PROPOSED

Species at Risk Act
Recovery Strategy Series

Recovery strategy for the Salish Sucker (*Catostomus* sp.) in Canada

Salish Sucker

2012

Fisheries and Oceans Canada
Pêches et Océans Canada

Canada

Recovery Strategy for the Salish Sucker (*Catostomus* sp.) in Canada [PROPOSED]

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About the *Species at Risk Act* Recovery Strategy Series

What is the *Species at Risk Act* (SARA)?

SARA is the Act developed by the federal government as a key contribution to the common national effort to protect and conserve species at risk in Canada. SARA came into force in 2003 and one of its purposes is "to provide for the recovery of wildlife species that are extirpated, endangered or threatened as a result of human activity."

What is recovery?

In the context of species at risk conservation, recovery is the process by which the decline of an endangered, threatened or extirpated species is arrested or reversed, and threats are removed or reduced to improve the likelihood of the species' persistence in the wild. A species will be considered recovered when its long-term persistence in the wild has been secured.

What is a recovery strategy?

A recovery strategy is a planning document that identifies what needs to be done to arrest or reverse the decline of a species. It sets goals and objectives and identifies the main areas of activities to be undertaken. Detailed planning is done at the action plan stage.

Recovery strategy development is a commitment of all provinces and territories and of three federal agencies — Environment Canada, Parks Canada Agency and Fisheries and Oceans Canada — under the Accord for the Protection of Species at Risk. Sections 37 to 46 of SARA (http://www.sararegistry.gc.ca/approach/act/default_e.cfm) spell out both the required content and the process for developing recovery strategies published in this series.

Depending on the status of the species and when it was assessed, a recovery strategy has to be developed within one to two years after the species is added to the List of Wildlife Species at Risk. Three to four years is allowed for those species that were automatically listed when SARA came into force.

What's next?

In most cases, one or more action plans will be developed to define and guide implementation of the recovery strategy. Nevertheless, directions set in the recovery strategy are sufficient to begin involving communities, land and water users, and conservationists in recovery implementation.

The series

This series presents the recovery strategies prepared or adopted by the federal government under SARA. New documents will be added regularly as species get listed and as strategies are updated.

To learn more

To learn more about the *Species at Risk Act* and recovery initiatives, please consult the SARA Public Registry (http://www.sararegistry.gc.ca/).

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PREFACE

The Salish Sucker is a freshwater fish and is under the responsibility of the federal government. The *Species at Risk Act* (SARA, Section 37) requires the competent minister to prepare recovery strategies for listed extirpated, endangered or threatened species. The Salish Sucker was listed as endangered under SARA in June 2005. The development of this recovery strategy was co-led by Fisheries and Oceans Canada, Pacific Region and the British Columbia Ministry of Environment, in cooperation and consultation with many individuals, organizations and government agencies, as indicated below. The strategy meets SARA requirements in terms of content and process (Sections 39-41) and the British Columbia Ministry of Environment has reviewed and accepts this document as scientific advice.

Success in the recovery of this species depends on the commitment and cooperation of many different constituencies that will be involved in implementing the directions set out in this strategy and will not be achieved by Fisheries and Oceans Canada or any other party alone. This strategy provides advice to jurisdictions and organizations that may be involved or wish to become involved in the recovery of the species. In the spirit of the National Accord for the Protection of Species at Risk, the Minister of Fisheries and Oceans invites all responsible jurisdictions and Canadians to join Fisheries and Oceans Canada in supporting and implementing this strategy for the benefit of the Salish Sucker and Canadian society as a whole. Fisheries and Oceans Canada and the Province of BC will support implementation of this strategy to the extent possible, given available resources and their overall responsibility for species at risk conservation.

The goals, objectives and recovery approaches identified in the strategy are based on the best available information and are subject to modifications resulting from new information. The Minister of Fisheries and Oceans will report on progress within five years.

This strategy will be complemented by one or more action plans that will provide details on specific recovery measures to be taken to support conservation of the species. The Minister of Fisheries and Oceans will take steps to ensure that, to the extent possible, Canadians interested in or affected by these measures will be consulted.

RESPONSIBLE JURISDICTIONS

The responsible jurisdiction for Salish Sucker under the *Species at Risk Act* is Fisheries and Oceans Canada.

ACKNOWLEDGEMENTS

Fisheries and Oceans Canada and the Province of British Columbia cooperated in the development of this recovery strategy. A recovery team was assembled to provide science-based recommendations to government with respect to the recovery of Salish Sucker, including the development of the initial draft of this recovery strategy.

Members of the Recovery Team for Salish Sucker are listed below:

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Financial support for the development of the recovery strategy was provided by the Habitat Conservation Trust Fund and the Province of British Columbia.

