Length

Information on accessible stream length for the Sucwoa River watershed was compiled from the Sucwoa River stream narrative (Fisheries and Oceans Canada, 2015), FISS, and accounts from Glova and McCart (1978). Based on the GIS distribution data presented in Figure 4,

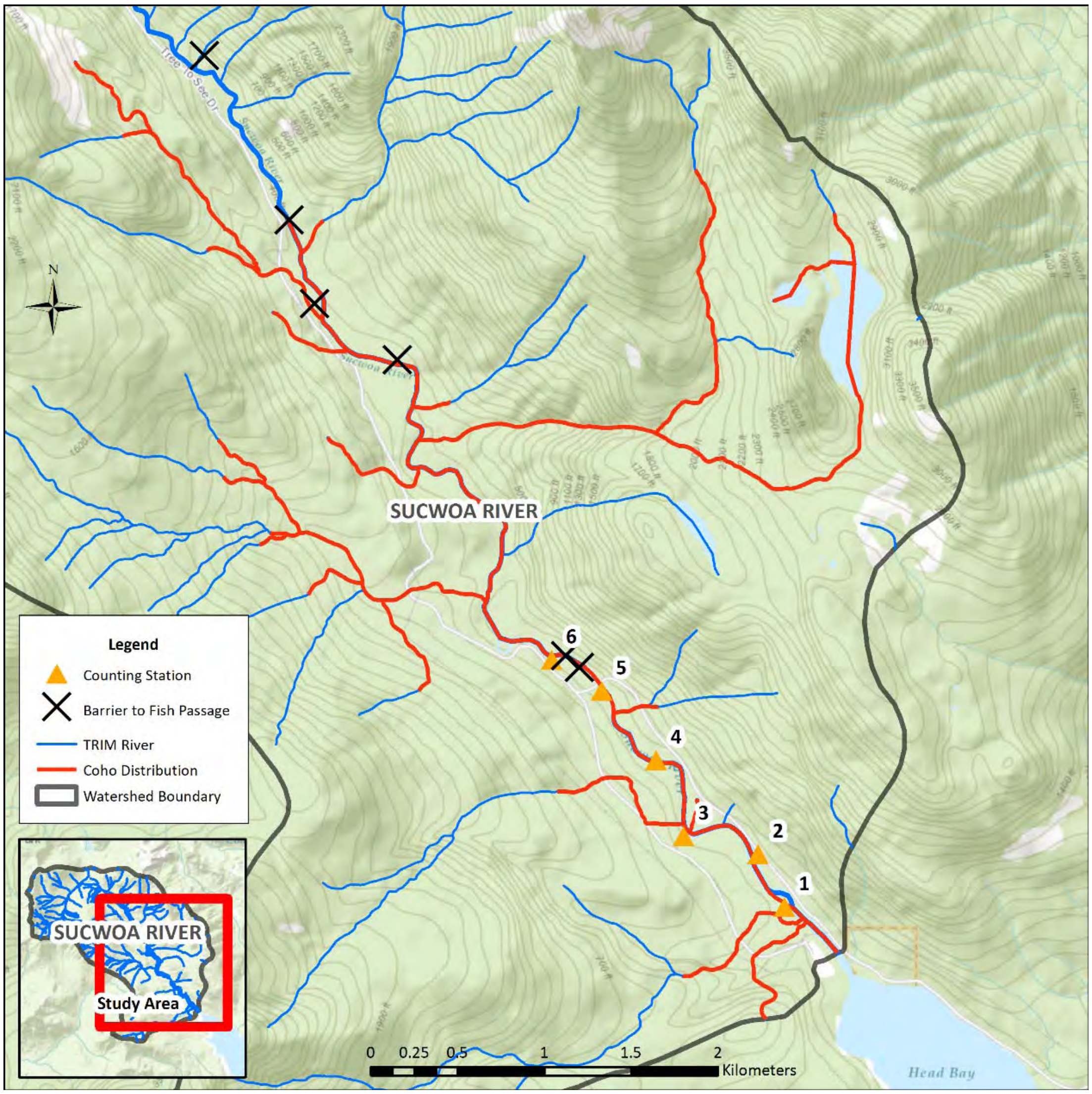

Figure 8, Figure 13, and Figure 16, the following table summarizes accessible stream length by species:

Table 4. Accessible stream length, by species, for the Sucwoa River watershed.

	Chinook	Coho	Sockeye	Chum
Mainstem	2.53km[i]	6.39km	2.53km[ii]	2.53km
Tributary	No Data	18.09km	No Data	No Data
Total	2.53km	24.50km	2.53km	2.53km

Note: No data is available for the accessible length of tributaries for chinook, sockeye and chum, although Glova and McCart (1978) noted the lower reaches (unknown length) of "Tributary A" and "Tributary B" (see Figure 16) were particularly important spawning grounds for Chum.

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

[i] Most available sources determined that the cascade upstream of the bridge (at counting station 5) is a barrier to upstream migration for chinook, sockeye, chum and pink; however, Glova and McCart (1978) stated that chinook and sockeye could surmount this barrier – although they do not state where the upstream extent of the distribution of these species are. Based on the lack of available information (snorkel surveys have not typically covered sections upstream of the cascade), ground truthing and/or local knowledge are needed to confirm whether or not the cascade is impassable for chinook and sockeye.

[ii] See above.

4.10 Stream State Indicator: Key Spawning Areas (Length)

Key spawning area lengths, by species, were calculated based on the locations presented in Figure 5, Figure 9, Figure 14, and Figure 17. For detailed descriptions of spawning locations for each species, please refer to Section 3.0.

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

Chinook	Coho	Sockeye	Chum
1.70km	1.70km*	0.81km	2.64km

* Coho spawning areas upstream of the cascade between counting stations 5 and 6 have not been identified (this is a data gap), although it is well-known that coho spawning does occur in the upper reach of the Sucwoa River, and likely its tributaries provide valuable spawning habitat.

As observed in Table 5, sockeye have been identified to have the smallest spawning grounds (by length) on the river, and chum 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 for spawning area length for each species 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 spawing habitat upstream of the survey area and tributary streams.

4.11 Stream State Indicator: Stream Crossing Density

The following table summarizes the available stream crossing data for the Sucwoa River watershed:

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

Stream Crossing Density: SUCWOA RIVER	
# of Crossings:	136
# of Fish-Bearing:	40
# of Non-Fish Bearing:	96
Crossing Density:	3.06 / km^2

The results based on the PSCIS database indicate that the Sucwoa River watershed has a higher stream crossing density (3.06/km^2) than the neighbouring Canton Creek watershed (2.21 / km^2) (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 Sucwoa River watershed, 29% of crossings are modeled as fish-bearing, whereas 71% of crossings are modeled as non-fish bearing. Based on the high stream crossing density, 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 28 shows modeled locations of culvert crossings.

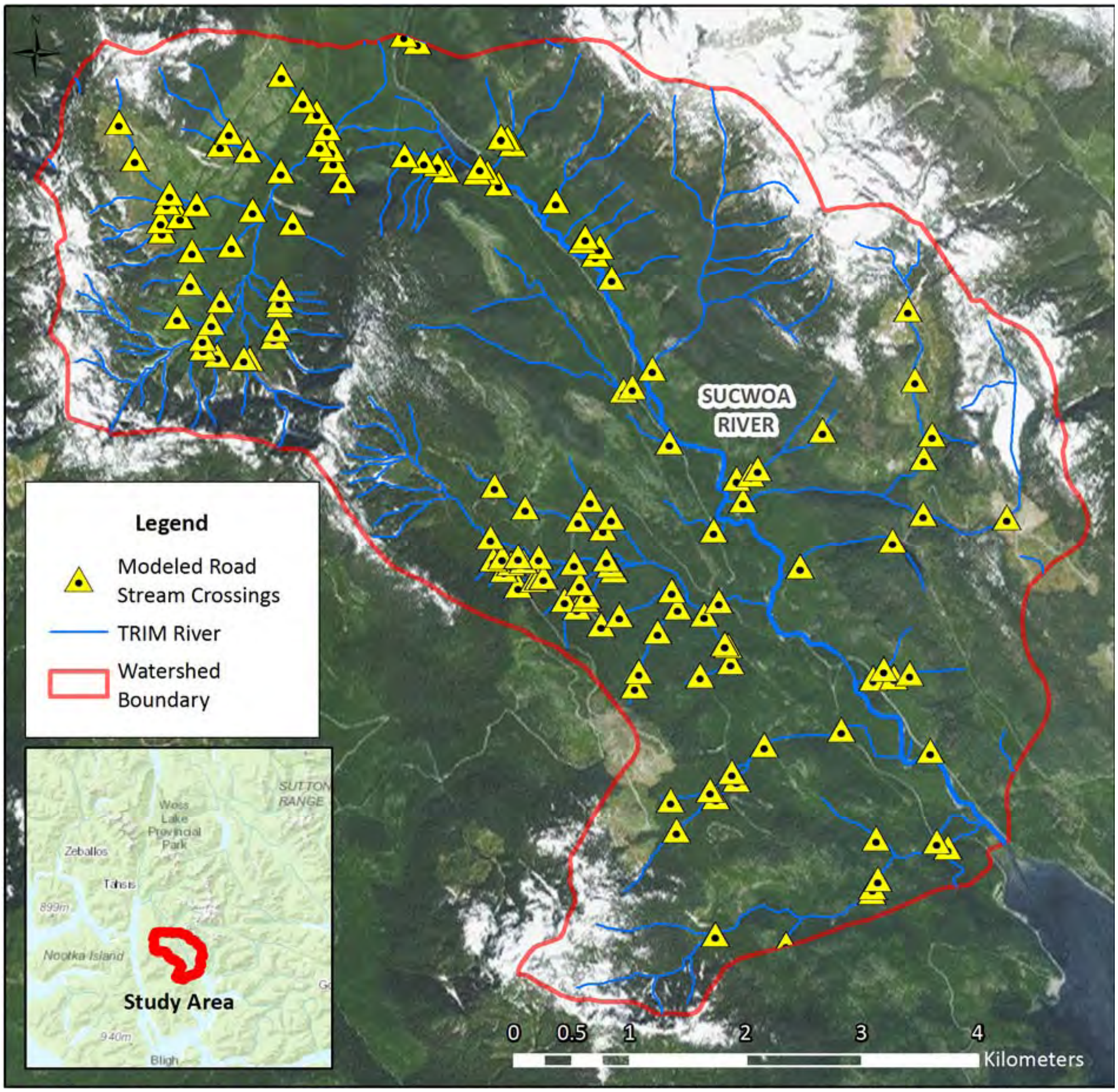

Figure 28. PSCIS modeled stream crossings in the Sucwoa River watershed.

4.12 Stream State Indicator: Habitat Composition

An analysis of habitat in the Sucwoa River watershed indicated this system to be dominated by gravel bars and contain very little pool habitat. Habitat between counting station 3 and 4 demonstrated the highest frequency of pools; above counting station 6, gravel bars, aggraded sections and riffle habitat is more frequent. Glide habitat is dominant from the river mouth up to counting station 4, with significant gravel bars between counting stations 1 - 2 and 3 - 4 (Figure 29).

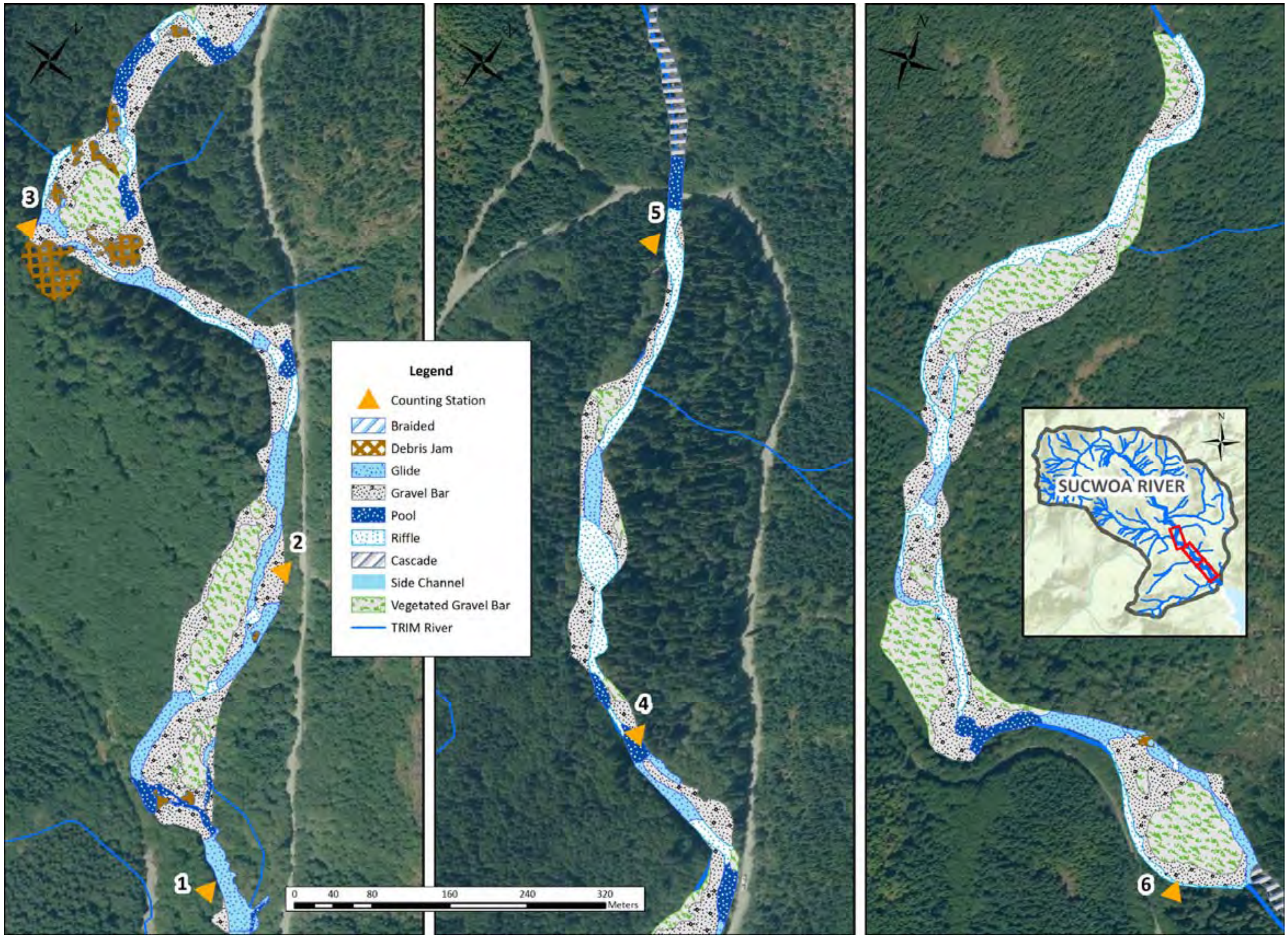

Figure 29. Habitat unit composition (2013) of the Sucwoa River.

Pool habitat available for holding and rearing was low; 4.98% for the anadromous distribution of the system (Figure 31). When gravel bars, vegetated gravel bars, and debris jams are removed from the composition analysis, percent pool habitat increased from 4.98% to 16%. The benchmarks described in Johnston and Slaney (1996) indicate that for systems with less than a 15m bankful width and with gradients of <2%, poor salmonid habitat condition for summer and winter rearing occurs with <40% pool habitat area by reach. Similar conditions are experienced in systems with gradients between 2% and 5% where <20% pool habitat area is observed. It is clear that there is a lack of pool habitat throughout the distribution of all salmon species in the watershed. Considering this benchmark, the habitat composition indicator for the Sucwoa River has been classified as high risk, as pool frequencies are low.

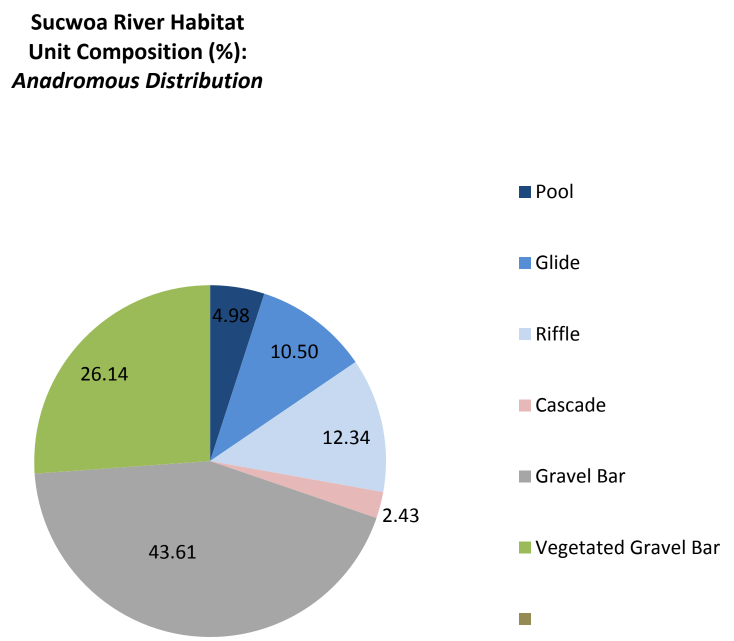

Figure 31. Habitat unit composition in 2013 for the anadromous reaches of the Sucwoa River.

A comparison of habitat unit composition between 1995 and 2013 (where data overlapped between counting stations 1 and 5) has demonstrated a decrease in pool habitat throughout these sections, indicating ongoing channel aggradation in this system (Figure 31). The overall percentage of pool habitat has decreased from 20.67% in 1995 to 7.85% in 2013. The increase in gravel bar area between 1995 and 2013 is a further indication of channel aggradation, while the increase in vegetated gravel bar area is a positive indication of channel recovery. Note that inconsistencies may have affected the results of this comparison, particularly the difference between the lower quality 1995 aerial photo and the higher quality 2013 orthophotographs.

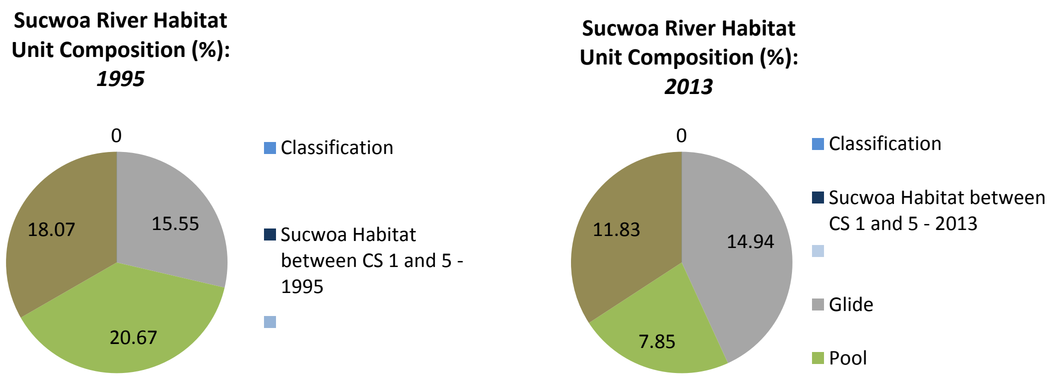

Figure 30. Change in habitat unit composition between 1995 and 2013 in the Sucwoa River, between counting stations 1 and 5.