STRATEGIC ENVIRONMENTAL ASSESSMENT

In accordance with the Cabinet Directive on the Environmental Assessment of Policy Plan and Program Proposals, the purpose of a Strategic Environmental Assessment (SEA) is to incorporate environmental considerations into the development of public policies, plans, and program proposals to support environmentally-sound decision making.

Recovery planning is intended to benefit species at risk and biodiversity in general. However, it is recognized that strategies may also inadvertently lead to environmental effects beyond the intended benefits. The planning process based on national guidelines directly incorporates consideration of all environmental effects, with a particular focus on possible impacts on non-target species or habitats.

While this recovery strategy will clearly benefit the environment by promoting the recovery of Salish Sucker, potential effects on other species were also considered. The strategy calls for the protection, creation, and enhancement of deep pool and marsh habitat, which could eliminate some of the riffle habitat of Nooksack Dace, another species listed as Endangered under SARA. The strategy recommends cooperation with local stewardship groups and agency staff on habitat management, and proposes to address potential conflicts with recovery of Nooksack Dace by coordinating recovery activities for both species in watersheds where they coexist through the development of a joint action plan. The recovery strategy also calls for minimizing probability of predator introductions, by documenting their occurrence and educating the public on their impacts, which could provide benefits to other species that could be affected by introduced predators. Further information on potential interactions with other species is presented in the Recovery section of the document, in particular under the headings Broad Strategies to Support Recovery Objectives and Effects on Other Species. Taking these into account, it was concluded that the benefits of this recovery strategy far outweigh any adverse effects that may result.

RESIDENCE

SARA defines residence as: “a dwelling -place, such as a den, nest or other similar area or place, that is occupied or habitually occupied by one or more individuals during all or part of their life cycles, including breeding, rearing, staging, wintering, feeding or hibernating” [SARA S2 (1)].

As stated in the *Recovery potential assessment for the Salish Sucker (*Catostomus *sp.) in Canada* (Fisheries and Oceans Canada, 2009), the concept of residence does not apply to Salish Sucker.

EXECUTIVE SUMMARY

The Salish Sucker (*Catostomus* sp.) is a small-bodied, fine-scaled fish documented in 11 British Columbia watersheds, all in the Fraser Valley. At least four other populations occur in northwestern Washington State. One of the 11 British Columbia populations (Little Campbell River) is believed to have been extirpated. Salish Sucker populations have been in decline since at least the 1960s in Canada, and probably for longer.

Adults are most abundant in headwater marshes and beaver ponds. Juveniles are found in shallow pools or glides containing cover, but may also use other habitats. Spawning occurs in riffles over fine gravel; diet is composed predominately of insect larvae. Most individuals have small home ranges (mean of 170 m of channel, May - Oct), although some individuals venture kilometres during the spawning period. Within watersheds, distribution is extremely clumped, with a few sites harbouring most of the population. Consequently spatial distribution and longevity of habitat patches, in addition to their size, may be important for long-term persistence of Salish Sucker.

Salish Sucker populations appear to be most vulnerable to acute hypoxia and to habitat loss. These conditions are common throughout the range and result primarily from over-application of fertilizers and manure, drainage, channelization, dredging and infilling activities associated with agriculture and residential land development. Hypoxia is difficult to address in the current regulatory and policy context and is likely the single largest threat.

Although it is poorly known, predation by introduced species is currently considered only a moderate threat, as these species appear to have coexisted with Salish Sucker for a decade in some parts of their range. However, the ubiquity of introduced predators and their documented impacts on other species justifies the ranking of this threat as moderate. Habitat fragmentation is currently a moderate threat to Salish Sucker, but its impacts are poorly understood. Sediment deposition and toxicity (in the form of contaminated sediments) appear to be major threats in some, but not all, watersheds.

Critical habitat for Salish Sucker includes all reaches in streams currently containing populations with more than 50 m of continuous pool and a water depth exceeding 70 cm at summer low flows. As the primary habitat for the majority of the life cycle, with the exception of spawning, all deep pools in such reaches are important features of critical habitat for Salish Sucker. The 50 m threshold was chosen because it is the minimum length of all reaches known to contain moderate or high densities of Salish Sucker (catch per unit effort > 1.8 individuals per trap[1], Pearson, unpublished data). Critical habitat for Salish Sucker includes all aquatic habitat and riparian reserve strips of native vegetation on both banks for the entire length of these reaches. Riparian reserve strips are continuous and extend laterally from the top of bank to a width equal to the widest zone of sensitivity (ZOS) calculated for each of five riparian features, functions and conditions. The ZOS values are

[1] Double ended cylindrical funnel traps 100 x 55 cm, 0.5" mesh, baited with dry cat food set for 24 h (see Pearson and Healey 2003).

calculated using methods consistent with those under the *Fish Protection Act* (S.B.C. 1997, c. 21).

The total length of critical habitat identified for Salish Sucker in this recovery strategy is 145.74 km (of 329.1 km of surveyed stream channel). The areas identified as critical habitat are those considered necessary to support the species survival and recovery and to reach the population and distribution objectives for Salish Sucker. Additional habitats that fall outside the definition above may also be identified as critical habitat in subsequent action plans if it is known to provide a critical function as per the description of habitat in SARA.

Under SARA, critical habitat must be legally protected once it is identified. This will be accomplished through a SARA order, which will prohibit the destruction of the identified critical habitat. SARA includes a provision for permitting related to the prohibition against destruction provided specific conditions are met.

Recovery

Recovery of Salish Sucker populations is both technically and biologically feasible. It will involve the establishment and/or maintenance of sufficient high quality habitat for all life stages in each creek. Required actions will vary, but will generally include water quality improvement and restoration of degraded or destroyed habitat. Management activities will be required in all watersheds.

The goal of recovery is:

> *To ensure long-term viability of Salish Sucker populations throughout their natural distribution in Canada.*

The recovery strategy has three objectives:

1. Prevent extirpation of Salish Sucker in each of the 10 watersheds with extant populations by preventing net loss of reproductive potential.
2. Reach or exceed each of the following targets by 2020:
    a. occupation of all instream critical habitats,
    b. watershed-specific abundance targets for mature individuals,
    c. one or more source habitats with high density in each watershed.
3. Reintroduce Salish Sucker to Little Campbell River, if extirpation is confirmed and reintroduction is feasible.

Nine broad strategies have been identified in support of these objectives.

1) Reduce incidence of severe hypoxia in instream critical habitats.
2) Protect existing habitat, restore lost or degraded habitat and create new habitat.
3) Increase the integrity and function of all riparian habitats.
4) Encourage stewardship among private landowners, local government and agencies, and the general public.
5) Reduce fragmentation of instream and riparian habitats.
6) Reduce toxic contamination of instream habitat.
7) Reduce sediment entry to instream habitats.

8) Reduce impacts of introduced predators.
9) Assess feasibility of reintroducing Salish Sucker into the Little Campbell River if extirpation is confirmed.

The objectives and strategies are presented in detail in the recovery strategy.

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1. BACKGROUND

1.1 Species Information

The status report and assessment summary for Salish Sucker is available from the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) Secretariat (www.cosewic.gc.ca).

Common Name:	Salish Sucker
Scientific Name:	*Catostomus* sp.
Assessment Summary:	November 2002
COSEWIC Status:	Endangered, April 1987 and May 2000
SARA Status:	Endangered, June 2005
Reason for Designation:	This species has a restricted range in Canada, and is in significant decline due to habitat loss and degradation.
Range in Canada:	British Columbia
Status History:	Designated Endangered in April 1996. Status re-examined and confirmed in May 2000. Last assessment based on an existing status report

1.2 Species Description

The Salish Sucker (*Catostomus* sp.) is closely related to the Longnose sucker (*C. catostomus*), a widespread fish species in North America. The two taxa diverged when a population became geographically isolated in the Chehalis River valley (present-day Washington State) sometime during the Pleistocene glaciations (McPhail 1987). The Salish Sucker is considered an evolutionarily significant unit (McPhail & Taylor 1999) and can be considered a "species in the making" (McPhail 1987), although its precise taxonomic status is currently being investigated.

The Salish Sucker is dark-green, mottled with black dorsally, dirty-white ventrally and develops a broad red lateral stripe during the spawning season. This stripe is especially vivid in males. Scales are fine, the snout is short and blunt, and the small mouth is located on the lower surface of the head (McPhail & Carveth 1994). Few males exceed 200 mm (fork length) and they can reach sexual maturity at less than 100 mm; females seldom exceed 250 mm (Pearson & Healey 2003).

1.3 Populations and Distribution

Populations of Salish Suckers have been documented in 11 British Columbia watersheds, all in the Fraser Valley. At least four others occur in northwestern Washington State (Figure 1). The population in Little Campbell River, BC is believed to have been extirpated, although there is an unconfirmed report of Salish Suckers in a pond within the floodplain of the Little Campbell (Pearson pers. comm. 2011). Current information suggests that approximately 25% of the global range and 70% of all populations are in Canada (Figure 1). The species has been in decline since at least the 1960s (McPhail 1987), and probably for much longer (Pearson 2004a).