Interviews with the NSWS and local experts indicated that significant bedload movement from channel instabilities continues to occur in the Sucwoa River. Accumulations of sand and fines has decreased the area of available refuge habitat, and a general infilling of pool habitat has been observed (NSWS, 2015).

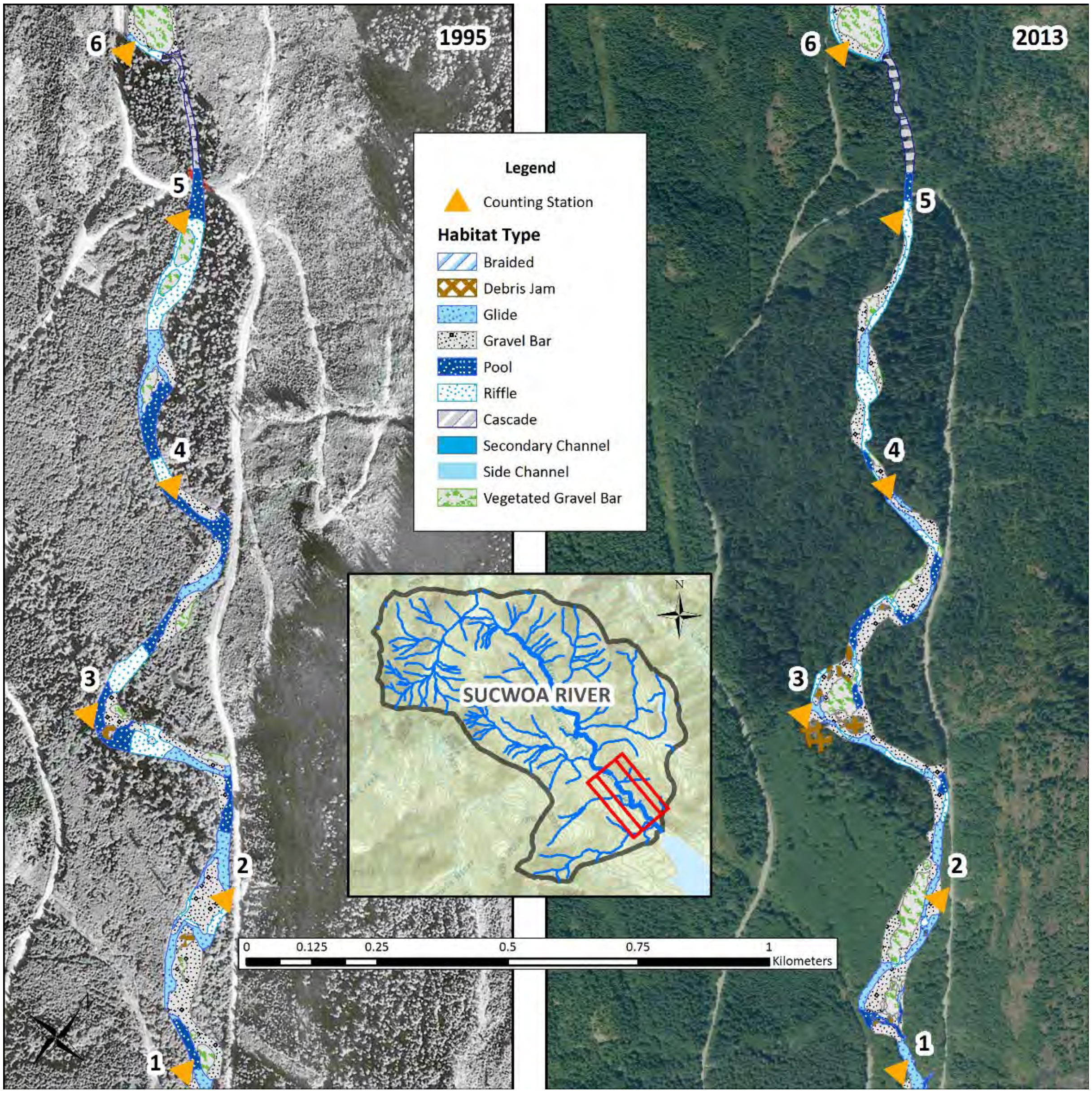

Figure 31. Habitat unit composition between 1995 and 2013 (note loss of pool habitat between counting stations 1 and 6).

4.13 Stream State Indicator: Channel Stability

A comparison of 1980, 1995, and 2013 imagery between counting stations 1 and 6 demonstrated significant migration of the channel banks in the lower river over time (Figure 32). The most significant observation of channel widening has occured at counting station 3 and upstream of counting station 1. Upstream of counting station 1, approximately 40m of bank has been lost between 1980 and 2013. Bank erosion immediately downstream of counting station 3 has resulted in a loss of approximately 70m x 35m of the right bank.

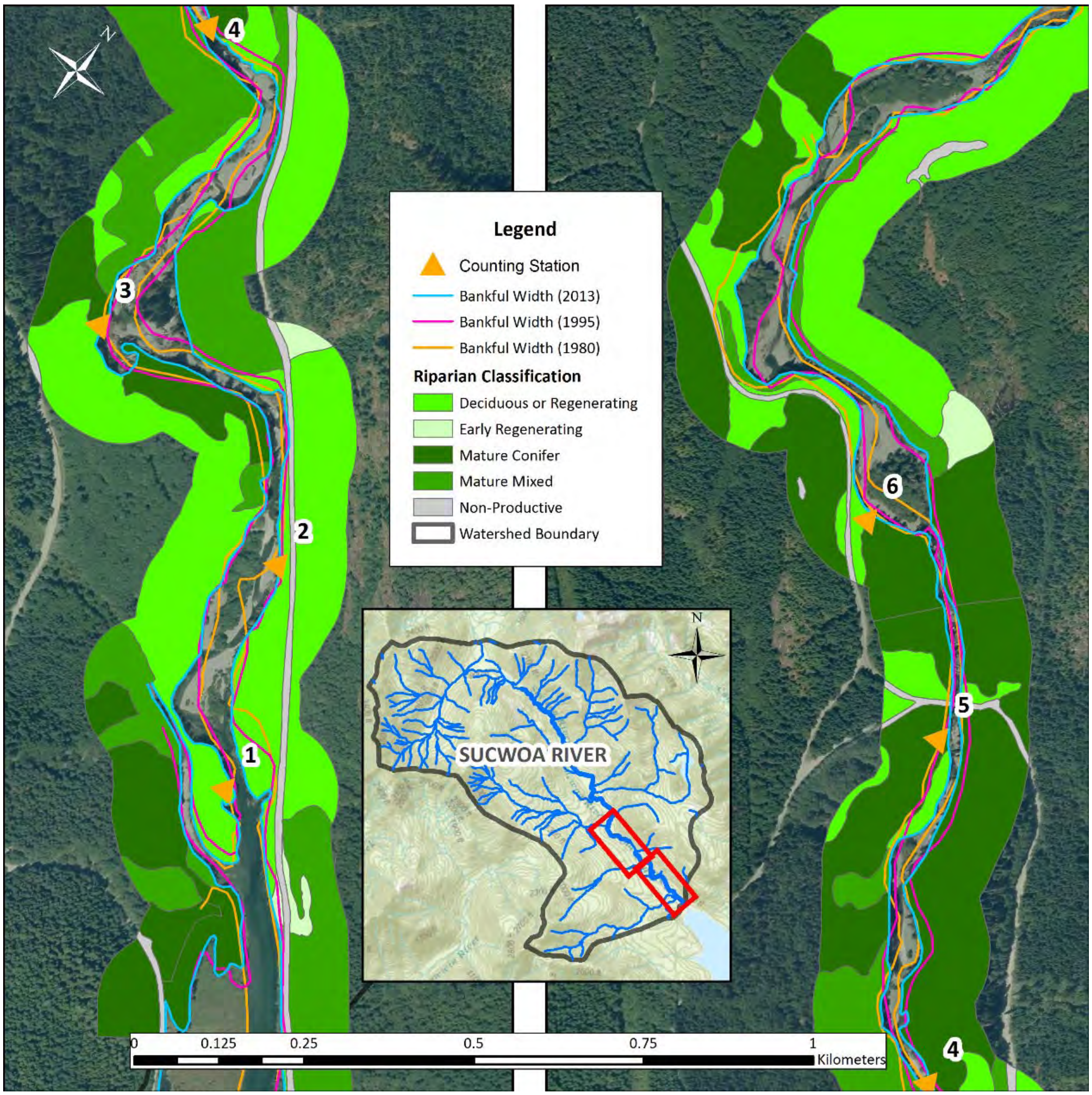

Figure 32. Bankful widths in 1980, 1995, and 2013 of the Sucwoa River.

Between counting stations 3 and 4, significant erosion of the right bank (near the road prism) was identified by local experts (NSWS, 2015). The known presence of clay in this bank indicated higher risk to downstream habitats through potential infilling of substrates with clay.

Where riparian zones consist of a significant component of deciduous and / or regenerating vegetation, the risk of bank erosion and channel mobility is high (Figure 32). The channel is clearly more stable between counting stations 4 and 6, where the riparian zone is composed of primarily mature conifer forest. Note that a proper study of the Sucwoa River 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 the Sucwoa River to the upstream extent of Reach 2 (Figure 2). Classification beyond reach 2 was not possible due to canopy cover and / or shadowing obscuring the river in the orthophotographs, and the portion of the river further upstream is not accessible to anadromous fish. The following table summarizes the results of LWD classification by reach:

Table 7. LWD classification in the Sucwoa River (reaches 1 - 12).

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
1 (CS1-5)	0.29	0.50	0.18	10	POOR
2 (CS5 to Coho Barrier)	0.16	0.29	0.12	1	POOR

Based on the results presented above, there is a lack of functional LWD in the Sucwoa River system. Reach 1 demonstrated the highest concentration of functional LWD; however, the number of pieces per bankful width still remained below 1 piece per bankful width. Photo 4 presents an example of functional and non-functional LWD in reach 5.

Non-functional LWD was present throughout the system, primarily present as wood accumulating on top of gravel bars (Photo 5). There was also a considerable component of this wood that was oriented parallel to the stream bank, and was therefore providing limited function to the system.

Photo 4. Example of functional LWD and non-functional LWD in the Sucwoa River.

Photo 5. Example of non-functional LWD near counting station 3 of the Sucwoa River.

Debris jams were most common throughout reach 1, with the largest jam observed just downstream of counting station 3. In most cases these jams were providing functional fish habitat and in some locations preventing further bank erosion.

The recruitment potential for functional LWD in the Sucwoa River system is low based on its riparian stand classification (i.e. predominantly deciduous). In addition, LWD present in the river is likely deciduous as well, given this stand has been dominated by alders since the riparian stands were first logged in the 1950s. While smaller deciduous LWD still provides some function in the river, larger 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 Sucwoa River system and the existing LWD being predominantly deciduous, this habitat indicator was ranked as high risk.

4.15 Stream State Indicator: Off-Channel Habitats

Potential off-channel habitats were identified just upstream of counting station 6, just upstream of the Head Bay FSR bridge, and along the left bank downstream of counting station 3 (NSWS, 2015). As no information with respect to the connectivity of these habitats was available for review, off-channel habitat was identified as a data gap in the Sucwoa River watershed.

4.16 Estuary State Indicator: Estuary Habitat Disturbance

The evaluation of historic and ongoing impacts to the Sucwoa River estuary was evaluated through information derived from the available aerial imagery and from interviews with local experts (NSWS, 2015).

In comparison to other systems in the area, the Sucwoa estuary was identified as one of the most heavily degraded (NSWS, 2015). Industrial lands have occupied approximately 400m of the foreshore on the west side of the estuary since 1954, and the estuary continues to be bordered on both sides by active roads. An active log dump is situated approximately 600m south of the river delta on the west shore. Log booming activity was observed as close as approximately 100m from the visible delta in 1954, and that distance increased to approximately 600m by 2013. Significant historical fill exists within the estuary, with commercial debris (i.e. scrap metal, fuel talks, etc.) likely present within this fill. Derelict equipment (including a sunken barge and an abandoned cat skidder) exists within the estuary and reports of fuel leaking from this equipment have been noted (NSWS, 2015). Further field investigation would be necessary to assess the impacts of past forest harvesting on the Sucwoa River estuary, such as excessive sedimentation deposition (resulting from bank erosion from riparian logging) and/or wood waste accumulation from log handling.

Based on historical and current aerial imagery interpretation of permanent alterations to the Sucwoa River estuary, and information gathered from local experts, this habitat indicator has been ranked as high risk. Note the condition of subtidal estuarine habitat has been identified as a data gap.

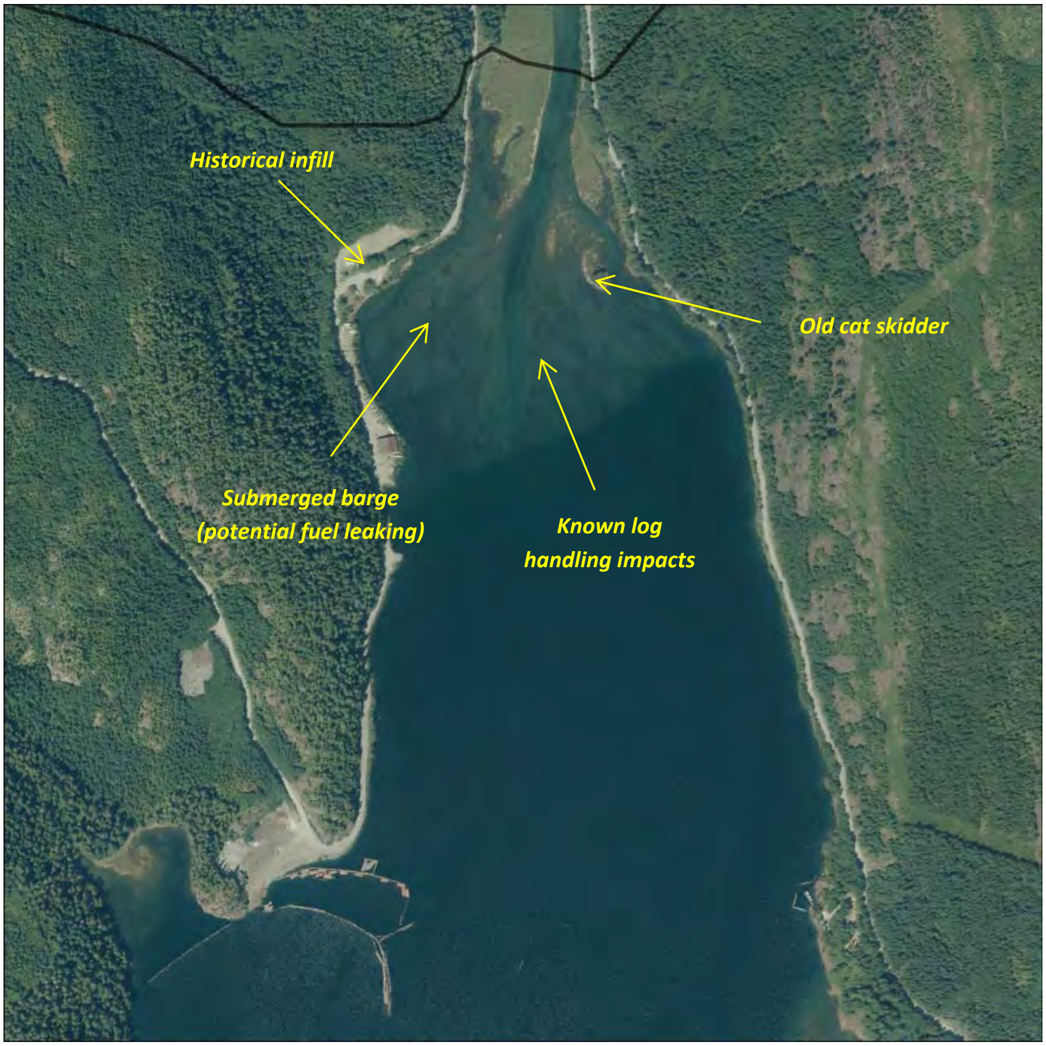

Figure 33. Present-day habitat disturbances in the Sucwoa River estuary.

4.17 Estuary State Indicator: Permitted Waste Discharges

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

4.18 Estuary State Indicator: Estuary Chemistry and Contaminants

No chemistry or contaminant data was available for the Sucwoa River estuary. However, interviews with local experts indicated that given the history of the estuary and the presence of commercial debris, water quality in the estuary could be a significant issue. As such, this indicator has been identified as a high priority data gap.

4.19 Estuary State Indicator: Dissolved Oxygen

No dissolved oxygen data for the Sucwoa River estuary was available. Considering that historical log handling has occurred as close as 100m to the intertidal portion of the estuary, and the known impacts log handling can have on DO levels through wood waste deposition (Picard et al, 2003), some impact to fish habitat can be expected from this indicator. However, based on the absence of information and / or studies, this habitat indicator has been identified as a data gap.

4.20 Estuary State Indicator: Estuarine Habitat Area

Historical and ongoing impacts to the Sucwoa River estuarine habitat appear to be limited to the infill associated with the camp on the west side of the estuary. However, the most recent imagery (2013) was captured during a mid to high tide, and therefore the extent to which habitat types could be differentiated over the portion of the estuary that was under water was limited. Distinct channel features were classified as water, and the majority of the remaining area appeared to be predominantly sand or mud flat, although there may be some salt marsh, eelgrass and gravel cover within the area of the delta that was included in the sand / mud flat polygons. The accuracy of the habitat classification in the Sucwoa River estuary could be improved with recent high resolution imagery captured during low tide, and/or a field assessment. The following figure details habitat composition within the estuary (areas shown in hectares):

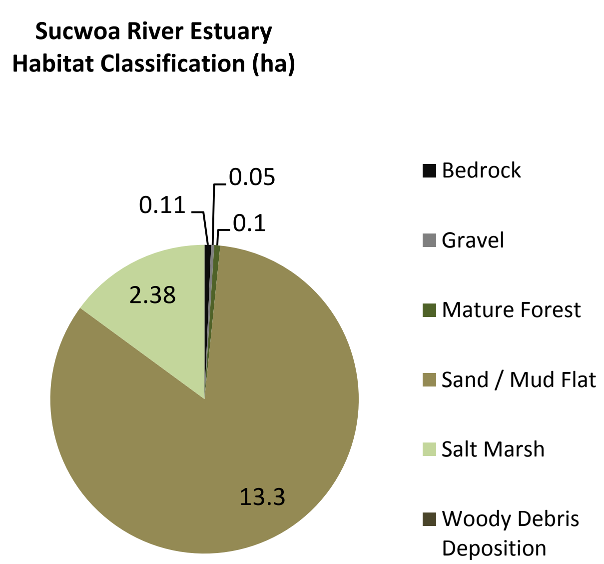

Figure 34. Habitat composition of the remaining Sucwoa River estuary.

As demonstrated in Figure 34, the intertidal estuarine habitat was classified as predominantly sand or mud flat. Figure 35 also shows the distribution of the classified estuarine habitat. It should be noted that no recent data was available pertaining to the subtidal component of the estuary (i.e. eelgrass presence / absence and the extent of historical log handling impacts), and has been identified as a data gap.

Given the known importance of the estuary as a critical rearing and foraging zone for all species of outmigrating salmonids, any historical loss of this habitat represents a loss in salmonid productivity for this watershed. Protection of the estuary habitat is critical to maintaining fish production in the watershed. Although the majority of the estuary area appears relatively unaltered (with the exception of the industrial land use on the west shoreline), there are a number of data gaps that need to be addressed, and discussions with local experts indicated that subtidal impacts to estuarine habitat could be significant (NSWS, 2015). Therefore this indicator has been ranked as high risk (with data gaps).

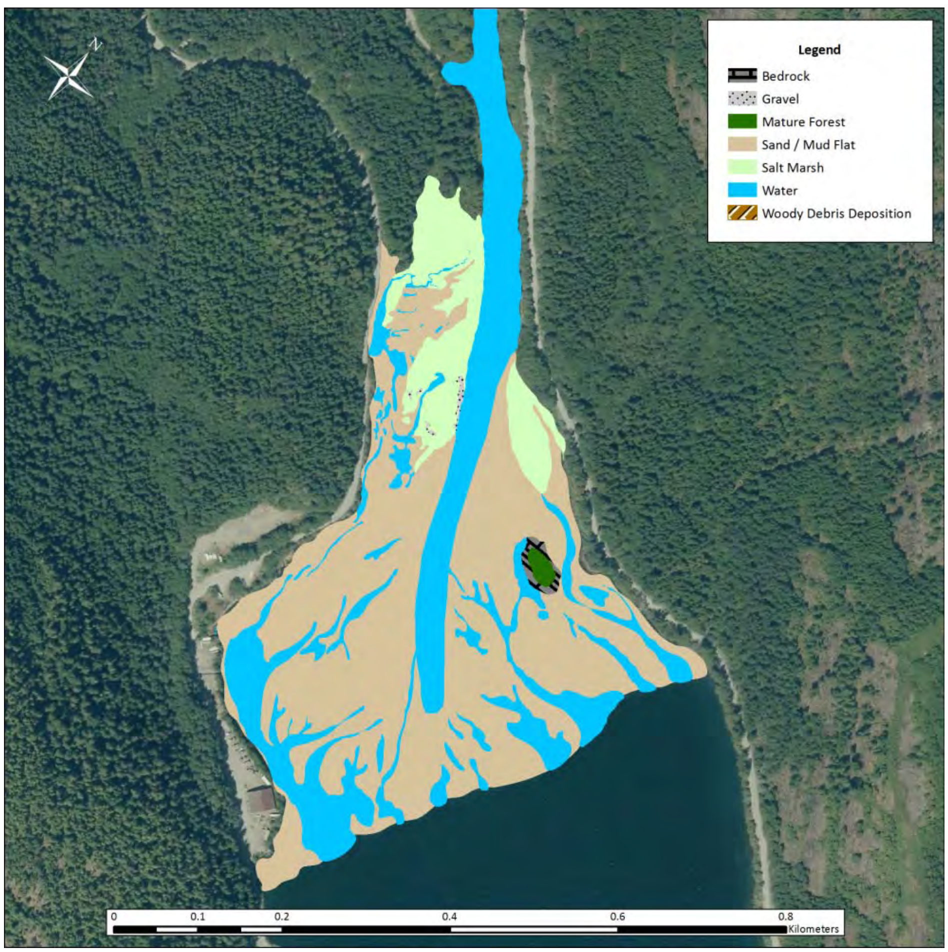

Figure 35. Estuary habitat classification and distribution of the Sucwoa River estuary.

5.0 SUMMARY OF HABITAT INDICATORS AND DATA GAPS

Based on the results of the habitat status assessment of the Sucwoa River watershed, it is clear that legacy impacts from forest harvesting continue to persist in this watershed. The Sucwoa River is considered to be highly sensitive and highly disturbed, in a state of improvement but still of concern with unstable alluvial channels resulting from riparian logging (Horel, 2008). The inherent characteristics of this system (i.e. unstable alluvial channel) have prevented riparian reclamation from streamside logging impacts. Degraded riparian zones have resulted in channel instabilities, particularly in the lower river, and subsequent sediment inputs have overwhelmed the system and resulted in overall aggradation and loss of pool habitat. Very little functional LWD remains in the system and recruitment potential is moderate to low considering that a deciduous canopy dominates approximately 40% of the riparian zone. Significant impacts to the estuary exist through the presence of estuarine infill, relic equipment, commercial debris, log handling impacts, and potential water quality issues from historical industrial activities. One positive sign of natural recovery has been the establishment of vegetation on gravel bars, which is expected to improve channel stability over time.

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

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

Indicator	Type	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. **Data gap for riparian classification of tributaries. Ground truthing for stand age and understory condition is required.**
Channel stability	Stream: State	HIGH (below counting station 6) MODERATE (above counting station 6)	Y - Partial	Significant channel migration observed in select locations between 1980 and 2013. In some cases, continued erosion is expected based on lack of stable channel banks and deciduous riparian vegetation in these zones. Ground truthing of these zones is recommended to complement the orthophotography assessment.
Habitat composition	Stream: State	HIGH	Y - Partial	Percent pool area remains below suggested benchmarks described in Johnston and Slaney (1996). Loss of pool habitat between 1995 and 2013 observed. Some groundtruthing should be considered.
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. Low functional LWD recruitment potential based on deciduous-dominated riparian zones. Ground truthing of LWD recommended to quantify additional LWD that may not be visible from orthophotographs (i.e. completely submerged LWD in deep pools).
Estuary habitat disturbance	Estuary: State	HIGH	Y	Industrial lands occupy the west shoreline, and the estuary is bordered on both sides by road. Infill, commercial debris, and relic equipment present. Historical log handling up to the edge of the estuary has potentially disturbed eelgrass habitat. Dive and/or ROV surveys would be required to determine the extent

				and severity of log handling impacts on the estuary.
Estuary habitat area	Estuary: State	HIGH	Y	Signfiicant infill along west shore of estuary resulted in historic loss of habitat. Field assessment would confirm whether additional productive habitats have been lost as a result of historic forestry practices. **Data gap: quantity and quality of productive intertidal and subtidal estuarine habitat (i.e. salt marsh and eelgrass beds).**
Watershed road development	Stream: Pressure	HIGH	N	Road density was high at 2.3km/km^2, and a significant portion of the road lies within the riparian zone.
Stream crossing density	Stream: Pressure	HIGH	Y	Highest stream crossing density of all watersheds assessed in Nootka Sound, at 3.06 /km^2. No data available on the state of deactivation of historic crossings. Watershed-wide culvert assessment needed to confirm the risk posed to fish by this indicator.
Water extraction	Stream: Pressure	LOW	N	Only one license exists, which represents a very low rate of extraction.
Water temperature: Migration and spawning	Stream: State	LOW	Y	No recorded water temperatures during spawn surveys from 2006 – 2014 approached the UOTR for adult salmonids. However, the available data was very limited.
Permitted waste management discharges	Estuary: State	LOW	N	No permitted waste discharges were identified in the Sucwoa River estuary.
Permitted waste management discharges	Stream: State	LOW	N	No waste management discharge permits are associated with the Sucwoa River watershed.
Water quality	Stream: State	Not ranked – data gap	Y	**No water quality data available for the Sucwoa River,** apart from the six Regional Geochemical Stream Survey (2007) samples, which reported low risk values of uranium, fluoride, and pH.

				Additional data is necessary to rate the water quality risk. Interviews with local experts indicate no reason to suspect significantly degraded water quality given history of the watershed (with the exception of intergravel DO levels).
Off-Channel habitats	Stream: State	Not ranked – data gap	Y	Anecdotal evidence indicated some off-channel habitat is available for juvenile rearing; however, ground-truthing of this habitat is required. **Requires further field work.**
Water temperature: Juvenile rearing and migration	Stream: State	Not ranked – data gap	Y	**No water temperature data available outside of the fall swim survey period.** This metric important to understand water temperature's influence on emergence timing and potential egg freezing events during winter low flows.
Stream discharge	Stream: State	Not ranked – data gap	Y	**No discharge data available for the Sucwoa River.**
Estuary chemistry and contaminants	Estuary: State	Not ranked – data gap	Y	**No water quality data (with the exception of historical pH, salinity, and temperature information) available for the Sucwoa River estuary.** Given industrial history of this estuary, impacts from degraded water quality likely persist.
Estuary dissolved oxygen	Estuary: State	Not ranked – data gap	Y	**No DO data available for the Sucwoa River estuary.** Given historical log handling initiatives in this zone a fiber mat likely exists in the subtidal zone. These fiber mats are known to result in reduced DO levels in the marine environment (Picard et al, 2003)
Accessible stream length	Stream: State	N/A	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.
Key spawning areas (length)	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 impacts of a degraded riparian zone on channel stability in the Sucwoa River, restoration efforts should be focused on both reclaiming these zones through riparian treatments and conducting appropriate instream works to stabilize actively eroding channel banks.

5.1.1 Riparian Treatments

Riparian restoration is recommended for riparian stands that are currently in an early regenerating, deciduous or regenerating state (Figure 36). Specific areas of concern include the deciduous-dominated left and right banks between counting stations 1 and 2, and right bank downstream of counting station 3. Note that additional riparian treatment opportunities exist upstream of counting station 6; however, restoration lower down in the watershed would target more critical habitats for all species observed in this river.

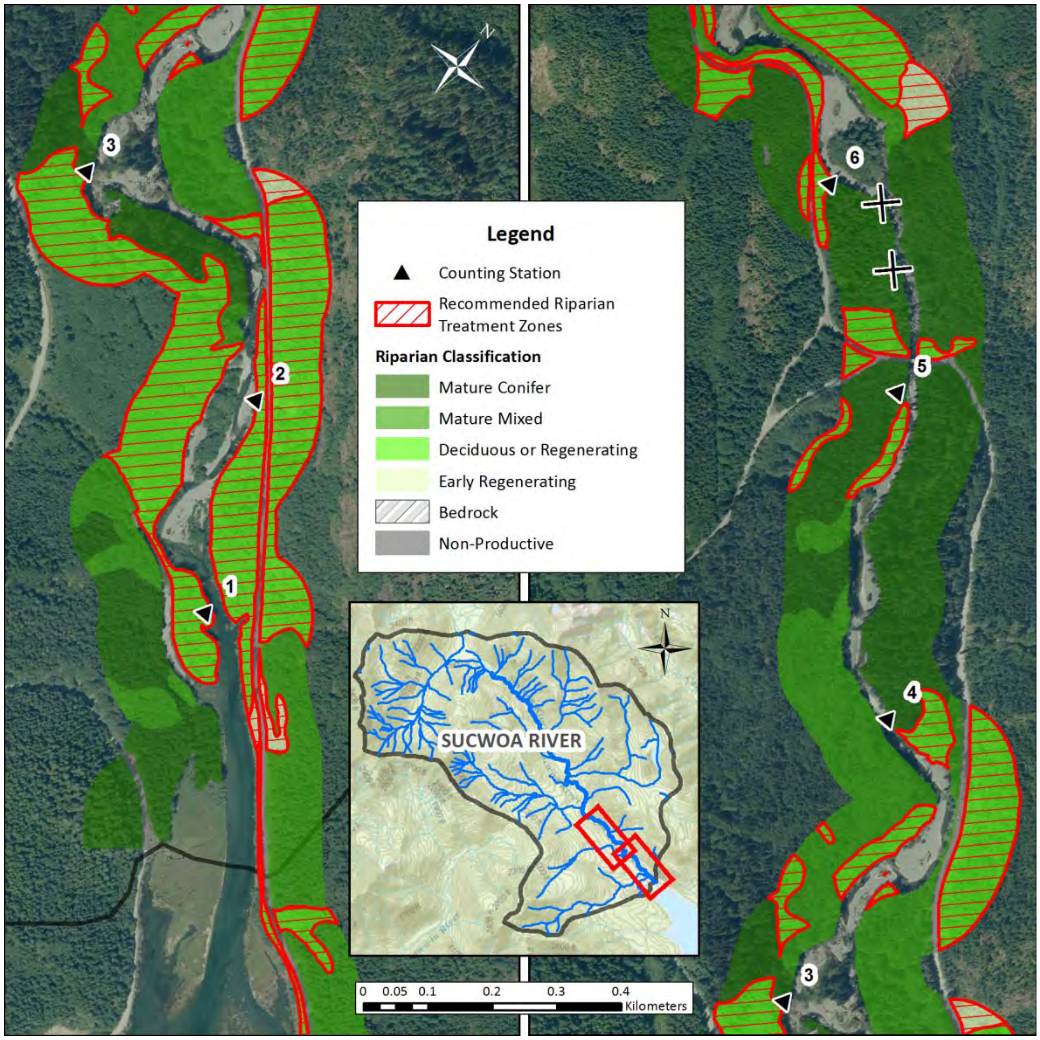

Figure 36. Recommended riparian treatment zones for the Sucwoa River.

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

- Conifer release: treatment removes competing overstory 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.

A riparian restoration prescription for the Sucwoa River has already been produced (McGeough, 2010) and it is recommended that this plan be carried out as soon as funds are available.

5.1.2 Channel Stabilization

Two locations have been identified as candidates for instream stabilization works along the right bank of the Sucwoa River (Figure 37). These locations include the eroding left bank between counting stations 3 and 4, and the right bank immediately downstream of counting station 3.

An analysis of air photos and interviews with local experts indicated continued erosion along the right bank between counting stations 3 and 4. The known presence of clay in this bank presents further risk to downstream habitat through the infilling of interstitial spaces with fines. Stabilization of this bank would prevent the future deposition of fines and also protect the adjacent road prism.

Bank erosion immediately downstream of counting station 3 has resulted in a loss of approximately 70m x 35m of the right bank. While this feature is inherently protected by a large debris jam, a field assessment is necessary to confirm whether it is adequately protected and if stabilization works may be required.

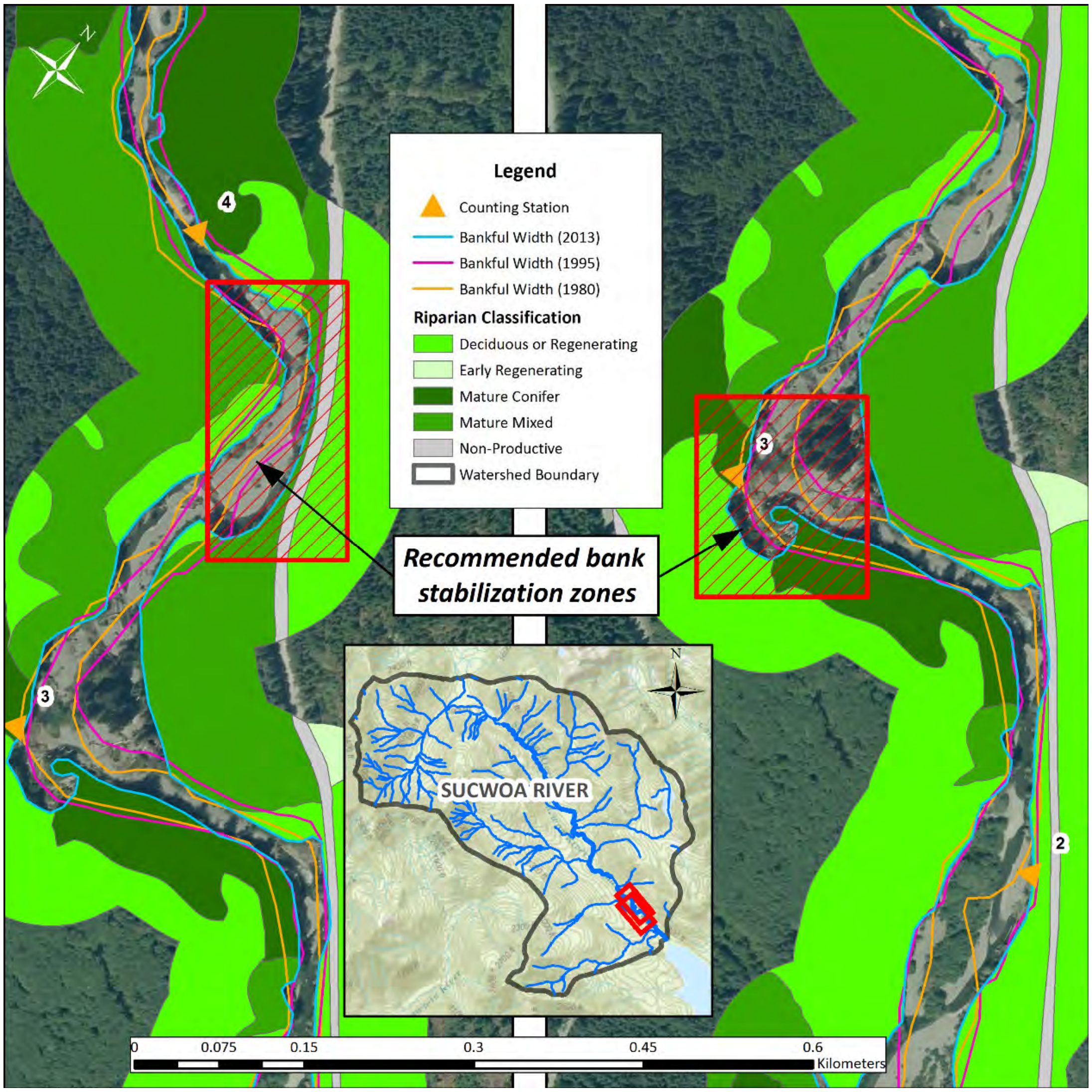

Figure 37. Proposed bank stabilization zones in the Sucwoa River.

Potential instream methods that could be employed to stabilize the banks identified in Figure 37 include the construction of groynes, debris catcher, and / or the installation of large woody debris revetments. Photo 6, Photo 7, and Figure 38 show examples of both groyne and woody debris revetment installations to protect existing eroding channel banks.

Photo 6. Rock groynes constructed on an eroding left bank in the Phillips River.

Photo 7. Large woody debris revetments installed on an eroding left bank of the Eve River.