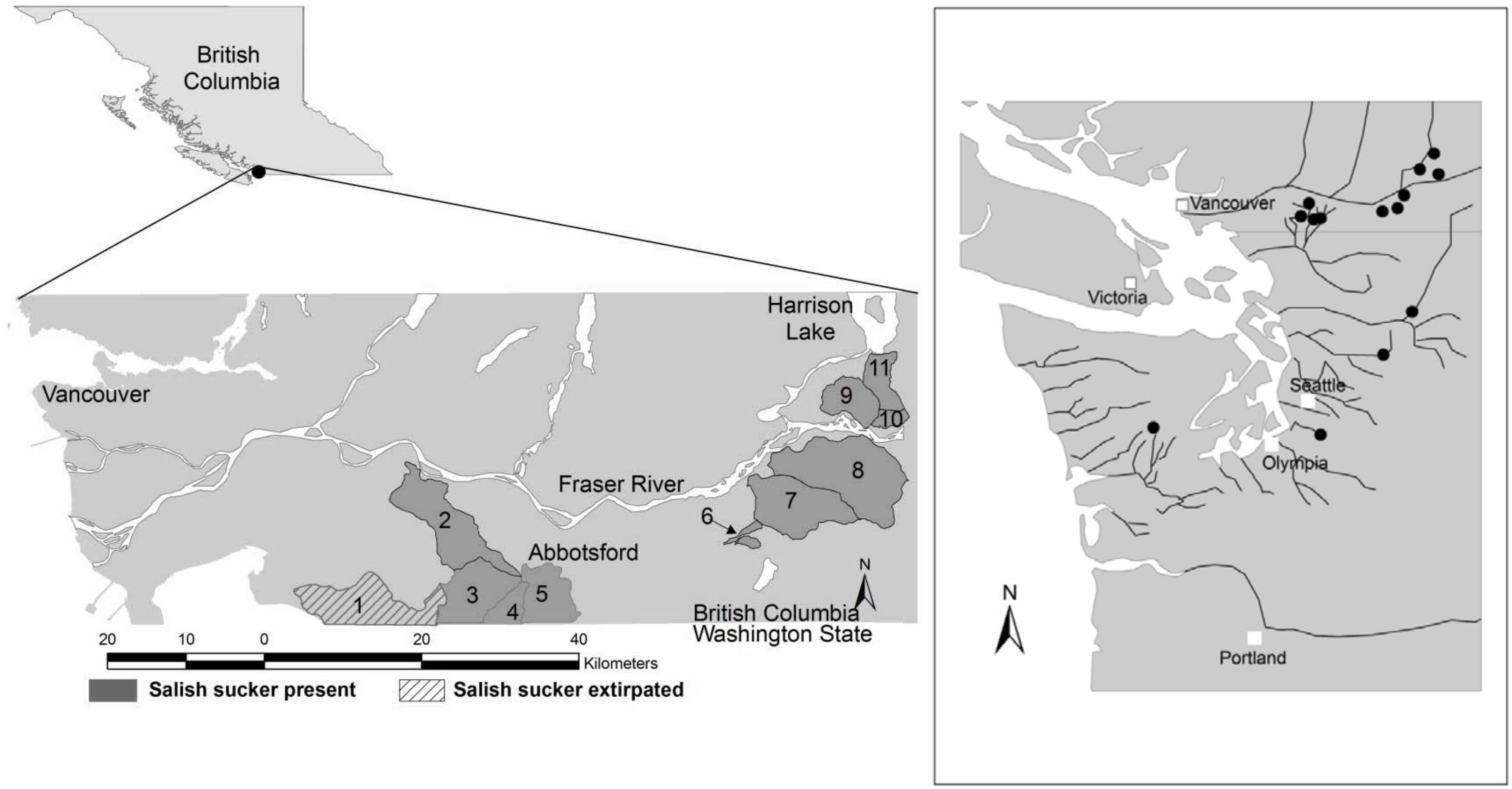

Figure 1 - Distribution of the Salish Sucker. In Canada (left panel), the Salish Sucker has been observed in eleven watersheds: (1) Little Campbell River, (2) Salmon River, (3) Bertrand Creek, (4) Pepin Brook, (5) Fishtrap Creek, (6) Salwein Creek/Hopedale Slough, (7) Chilliwack Delta (Atchelitz/Chilliwack/ Semmihault Creeks), (8) Elk Creek/Hope Slough, (9) Mountain Slough, (10) Agassiz Slough, (11) Miami Creek. Globally, it is also found in four other watersheds in northwestern Washington (right panel, adapted from Pearson 2004a and McPhail 1997).

In the current landscape, there are virtually no aquatic connections between adjacent populations. Exceptions include a small headwater pond that feeds both Mountain Slough and Miami Creek and an occasional high water connection between Bertrand Creek and the Salmon River via a headwater wetland (Pearson pers. comm. 2010). The only other route between watersheds is via the mainstem Fraser River or Nooksack River, although no Salish Suckers have ever been reported from either and captures in larger sloughs are extremely rare (Pearson pers. comm. 2010). Prior to the drainage of Sumas Lake (1920s) and the construction of the dyke system following the 1948 flood, permanent and high water connections among populations would have been more common. This raises the possibility that the populations were historically linked in a meta-population structure.