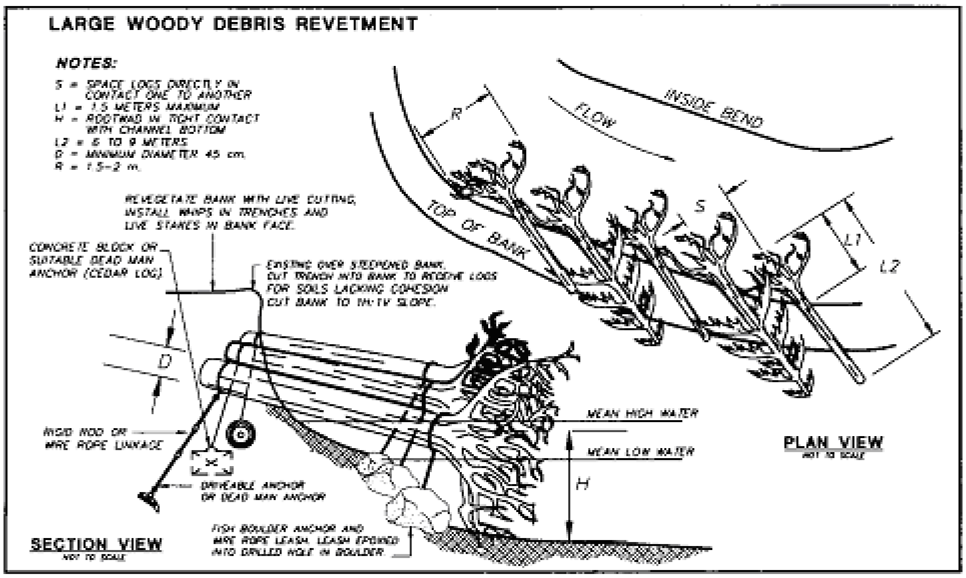

Figure 38. Typical large woody debris revement installation (Slaney & Zaldokas, 1997).

For the sites identified above, it is recommended that a fluvial geomorphologist conduct a field assessment and develop a design to restore the channel stability. Instream methods should be combined with riparian treatments to address both short and long-term channel stability.

5.1.3 Estuary Reclamation

Identifiable impacts to the Sucwoa River estuary included the active industrial land occupying approximately 400m of the foreshore on the west side of the estuary, as well as the road bordering the estuary on both sides, and the log booming grounds on the west shore extending from 100m to 600m south of the river delta. Without a field assessment of historical log handling impacts, insufficient information is available to propose any reclamation or restoration works within the estuary. Potential habitat restoration or enhancement in the estuary could include salt marsh and eelgrass habitat creation, where suitable transplant sites exist. Photo 8 shows an example of transplanted salt marsh habitat on reclaimed foreshore at the East West Bay log handling facility (near Campbell River, B.C.).

Photo 8. Example of reclaimed salt marsh habitat as part of a foreshore pullback at the East West Bay log handling facility.

A detailed survey of the Sucwoa River estuary is recommended to identify impacts from historical log handling (i.e. wood waste accumulation) and riparian logging (i.e. excessive sediment deposition burying salt marsh and / or eelgrass beds). If impacts are identified, suitable sites for salt marsh and / or eelgrass habitat creation should be located.

5.1.4 LWD Placement

Previous studies have identified that the in-stream placement of LWD can increase the habitat capacity and subsequent productivity levels of coho and chinook salmon (Polivka et al, 2014). Given the Sucwoa River 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 9. Data gaps and recommended studies for habitat indicators in the Sucwoa River.

Data Gap	Priority	Recommendation
Subtidal estuarine habitat condition	High	Conduct a detailed subtidal habitat study of the estuary, 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. Considering the close proximity of log handling to the estuary, some degradation of subtidal estuarine habitat is likely.
Estuary chemistry and contaminants	High	
Estuary dissolved oxygen	High	
Channel stability	High	Ground-truth key eroding sections and have channel stability assessed by a fluvial geo-morphologist.
Intergravel flows and DO levels	High	Direct field efforts to collect this intergravel flow and DO data at known spawning grounds.
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. Use field data of tributary locations to classify riparian vegetation using most recent high resolution orthophotographs. Extract additional information from WFP's 3D orthophotographs. Ground truthing of all riparian stand ages required.
Large woody debris	High	Ground-truth LWD for functionality and assess submerged LWD not visible from orthophotographs.
Species-specific holding and spawning habitat throughout the anadromous length of river.	Moderate	Conduct a snorkel survey throughout the anadromous reach of the river focused on geo-referencing known holding and spawning grounds.
Key spawning areas (length)	Moderate	Collect GPS coordinates of upstream and downstream extents of known spawning grounds.
Stream discharge	Moderate	Install a hydromet station on the Sucwoa River to measure continuous discharge and temperature information.
Water temperature	Moderate	
Watershed road and stream crossing condition	Moderate	Conduct a detailed culvert assessment to identify potential fish passage issues with modeled crossings; in addition, note the condition of roads (i.e. de-activated, overgrown, etc.) to provide further information with respect to the road density metric.
Water quality (instream)	Low	Collect point-sample water quality data and begin to compile a database of water quality data.

Upper watershed tributary stability	Low	Have a fluvial geo-morphologist assess terrain stability in upper tributaries to identify future sediment sources (both location and potential relative quantities).

5.3 Best Functioning Habitats Requiring Protection

The protection of existing functioning habitats is important to maintain existing fish productivity levels and prevent the loss of these important zones. Figure 39 summarizes all of the known spawning, holding, and juvenile rearing and migration habitat identified during this assessment. All of these habitats have been considered critical and therefore require consideration and protection from future industrial initiatives. Monitoring of these locations on a periodic basis is also recommended to determine if these habitats are improving or degrading over time.

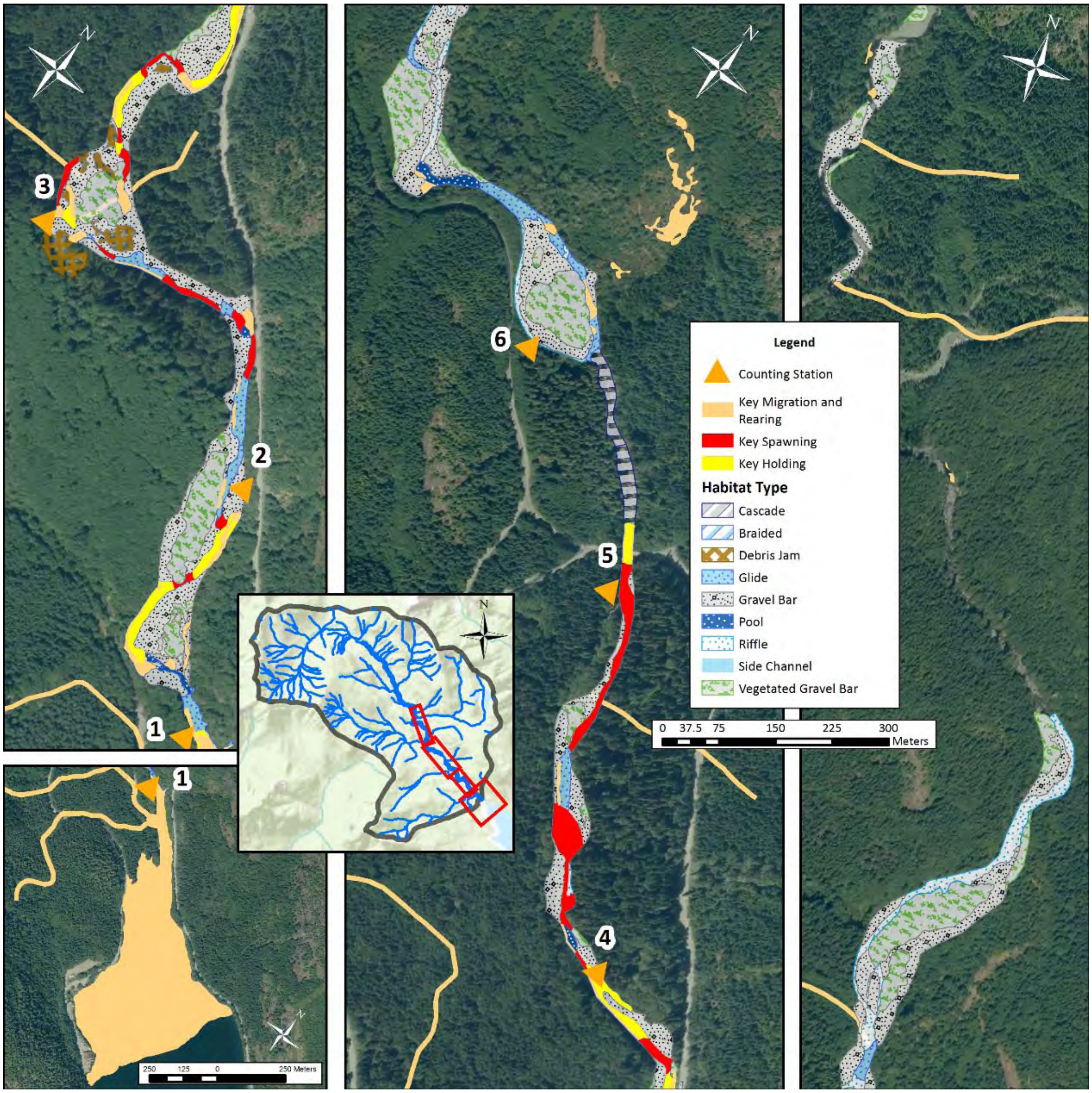

Figure 39. Best functioning (i.e. critical) habitats in the Sucwoa River watershed that are recommended for protection. See Figure 11 for full extent of known migration and rearing habitat for coho (tributaries).

6.0 CONCLUSION

The Sucwoa River watershed remains highly degraded from historical logging practices removing riparian vegetation to the stream banks. Based on unstable alluvial channel that resulted from historical riparian logging, observable recovery of the Sucwoa River was estimated to take 20 years (Horel, 2008).

The habitat status assessment for the Sucwoa River watershed has identified high risk habitat indicators to be high total land cover alterations adjacent to fish habitat, riparian disturbances, persistence of a degraded riparian zone due to channel bank instabilities, negative changes in habitat composition (i.e. loss of pool habitat) due to upstream sediment sources, a lack of functional LWD, and estuarine impacts. Important data gaps to note include estuarine water quality and subtidal habitat condition, off-channel habitat condition, and intergravel flows and DOs in key spawning grounds.

Both riparian and instream restoration opportunities have been provided in response to the results of this assessment. Potential riparian treatment areas have been identified on the right bank downstream of counting station 3, and the left and right banks between counting stations 1 and 2. The eroding right bank immediately downstream of counting station 3 and the left bank upstream of counting station 3 were selected as candidates for bank stabilization through groyne construction and / or LWD revetment placement.

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, off-channel habitats, and estuarine habitat condition is necessary to obtain a more comprehensive understanding of limiting factors in the Sucwoa River watershed.

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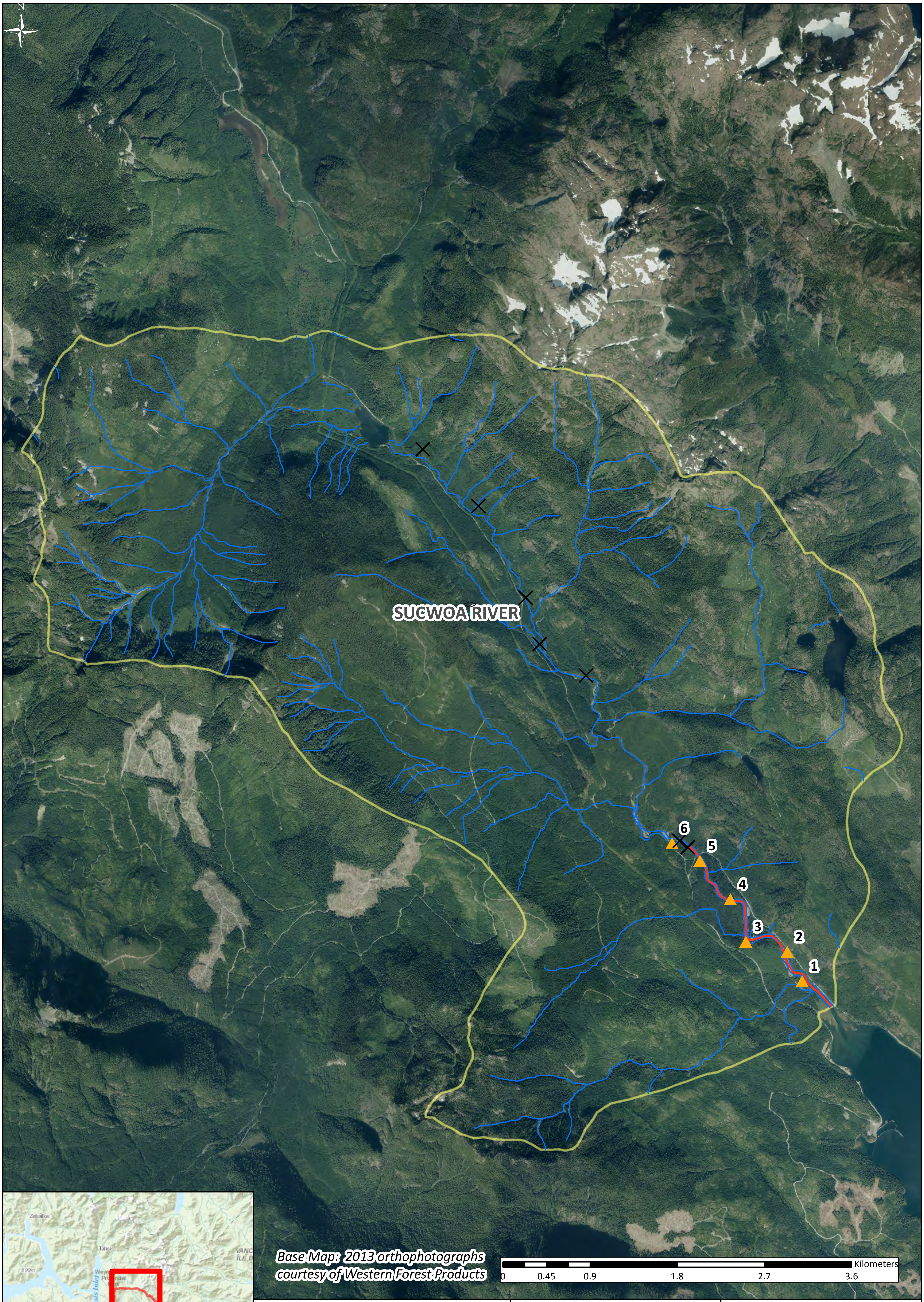
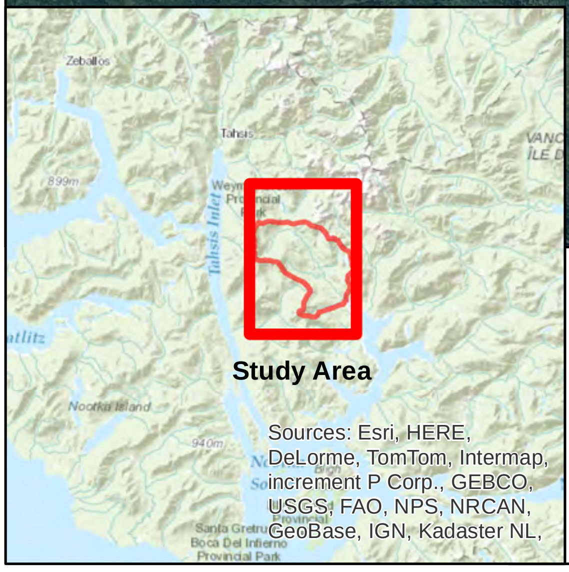
APPENDIX 1: SUCWOA RIVER WATERSHED MAP ATLAS





Legend

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

Prepared For: Nootka Sound Watershed Society

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

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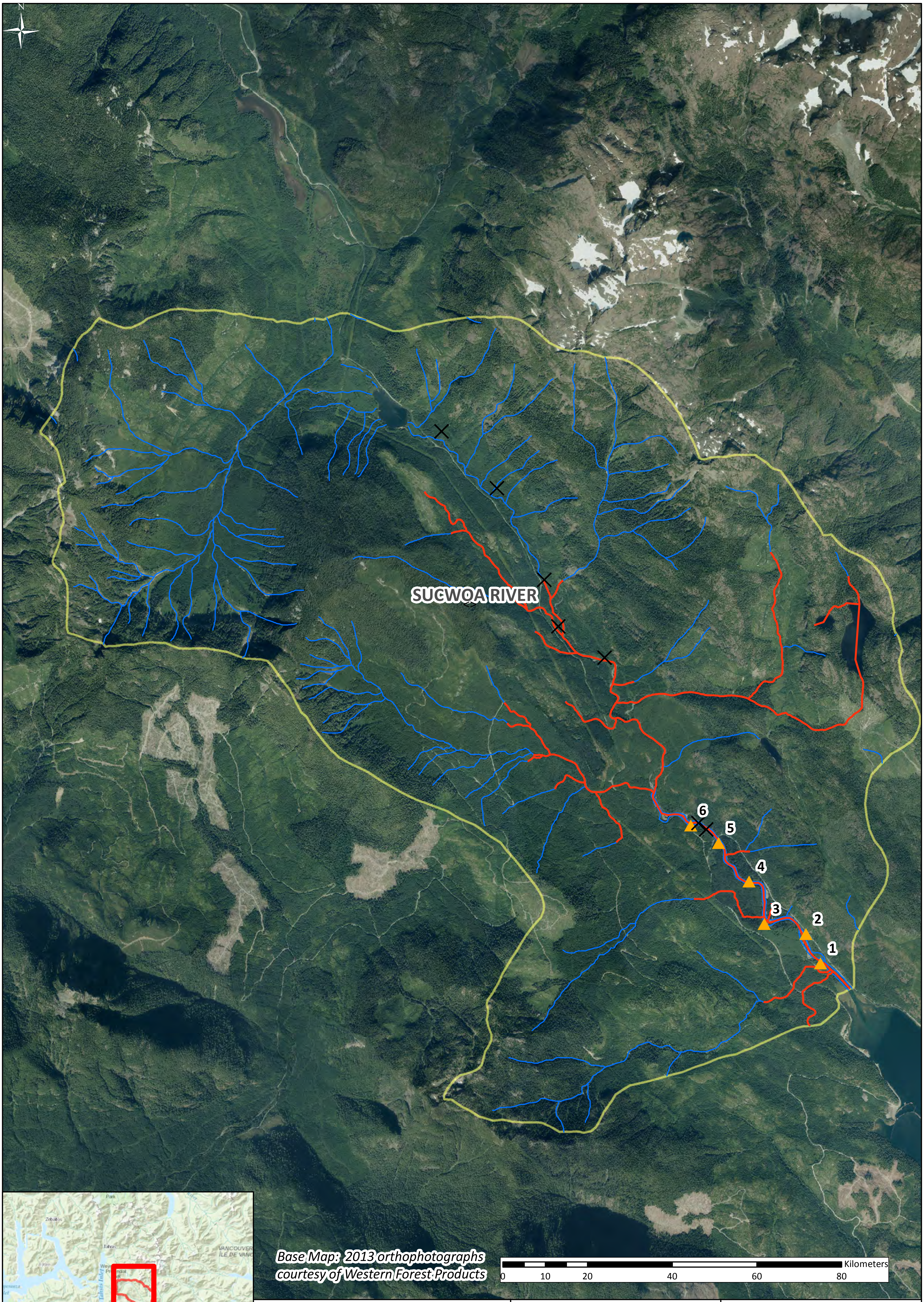
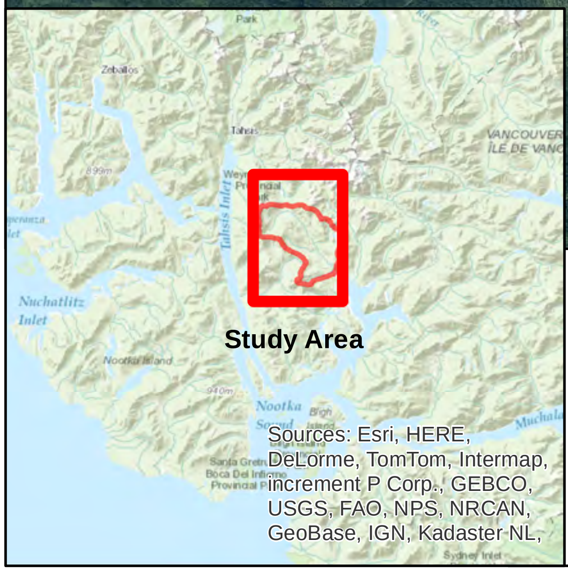
MAP 1

Sucwoa River Watershed Known Chinook Distribution





Legend

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

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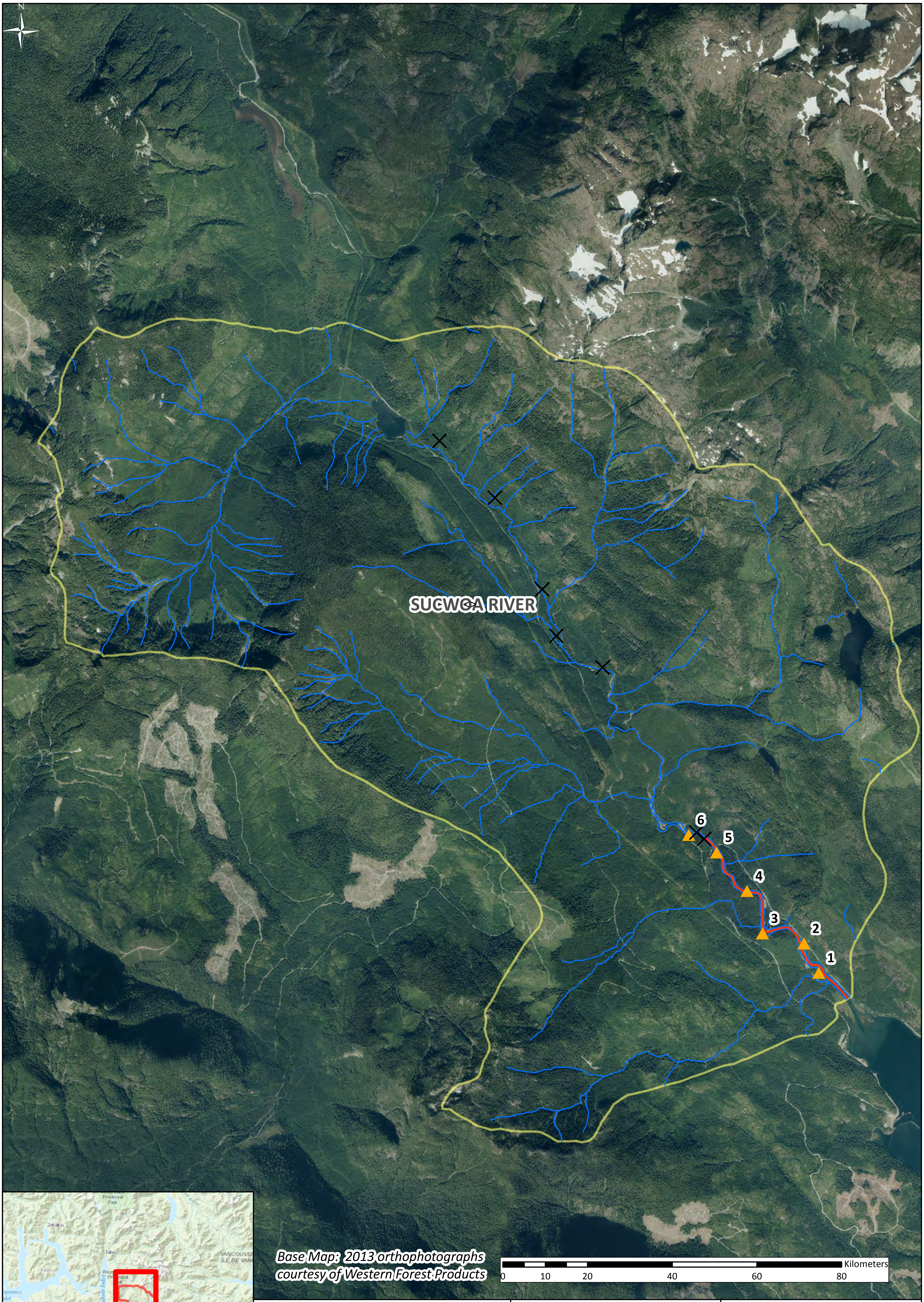
MAP 2

Sucwoa River Watershed Known and Inferred Coho Distribution



Legend

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

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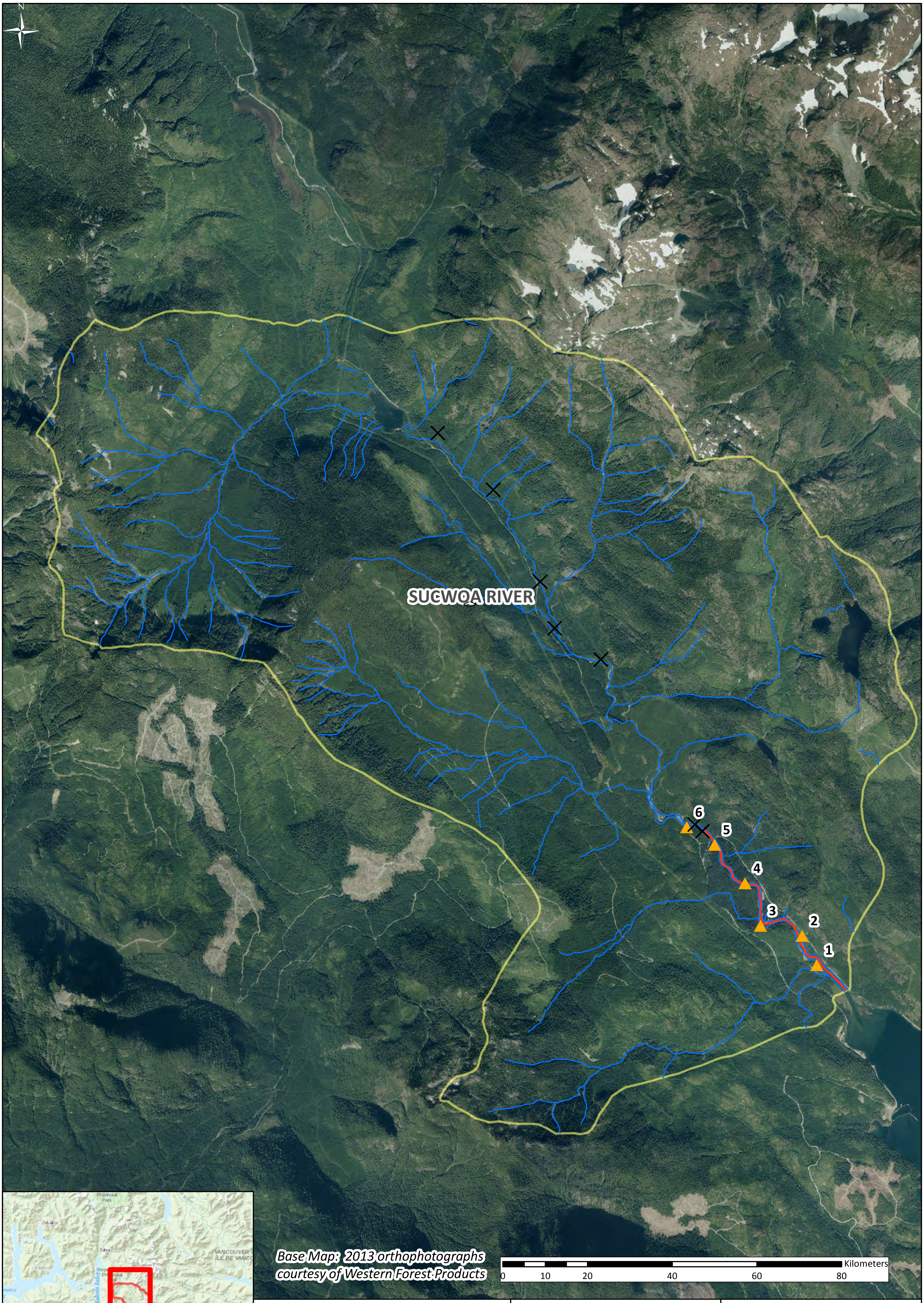
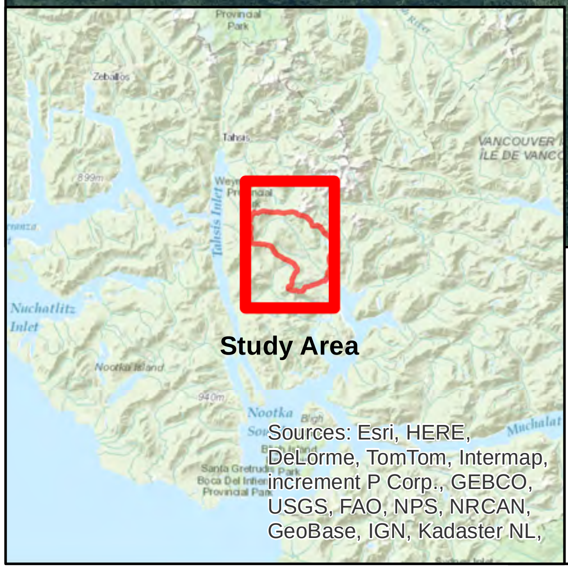
MAP 3

Sucwoa River Watershed Known Sockeye Distribution





Legend

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

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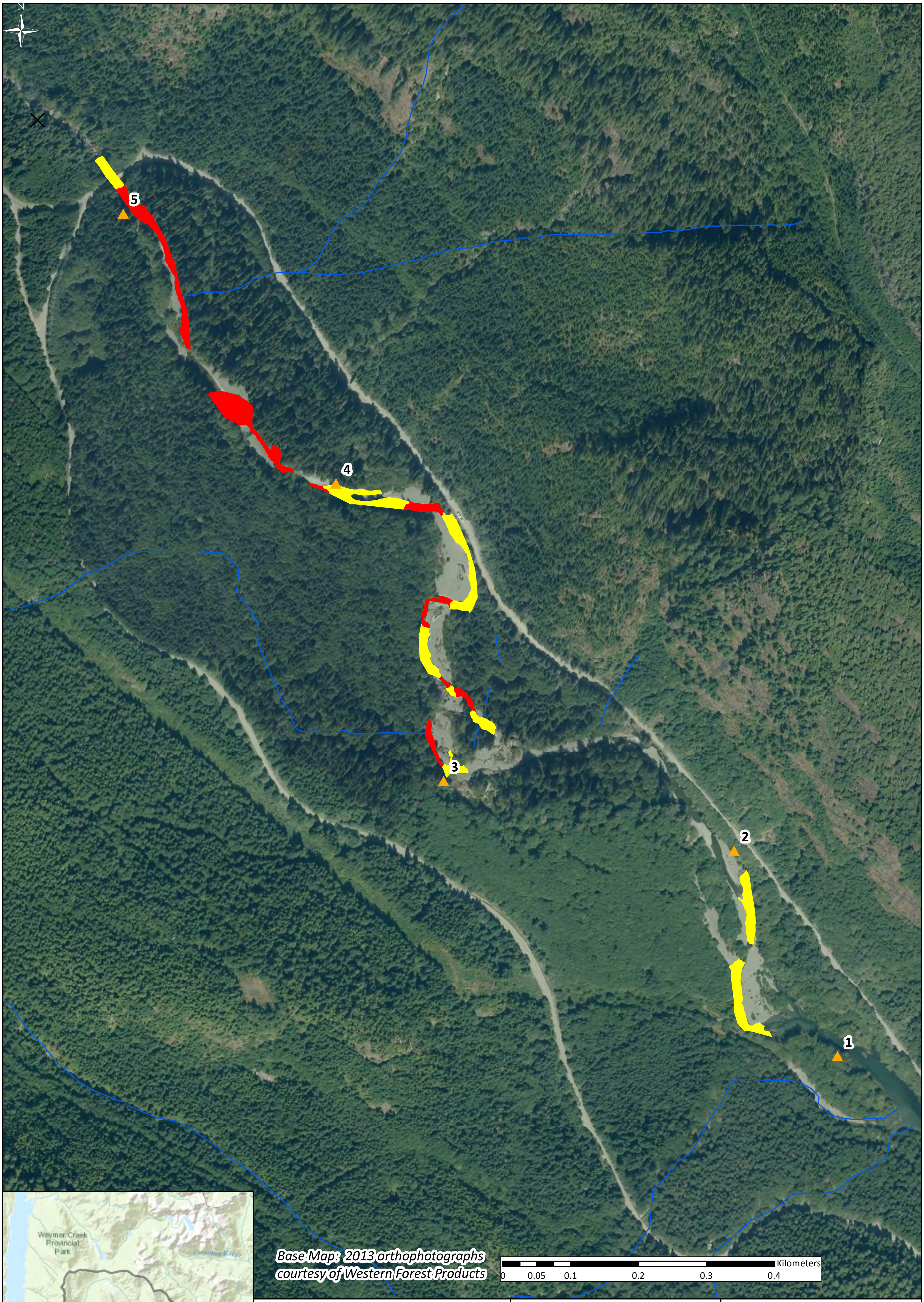
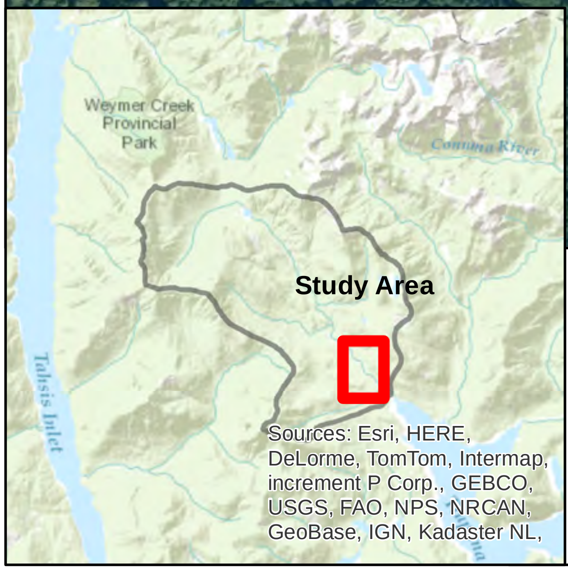
MAP 4