1.4 Description of the Species' Needs

1.4.1 Biological Needs, Ecological Role, and Limiting Factors

Salish Suckers are well-equipped to inhabit headwater streams, where habitat conditions may vary widely on daily, seasonal, and longer time scales. They tolerate higher temperatures and lower dissolved oxygen levels than most other native fish that occur in this region of British Columbia. The major natural limiting factor for populations is the availability of high quality habitat. Salish Suckers have life history characteristics that promote rapid population growth, given adequate habitat. Compared to Longnose sucker, the Salish Sucker is small, short-lived, and early-maturing. Most spawn for the first time in their second year, and they rarely live beyond 5 years (McPhail 1987). Salish Suckers begin spawning in April, but the period is protracted (6 to 8 weeks, Pearson 2004a), relative to the Longnose sucker (2 to 3 weeks, Barton 1980; Schlosser 1990; Scott & Crossman 1973), a trait that increases fecundity in species otherwise limited by small female body size (Blueweiss et al. 1978; Burt et al. 1988). Spawning occurs between early April and mid July (McPhail 1987; Pearson & Healey 2003) and egg incubation is likely complete by mid-August.

1.4.2 Habitat Needs

Physical Habitat

Adults are most abundant in marshes and American beaver (*Castor canadensis)* ponds with mud or silt substrates. The proportion of channel deeper than 70 cm is the strongest predictor of adult presence in a reach. Occupied reaches also have significantly less riffle and more in-stream vegetation than reaches in which Salish Suckers are absent. Although fewer data exist for young-of-the-year, they appear to be associated with shallow pool and glide habitats containing abundant vegetation (Pearson 2004a). Spawning typically occurs in gravel riffles (McPhail 1987), but groundwater upwellings are likely used in systems lacking riffle habitats (Pearson unpublished data). Most individuals appear to have small home ranges (mean of 170 m of channel) although some individuals are known to venture thousands of metres during the spawning period (Pearson & Healey 2003).

Water Quality

Water must have oxygen, pH, temperature, and toxin levels that are not harmful to the species. Salish Suckers appear well-adapted to low oxygen environments and have been captured in areas with concentrations below 2 mg/L (Pearson unpublished data). Sublethal effects (e.g., reduced growth and fecundity) likely occur at these concentrations. Based on observation and experience, an appropriate target for dissolved oxygen in Salish Sucker habitat is ≥ 4 mg/L. This is lower than the federal water quality guideline for aquatic life (5 mg/L, CCREM 1987), but these are intended to protect species like salmonids, which are very intolerant of hypoxia. Thermal tolerances of the Salish Sucker are unknown, but activity is minimal at temperatures below 6^{o}C (Pearson & Healey 2003) and apparently healthy fish have been caught in temperatures of up to 23^{o}C (Pearson unpublished data). The sensitivity of Salish Suckers to toxic contamination is unknown. Salish Suckers are generally absent from reaches where the landscape within a 200 m radius of the channel is more than 50% urban by area (Pearson 2004a). These reaches invariably receive urban stormwater containing contaminated sediments from road runoff (Hall et al. 1991). As bottom-dwelling fish, Salish Suckers in these habitats are likely to be chronically exposed to toxins in sediments.

Spatial Distribution and Temporal Stability of Habitats
Distribution of the Salish Sucker is clumped, with a few sites harbouring most individuals (Pearson 2004a). These 'hotspots' likely result from rare convergences of optimal levels in a few key environmental variables (Brown et al. 1995). For Salish Suckers these variables likely include extensive areas of deep water (100s of square metres of channel) close to spawning riffles and shallow nursery habitat, adequate water quality, and low predation pressure (Pearson 2004a). Most individuals appear to confine their movements to a single reach but some individuals travel more widely (Pearson & Healey 2003). Clumped distribution and bimodal movement patterns suggest that metapopulation and/or source-sink population dynamics characterize the species. If so, factors affecting migration between sub-populations (the proximity of 'hotspots' to one another and the occurrence of movement barriers between them) are likely important to long-term population viability. Natural disturbance and succession may produce a pattern in which the location of hotspots moves throughout the landscape over time, but are occasionally eliminated by catastrophic events (Ives & Klopper 1997). Such catastrophic declines at the reach scale have been documented for the Salish Sucker (Pearson 2004a), but the effect on extinction risk for Salish Sucker populations is unknown.

2. THREATS

2.1 Identification of Threats to the Survival of the Species

The potential for recovery of a species at risk depends on the magnitude, timing, frequency, duration and extent of threats it faces. The following sections summarize detailed analyses published elsewhere (Pearson 2004a, b).

Eight factors (Table 1) were considered threats based on knowledge of species biology and habitat conditions across the Canadian range. All are proximate, in that they act directly on Salish Suckers or their habitats. Factors known to drive or trigger threats are described in Figure 2. The vulnerability of the Salish Sucker to each threat and the severity of each threat in each watershed are rated and summarized in Table 2. The ratings are based on analyses of a suite of indicators that cause, exacerbate or mitigate threats. A summary by watershed is presented in Table 3. For details of assessment methods and rationale for ratings see Pearson (2004a; 2004b).