Sucwoa River Watershed Known Chum Distribution





Legend

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

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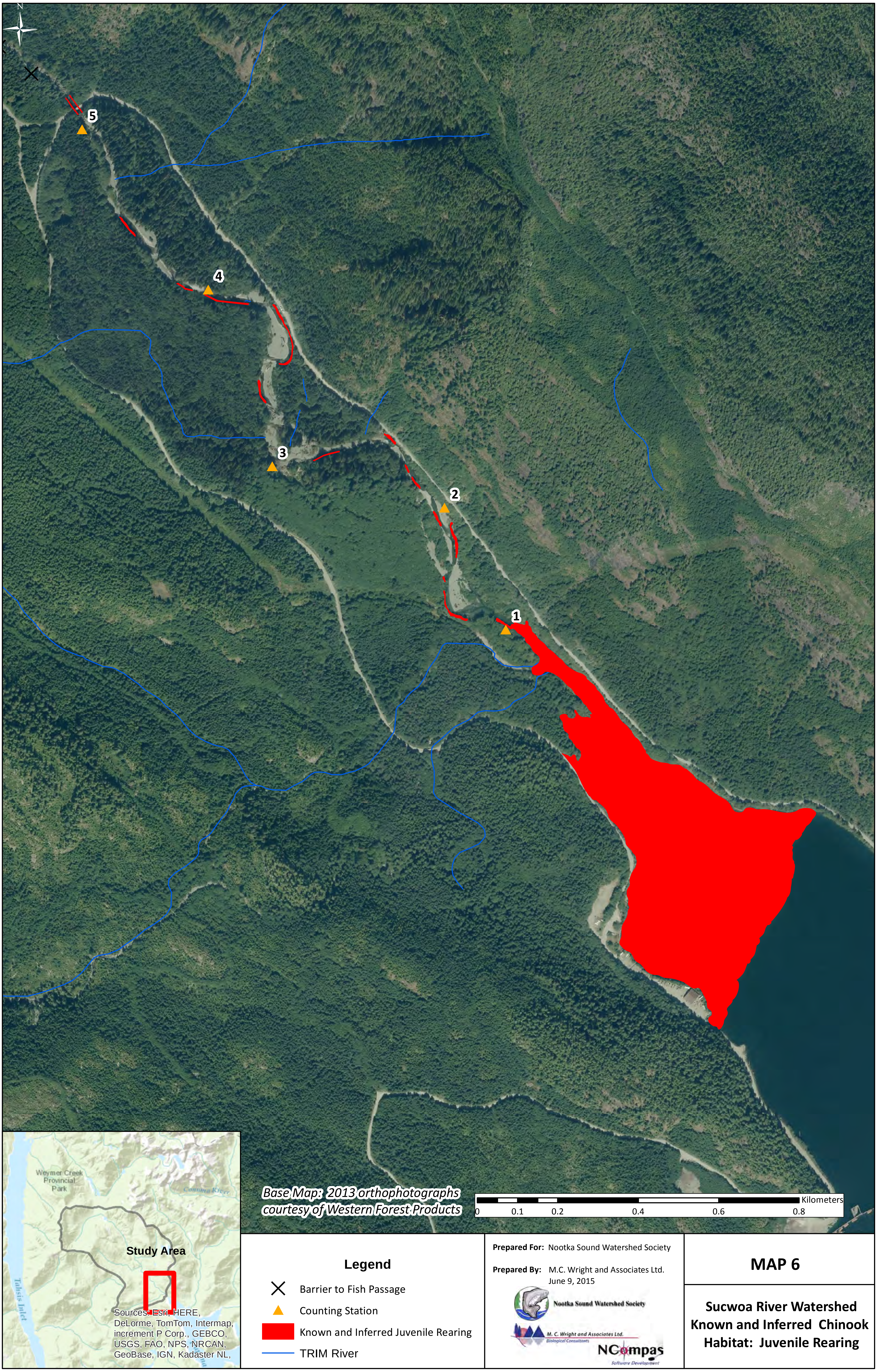
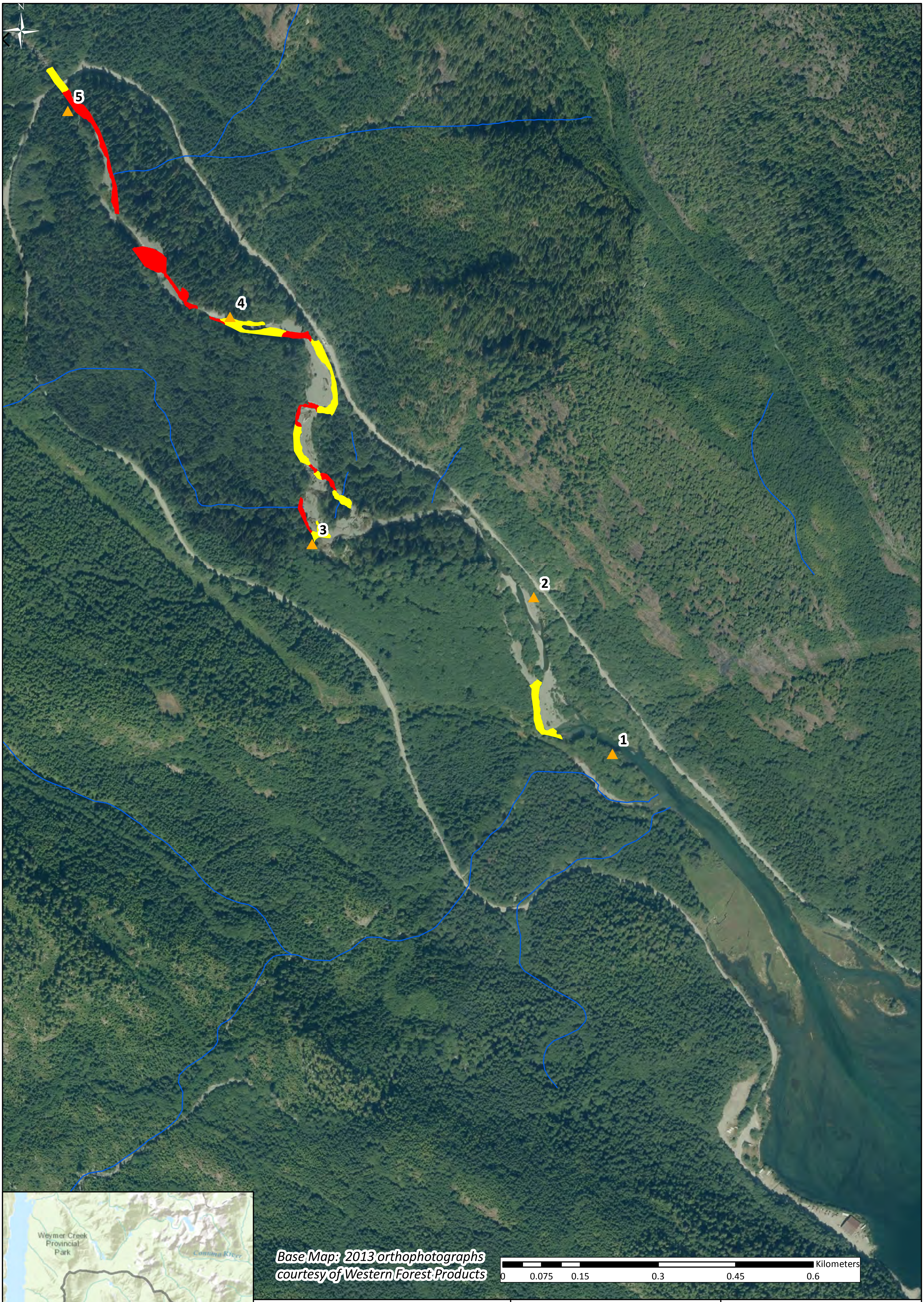
MAP 5

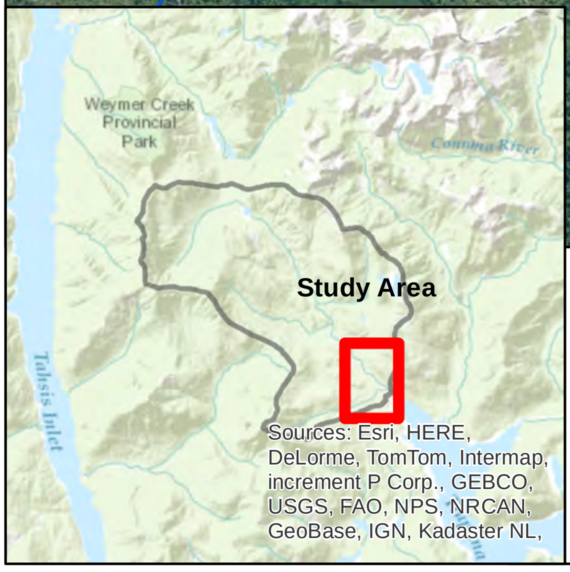
**Sucwoa River Watershed
Known Chinook Habitat:
Adult Holding and Spawning**



MAP 6

Sucwoa River Watershed Known and Inferred Chinook Habitat: Juvenile Rearing





Legend

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

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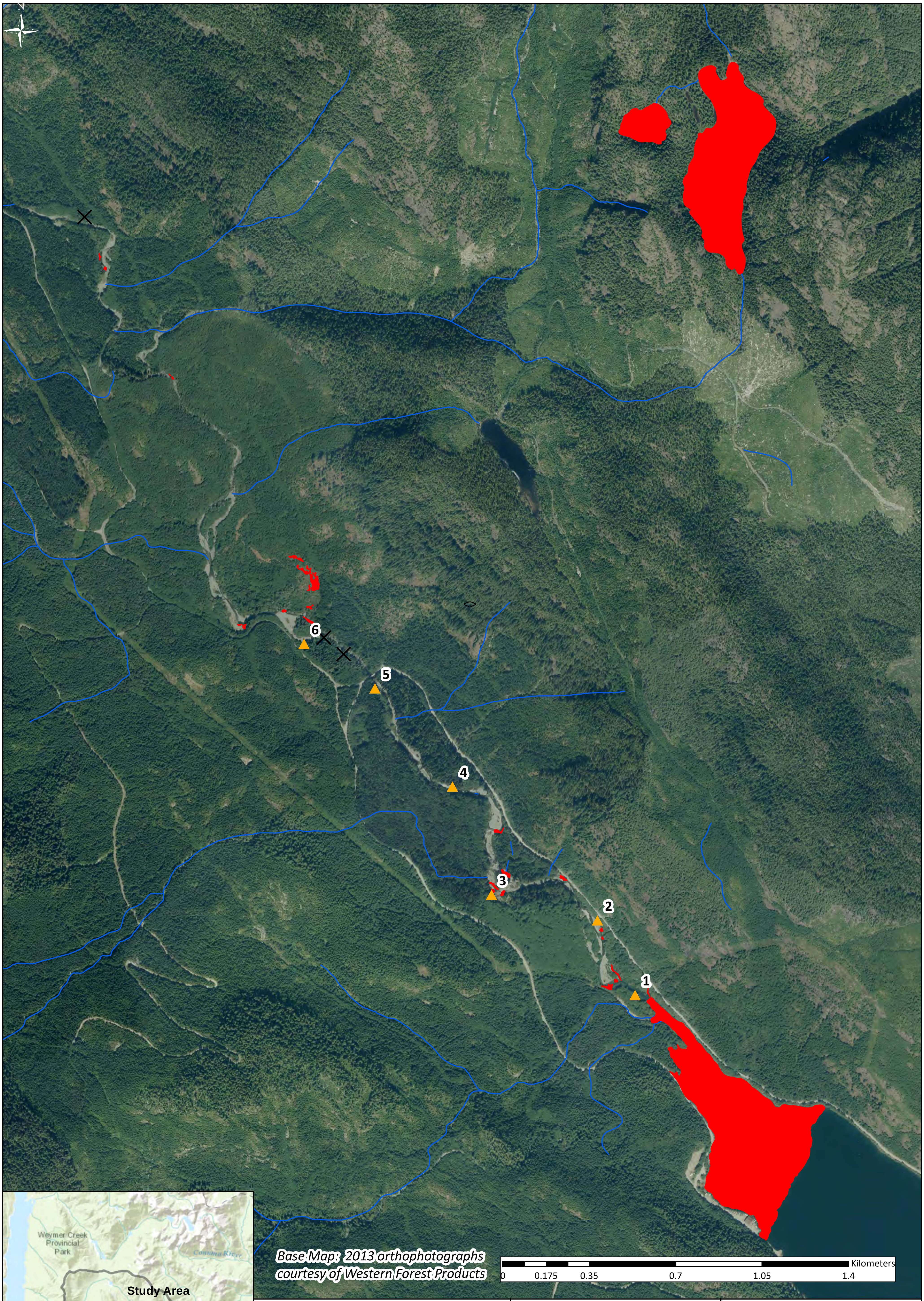
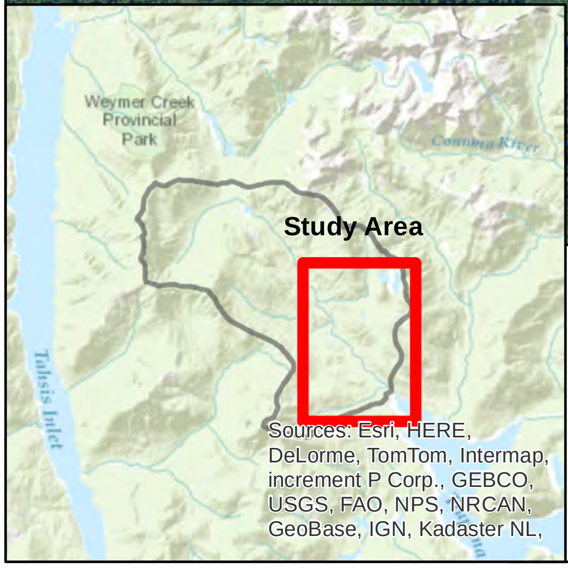
MAP 7

Sucwoa River Watershed Known Coho Habitat: Adult Holding and Spawning





Legend

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

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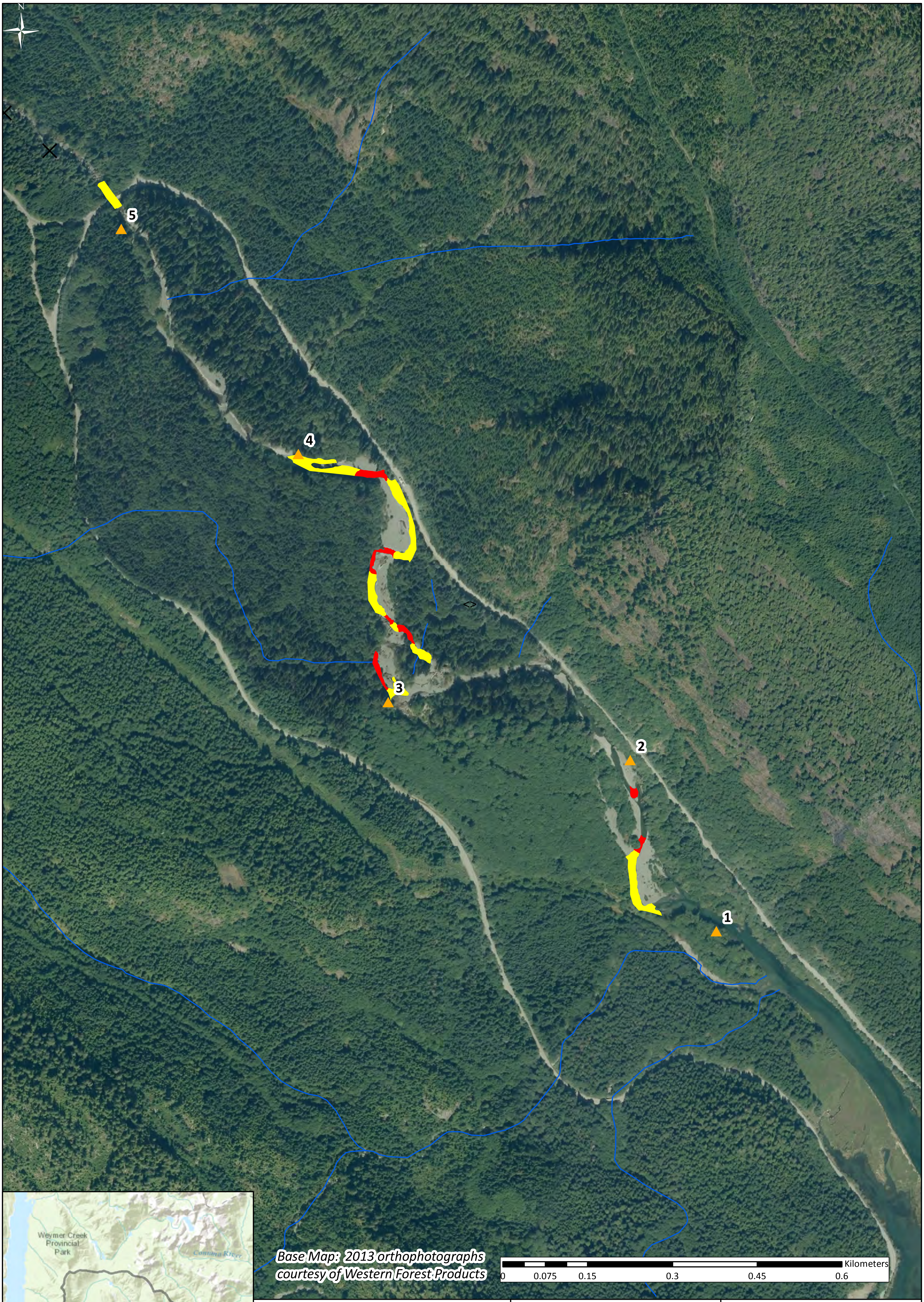
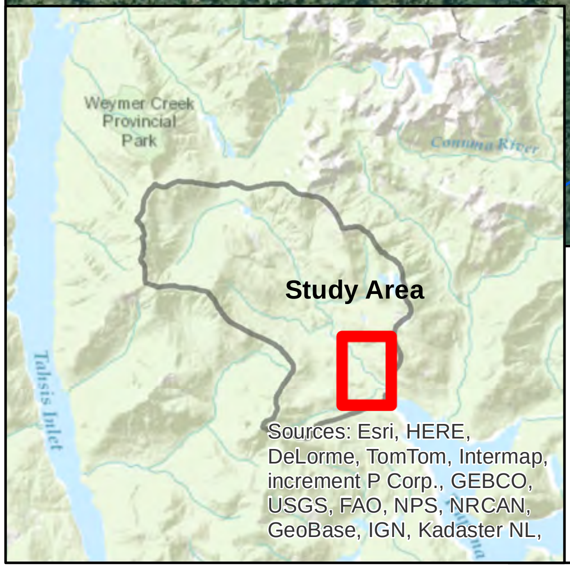
MAP 8

Sucwoa River Watershed Known and Inferred Coho Habitat: Juvenile Rearing





Legend

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

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June 9, 2015

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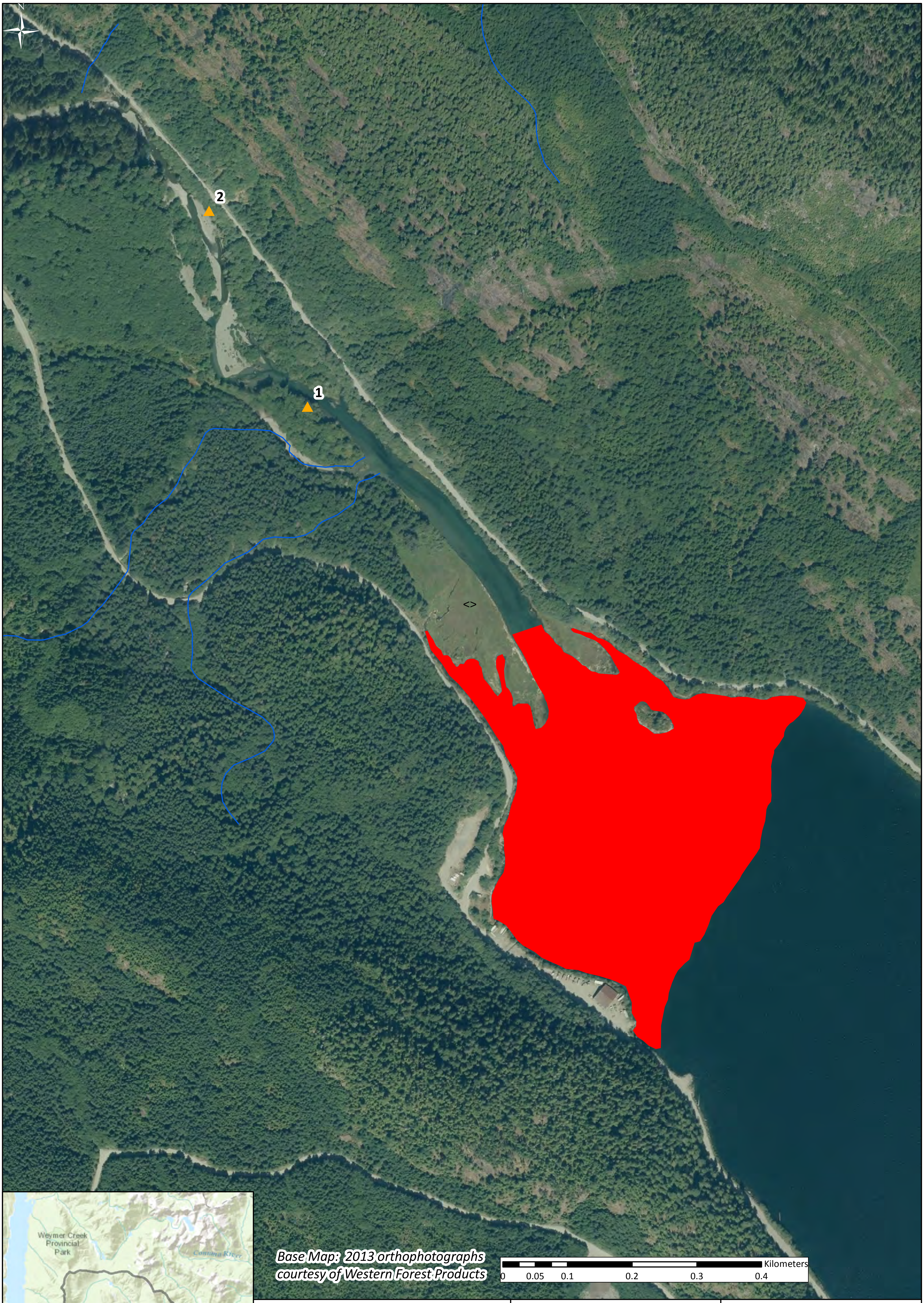
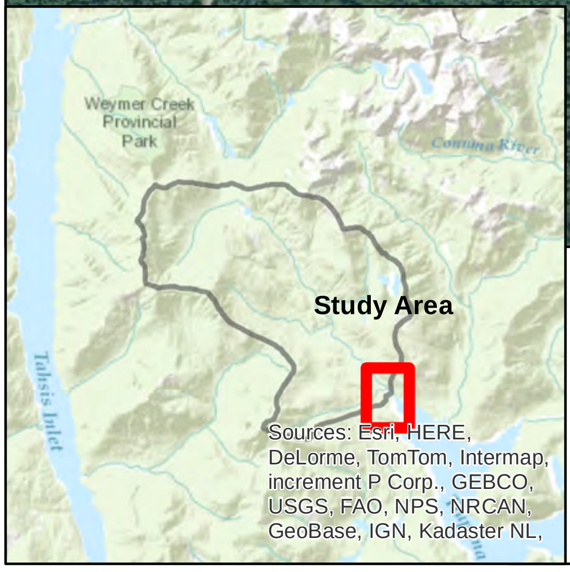
MAP 9