Table 1. Potential threats to the Salish Sucker in Canada.

Threat	Management Concern
1) Hypoxia	Episodes of extreme hypoxia cause acute mortality or reduced fitness.
2) Physical Destruction of Habitat	Drainage, dyking, channelization and infilling of waterbodies destroys habitat.
3) Habitat Fragmentation	Permanent or temporary barriers such as perched culverts, beaver dams, and agricultural weirs prevent or inhibit fish from traversing some stream reaches. This restricts access to usable habitats and/or alters metapopulation dynamics, and increases extinction risk.
4) Toxicity	Toxic discharges from point and non-point sources reduce survival or fitness.
5) Sediment Deposition	Deposited sediment degrades habitat by reducing invertebrate (food) density, reducing the flow of oxygenated water to eggs in riffles and, in severe cases, by infilling pools.
6) Seasonal Lack of Water	Low flows in late summer eliminate habitat, reducing fitness or survival.
7) Increased Predation	Introduced predators consume individuals or reduce their fitness by inducing behavioural changes (e.g. increased energy expenditure and reduced energy intake)
8) Riffle Loss to Beaver Ponds	Beaver ponds flood riffle habitat.

Table 2. A threats assessment summary for the Salish Sucker. See text for more details.

Threat	Vulnerability	Severity Across Range
1) Hypoxia	***	***
2) Physical Destruction of Habitat	***	***
3) Habitat Fragmentation	**	***
4) Toxicity	**	**
5) Sediment Deposition	**	**
6) Seasonal Lack of Water	*	**
7) Increased Predation	*	**
8) Riffle Loss to Beaver Ponds	*	*