Sucwoa River Watershed Known Sockeye Habitat: Adult Holding and Spawning





Legend

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

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June 9, 2015

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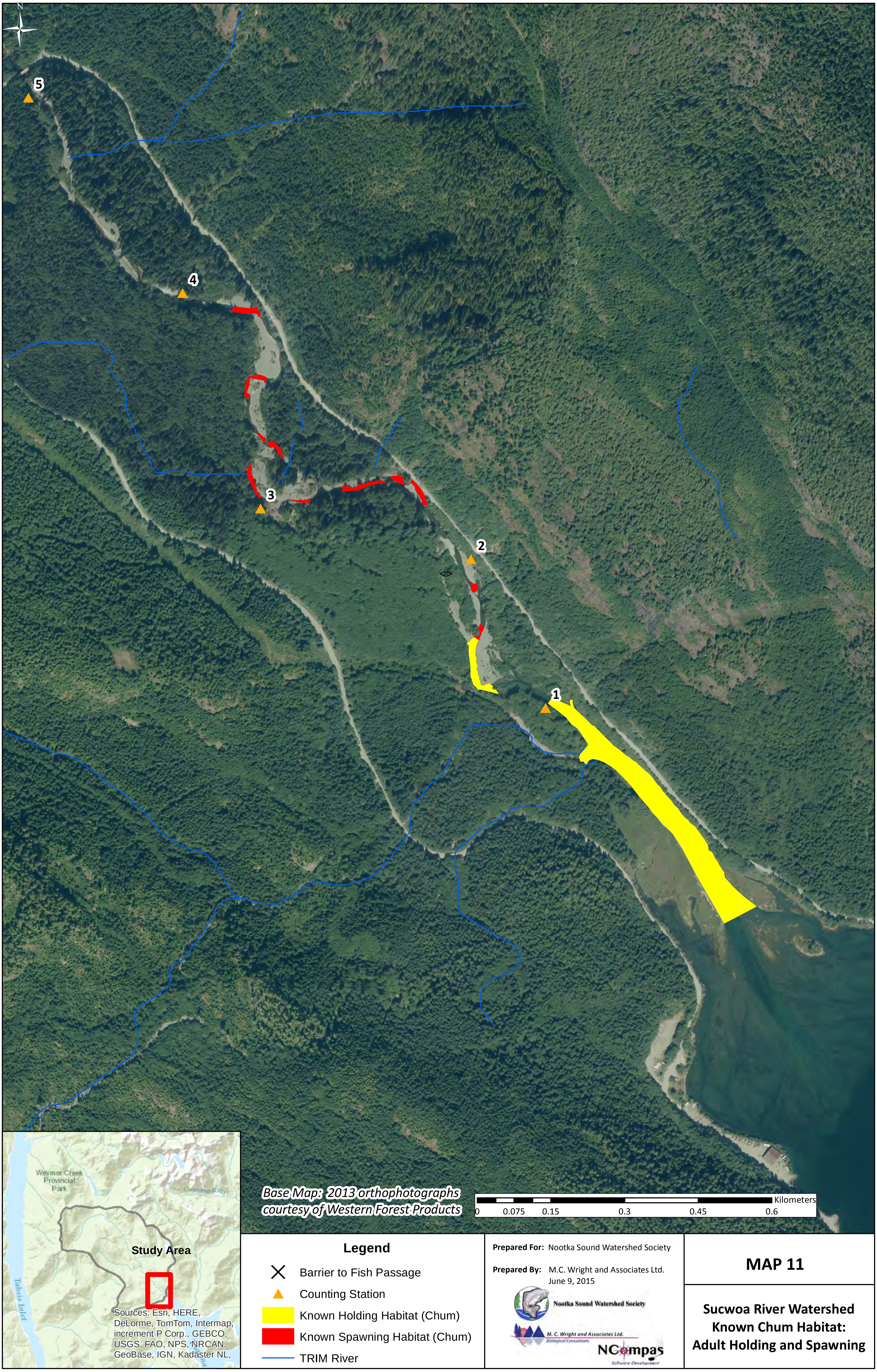
MAP 10

Sucwoa River Watershed Known Sockeye Habitat: Juvenile Rearing


5
4
3
2
1
Base Map: 2013 orthophotographs
courtesy of Western Forest Products
0 0.075 0.15 0.3 0.45 0.6
Kilometers
Weymer Creek Provincial Park
Tahsis Inlet
Study Area
Sources: Esri, HERE, DeLorme, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL,
Legend
Barrier to Fish Passage
Counting Station
Known Holding Habitat (Chum)
Known Spawning Habitat (Chum)
TRIM River
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
NCompas
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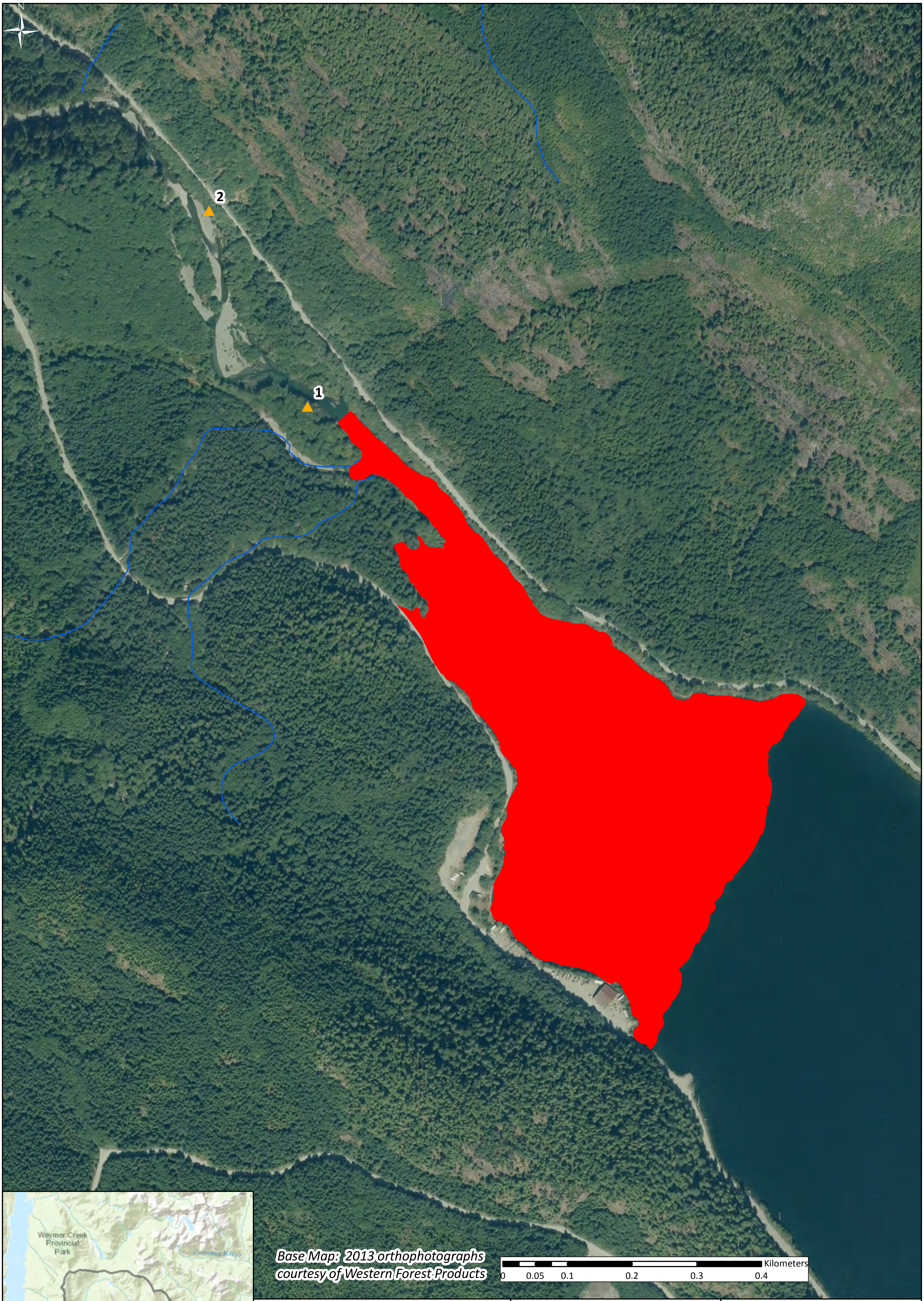
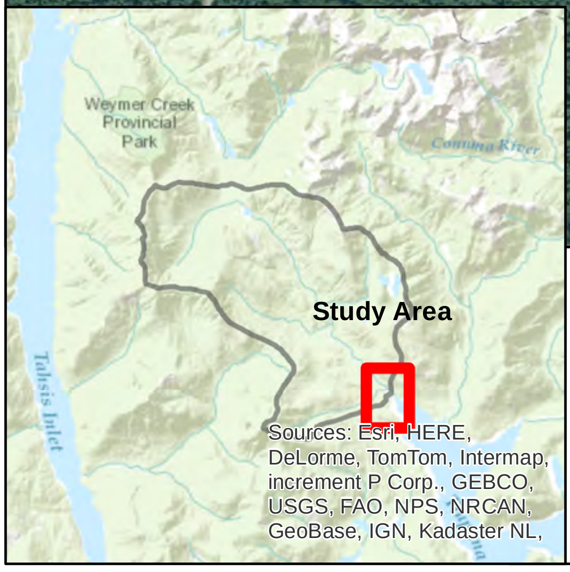
MAP 11
Sucwoa River Watershed
Known Chum Habitat:
Adult Holding and Spawning





Legend

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

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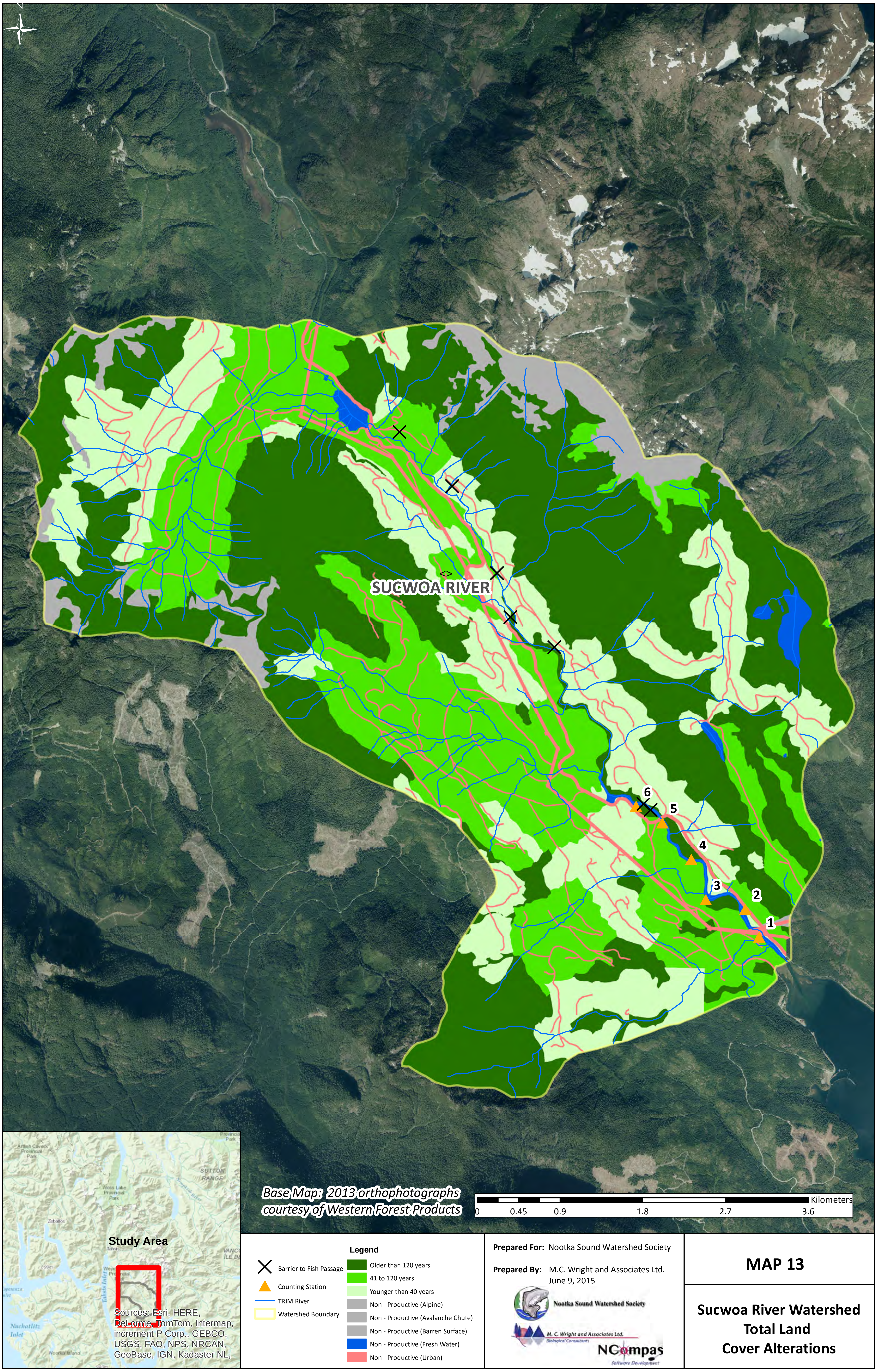
MAP 12

Sucwoa River Watershed
Known Chum Habitat:
Juvenile Rearing


SUCWOA RIVER
1
2
3
4
5
6
Base Map: 2013 orthophotographs
courtesy of Western Forest Products
Kilometers
0 0.45 0.9 1.8 2.7 3.6
Study Area
Sources: Esri, HERE, DeLorme, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL,
Legend
Barrier to Fish Passage
Counting Station
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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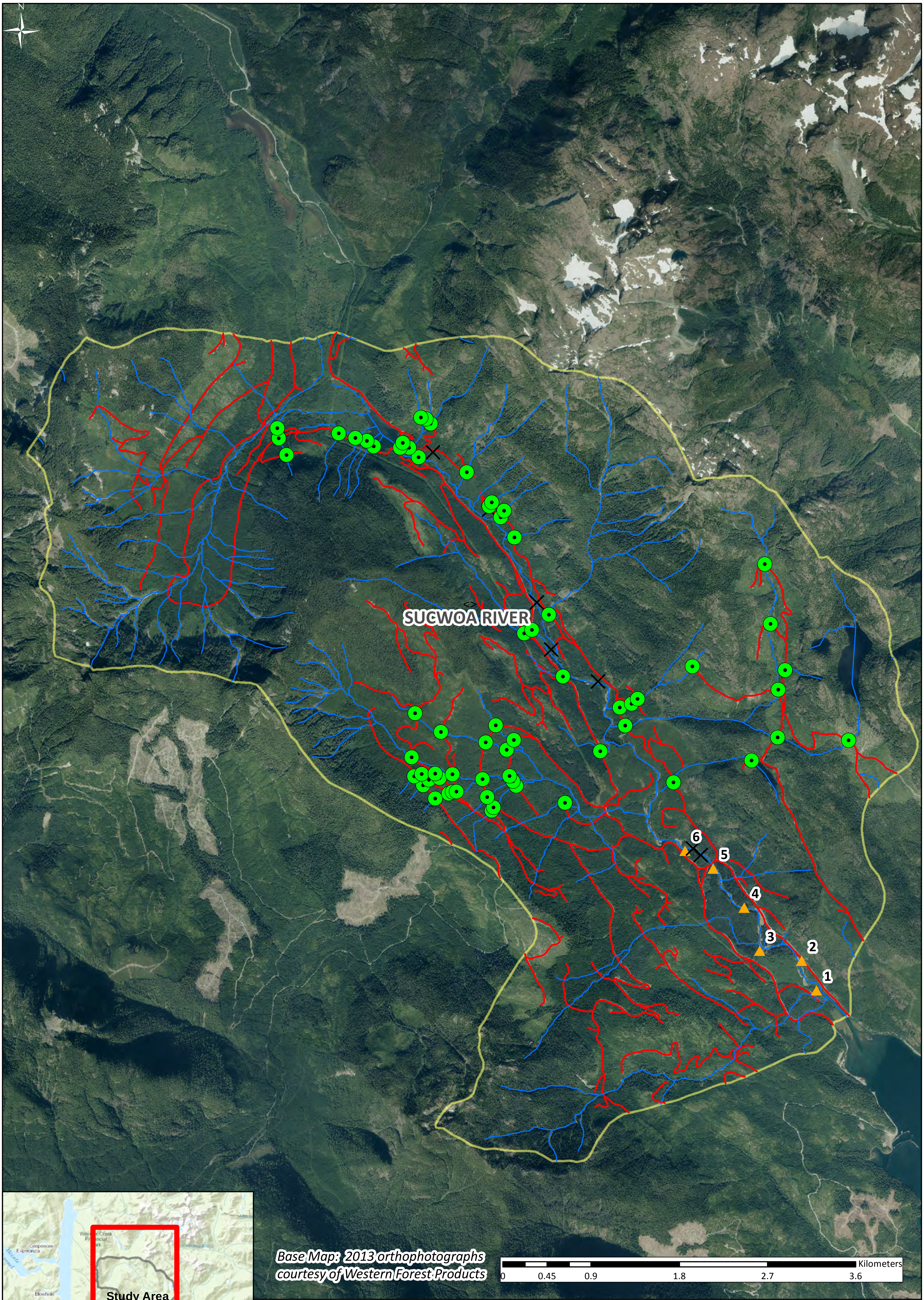
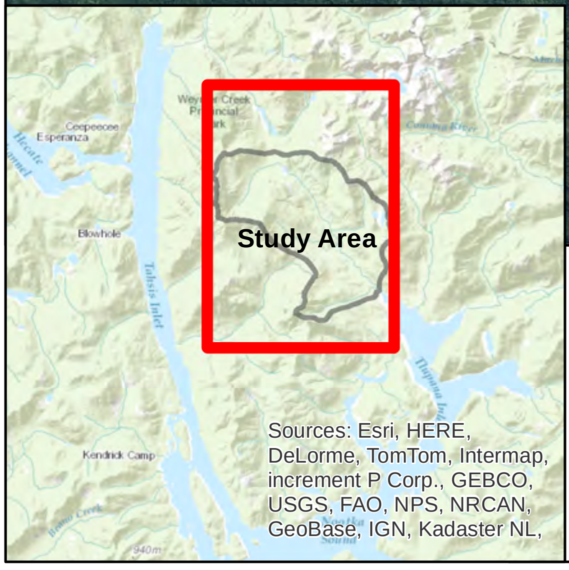
MAP 13
Sucwoa River Watershed
Total Land
Cover Alterations