***	major concern	**	moderate concern	*	minor concern

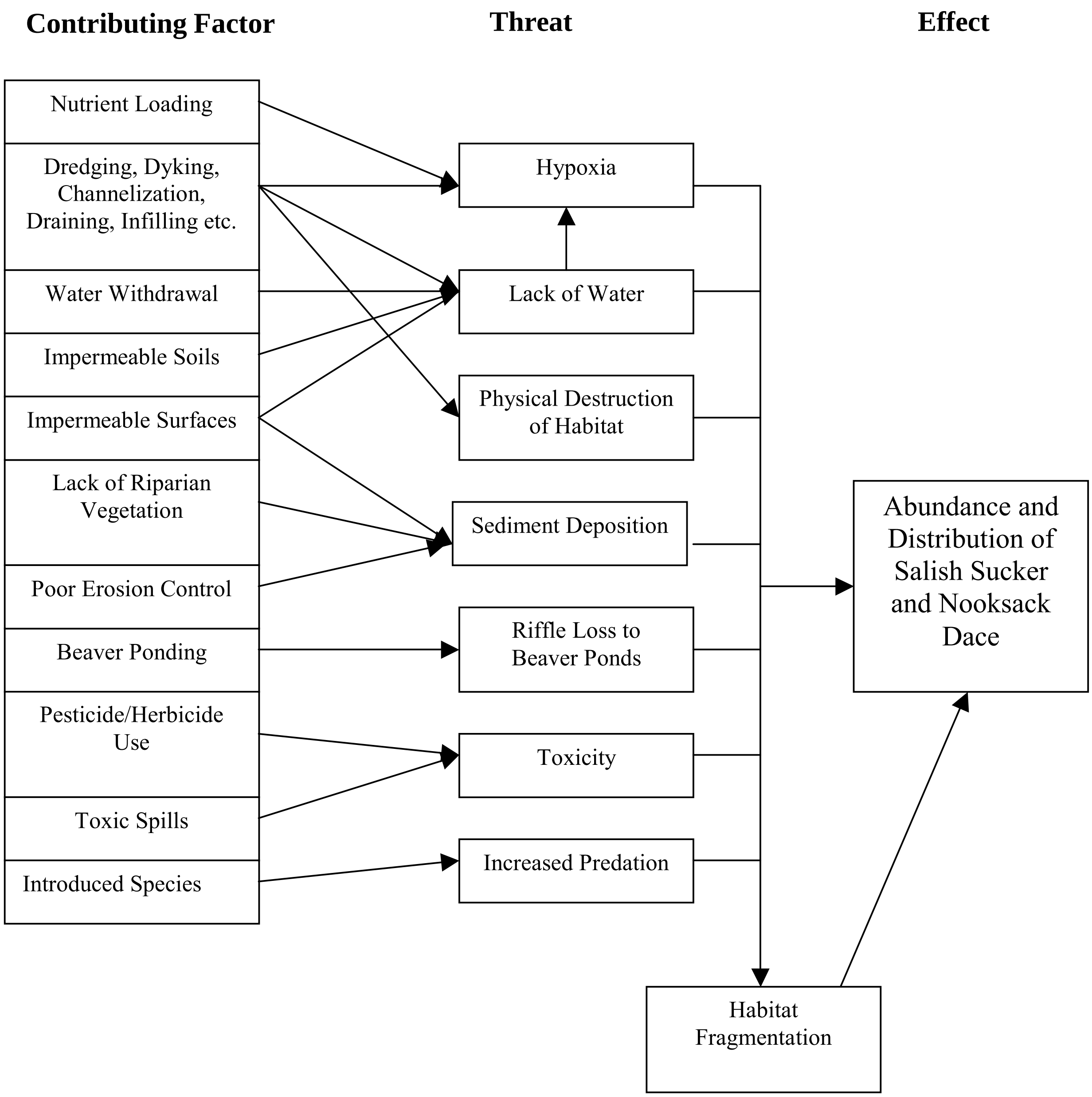

Figure 2: Factors known or suspected to drive or trigger threats to the Salish Sucker (from Pearson 2004a).

Table 3. Assessment of threat severity in each of the watersheds in Canada where Salish Suckers have been observed. Background data and details of assessment methods are provided by Pearson (2004a). The assessment of Elk/Hope Slough is based on recent data (Pearson, unpublished data).

Threat	Bertrand Creek	Pepin Brook	Fishtrap Creek	Upper Salmon River	Salwein/ Hopedale Slough	Atchelitz/ Chilliwack/ Semmihault	Miami Creek	Mountain Slough	Agassiz Slough	Elk / Hope Slough	Little Campbell River
Hypoxia	**	***	**	***	***	**	***	***	***	**	***
Physical Destruction of Habitat	**	***	***	**	***	***	**	***	***	***	**
Habitat Fragmentation	***	**	**	**	***	***	**	**	***	**	**
Toxicity	**	*	***	*	**	**	**	**	***	**	**
Sediment Deposition	**	***	**	**	*	**	**	***	**	***	**
Seasonal Lack of water	***	*	**	***	*	*	**	**	***	*	**
Increased Predation	**	**	**	*	**	**	*	*	*	**	***
Riffle Loss to Beaver Ponds	*	***	*	*	*	*	*	*	*	*	**

***	major concern	**	moderate concern	*	minor concern

2.1.1 Threat 1: Hypoxia

Description
There are several interacting causes of hypoxia, but it is ultimately caused by the cumulative effects of local and watershed-scale impacts. Nutrients in Fraser Valley groundwater and streams are elevated, primarily as a consequence of over-application of manure and fertilizers to agriculture lands (Lavkulich et al. 1999; Schreier et al. 2003), but also from urban stormwater runoff and septic systems (Lavkulich et al. 1999). Increased nutrients result in algal blooms and high densities of macrophytes that strip the water of oxygen at night. Decomposition of dead algae and vegetation exacerbates the problem and may severely depress daytime oxygen levels as well. Lack of shade from riparian vegetation promotes increased water temperatures. Warmer water has less capacity for dissolved oxygen (DO) and increases the metabolic demands of fish and other organisms. Reduced water movement impairs reoxygenation of water and may be caused by channelization, (Schreier et al. 2003), beaver ponds (Fox & Keast 1990; Schlosser & Kallemyn 2000), or low flows.

Vulnerability (major concern)
Salish Suckers are able to tolerate moderate hypoxia and have been captured in areas with concentrations below 2 mg/L (Pearson, unpublished data), yet occasional reach-scale kills of Salish Suckers due to severe hypoxia likely occur. A marsh in Pepin Brook that contained a very high density of Salish Suckers between 1999 and 2002 (over 1000 fish in 1420 m^2 of habitat) was near anoxic (DO <1.5 mg/L) and apparently devoid of fish in 2003 (Pearson 2004a). Levels at which sub-lethal effects (e.g., reduced growth, fecundity) occur are unknown. Eggs, larvae, and over-wintering fish are unlikely to be affected by severe hypoxia as it usually occurs in mid to late summer when flows are low and temperatures are high. A DO concentration of ≥ 4 mg/L is likely adequate for the Salish Sucker (see 1.4 Description of the Species' Needs).

Severity (major concern)
Along with direct habitat destruction, hypoxia appears to be the most serious threat to Salish Sucker populations range-wide. It is a major concern in seven of the 11 watersheds (Table 3). When 58 km of stream areas identified as critical habitat in this recovery strategy were surveyed during late summer 2004, the DO concentration was less than 4 mg/L in 40% of the habitat and less than 2 mg/L in 21% of the habitat (Pearson unpublished data). DO measurements were made during the day, but since the lowest dissolved oxygen levels occur at dawn these are conservative numbers. One of the main factors contributing to hypoxia, nutrient loading, has increased greatly with agricultural intensification in the Fraser Valley (Hall & Schreier 1996). Manure application on agricultural lands in Abbotsford is currently adding approximately three times the amount of nitrate that crops can take up, and the ratio is increasing (Schreier pers. comm. 2005); the excess enters groundwater and surface waters.