Legend

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

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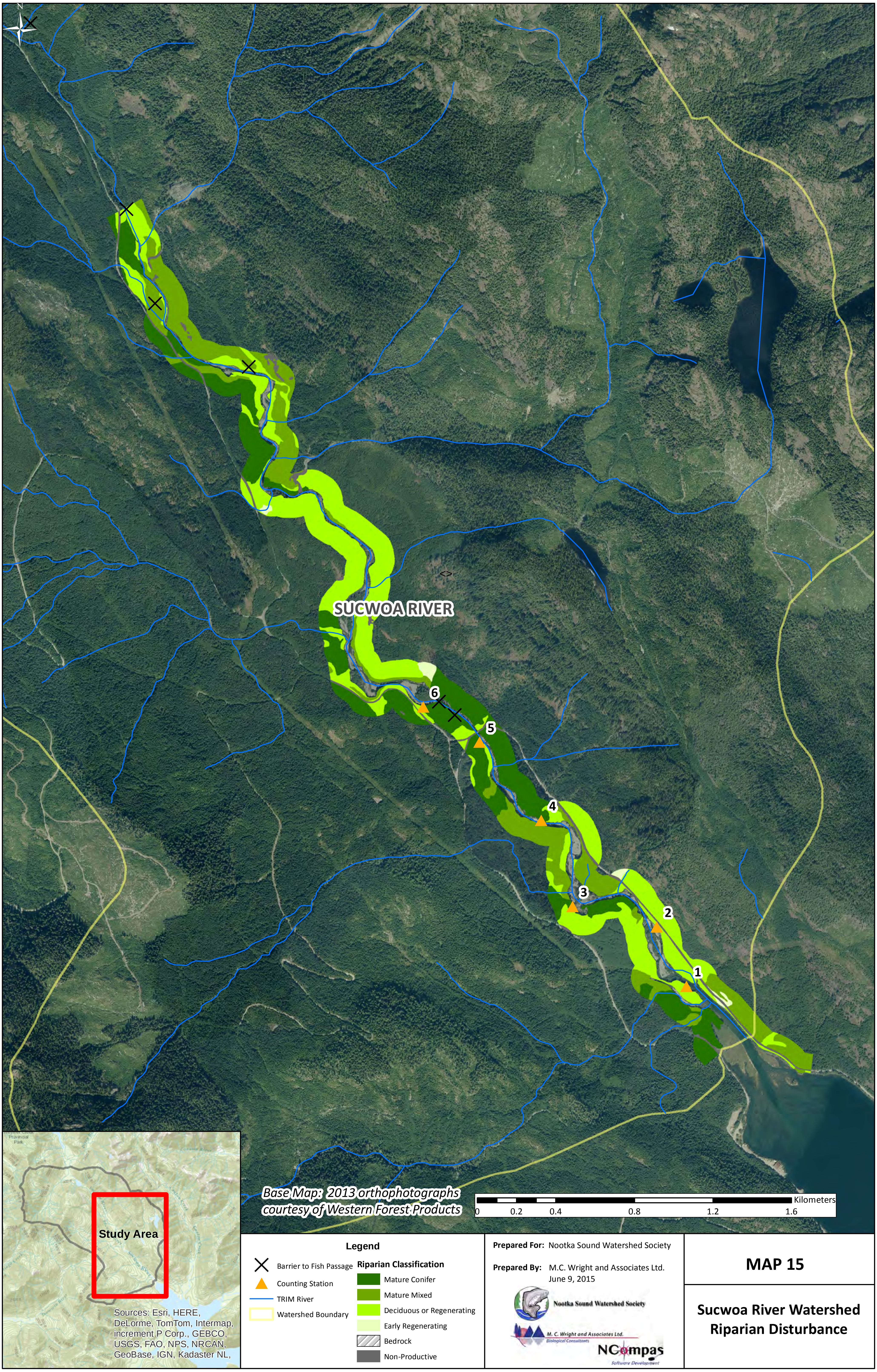
MAP 14

Sucwoa River Watershed Road Density and Stream Crossings



SUCWOA RIVER
1
2
3
4
5
6
Base Map: 2013 orthophotographs courtesy of Western Forest Products
Kilometers
0 0.2 0.4 0.8 1.2 1.6
Study Area
Sources: Esri, HERE, DeLorme, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL,
Legend
Barrier to Fish Passage
Counting Station
TRIM River
Watershed Boundary
Riparian Classification
Mature Conifer
Mature Mixed
Deciduous or Regenerating
Early Regenerating
Bedrock
Non-Productive
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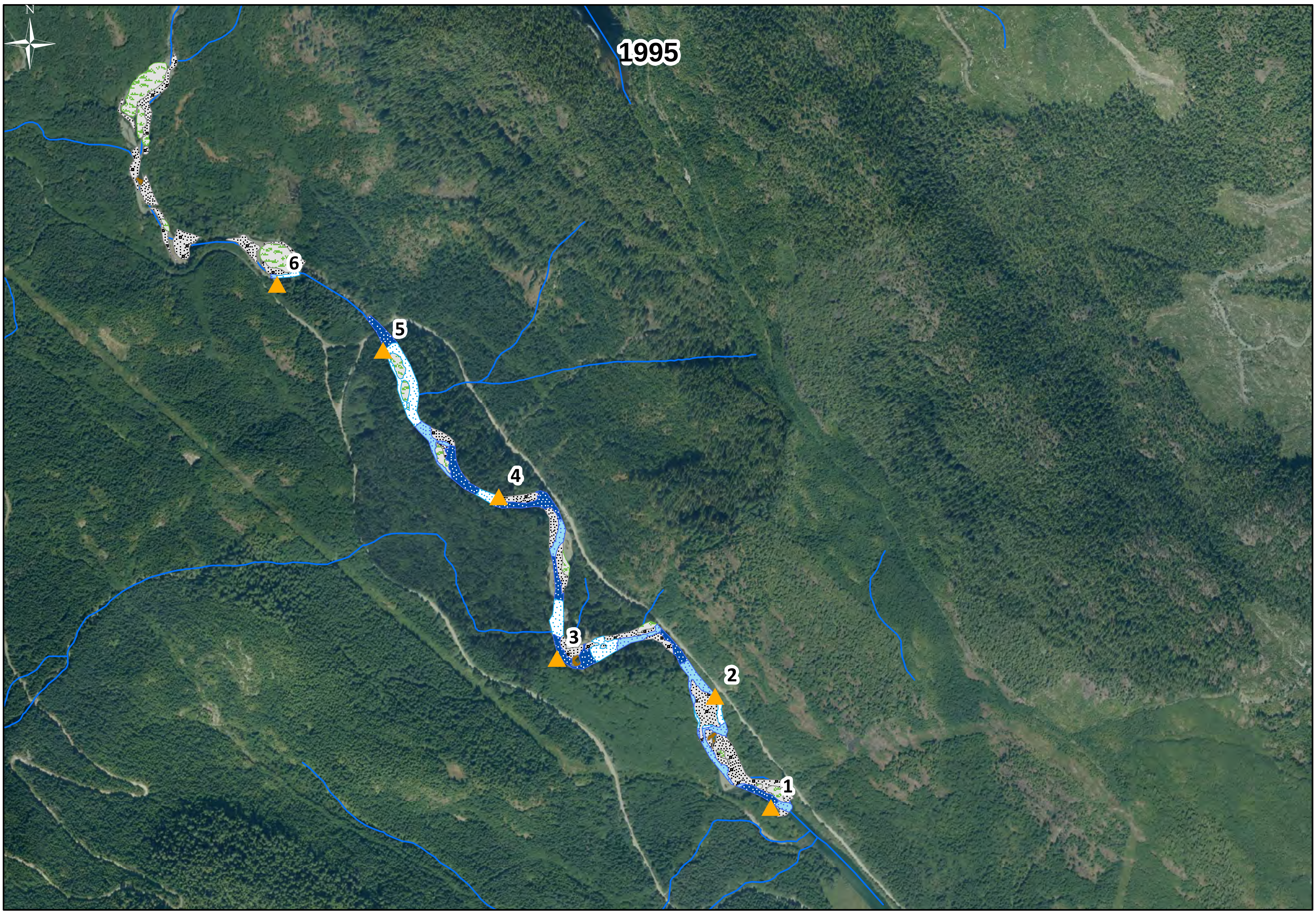
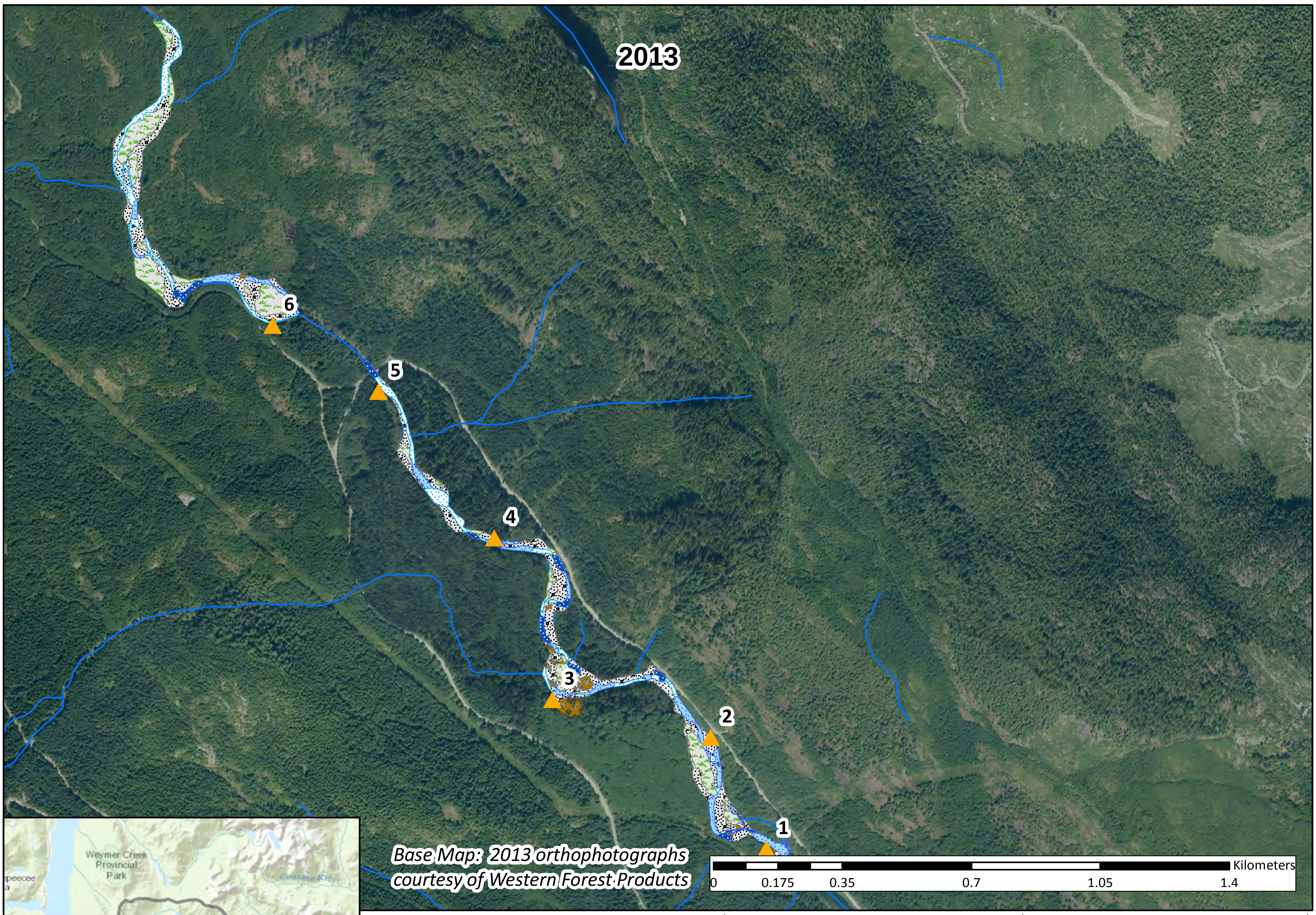
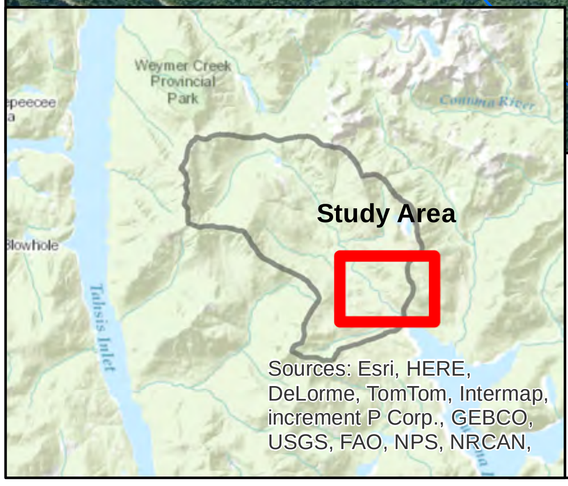
MAP 15
Sucwoa River Watershed Riparian Disturbance







Legend

Habitat Type

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

- Counting Station
- TRIM River

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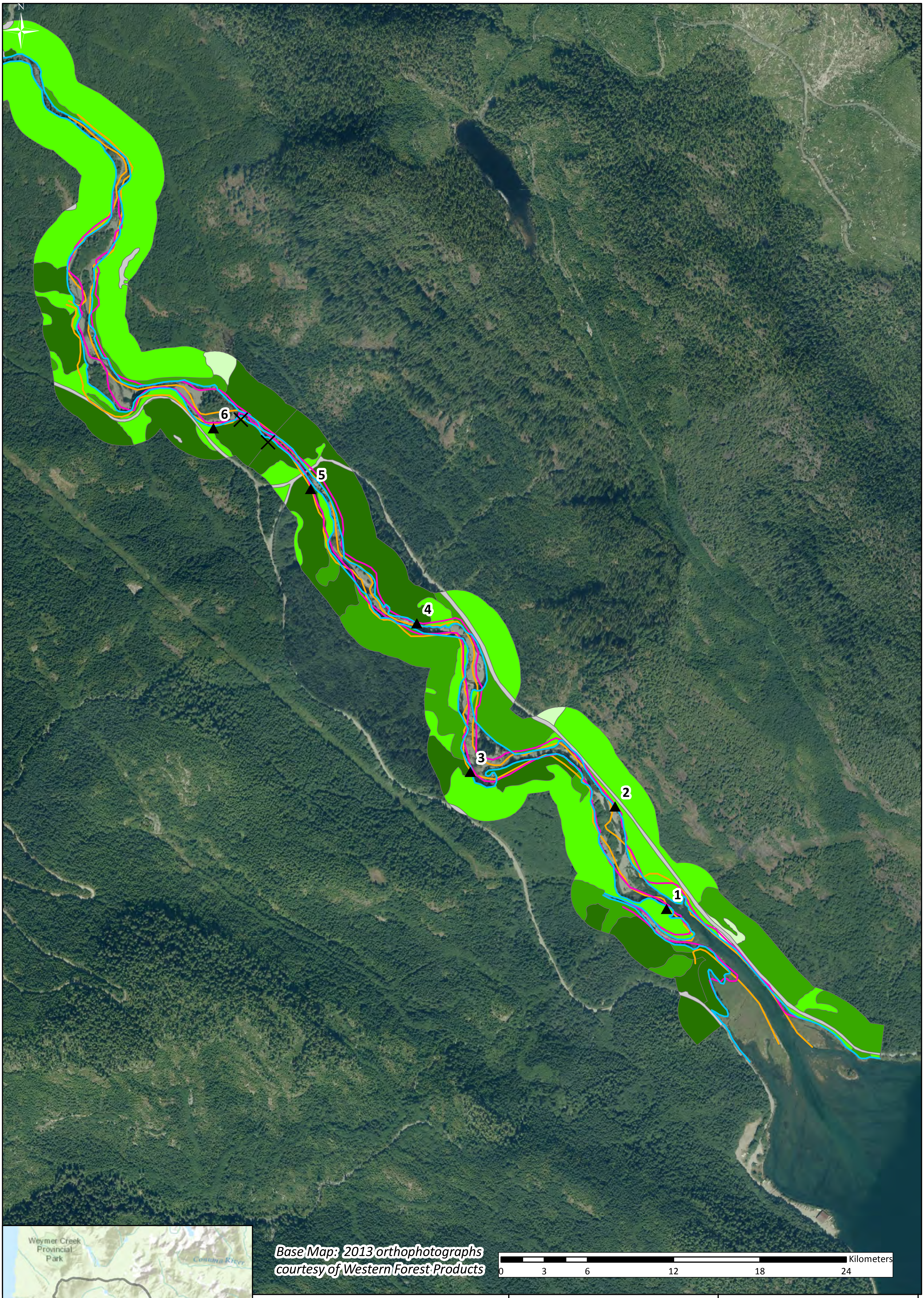
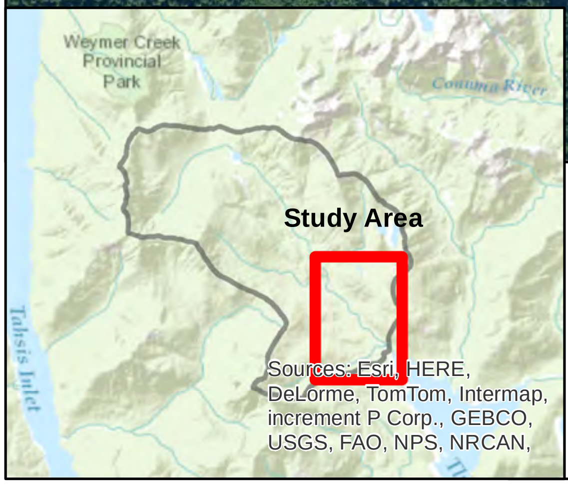
MAP 16

Sucwoa River Watershed Habitat Composition 1995 vs. 2013





Legend

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

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MAP 17

Sucwoa River Watershed
Channel Bank Stability
1980 to 2013