2.1.2 Threat 2: Physical Destruction of Habitat

Description
Channelization, dredging and infilling directly destroy or degrade stream habitats. Channelization reduces channel length (and habitat area), and exacerbates hypoxia by

reducing mixing. Dredging removes spawning riffles and other habitat features, and infilling destroys all affected habitats.

Vulnerability (major concern)
Like all species, Salish Suckers are highly vulnerable to large-scale destruction of their habitat. The highest densities of Salish Suckers are found in marshes and beaver ponds (Pearson 2004a), habitats that have often been drained and turned into agricultural lands.

Severity (major concern)
Approximately 77% of pre-settlement wetland areas in the Fraser Valley have been drained or infilled (Boyle et al. 1997). Fifteen percent of the area's streams no longer exist, having been paved over or piped (Fisheries and Oceans Canada 1998). A large, but unknown, proportion of those that remain have been channelized and/or repeatedly dredged for agricultural or urban development. It is difficult to overstate the historical extent of fish habitat loss from these activities. Both permitted and illegal dredging of ditches and stream channels for flood control and agricultural drainage still occur annually in all watersheds known to have Salish Suckers. Along with hypoxia, physical habitat destruction ranks as the most severe threat facing the species. It is considered a major concern in seven of the 11 watersheds and a moderate concern in the remaining four (Table 3). The loss of historic habitats means Salish Suckers are now more dependent on those habitats remaining.

2.1.3 Threat 3: Habitat Fragmentation

Description
Physical barriers such as perched culverts, beaver dams, and agricultural weirs commonly prevent fish movement between habitats for all or part of the year in Fraser Valley streams. In addition, any of the other threats discussed may fragment habitat by preventing or curtailing movement of fish within and among affected reaches. On a larger scale, connections between watersheds during floods were undoubtedly more common prior to the extensive dyking and drainage works of the past century.

Vulnerability (moderate concern)
Distribution of the Salish Sucker is clumped, and a small proportion of habitat contains the majority of individuals (Pearson 2004a). Individuals usually stay within a small home range (less than 200m of channel), but occasionally travel longer distances, especially during the spawning period (Pearson & Healey 2003). This suggests that each watershed is inhabited by core subpopulations connected by occasional migration. Movement between these subpopulations typically requires traversing several kilometres of stream, or crossing watershed boundaries during occasional high-water connections. Most barriers and habitat fragmentation in Salish Sucker watersheds date from the past 50 to 130 years, and surviving populations have shown some resilience (Pearson 2004a). The effects, however, may occur over longer time frames. The effect of fragmentation on the long-term persistence of the Salish Sucker is unclear, though where access is available, Salish Sucker populations have demonstrated an ability to colonize new habitat quickly (Patton 2003).

Severity (major concern)

The destruction of aquatic habitat that has occurred within the Fraser Valley over the past 150 years has fragmented available habitat. At the regional scale, high-water connections between watersheds still occur annually in some systems (Miami Creek with Mountain Slough) and at least every few years in others (Bertrand Creek with the Salmon and Little Campbell Rivers, Pearson 2004a), but many former connections have been lost or weakened. The drainage of Sumas Lake, the diversion of the Chilliwack River away from its delta, and the isolation of Agassiz Slough by a dyke and highway overpass are the starkest examples (Pearson 2004a). Within watersheds, physical barriers such as perched culverts, beaver dams, and agricultural weirs commonly prevent movement between some habitats for all or part of the year in virtually all Fraser Valley streams. Historic habitat losses mean greater dependence of the Salish Sucker on those habitats that remain.

2.1.4 Threat 4: Toxicity

Description

Toxic compounds enter Fraser Valley streams through urban storm runoff, contaminated groundwater (e.g., agricultural pesticides and herbicides), direct industrial discharges, sewage treatment plant effluents, aerial deposition, and accidental spills (Hall et al. 1991). Concentrations in the water column are variable over time because dilution varies with stream discharge and inputs are often pulsed (e.g., first flush of stormwater following a long dry spell, Hall et al. 1991). Some contaminants, particularly heavy metals, bind to sediments where they may be taken up and bioaccumulated by aquatic invertebrates and subsequently fish.

Vulnerability (moderate concern)

Data on threshold concentrations for acute and sublethal effects to the Salish Sucker are lacking. The Salish Sucker may be sensitive to contaminants in food items and the water column, and as a bottom-dwelling species that feeds primarily on benthos it may be sensitive to contaminants bound to sediment. Salish Suckers are less likely to be found in reaches where land use within 200 m of the channel is predominantly urban (Pearson 2004a). This may be partly due to toxic materials originating from storm sewer outfalls.

Severity (moderate concern)

Toxicity is considered a moderate threat range-wide. It is poorly documented in most Salish Sucker streams, but is likely present to some degree in all. It is a major concern in localized areas. Agassiz Slough sediments, for example, are contaminated by urban storm runoff and contain copper and zinc levels in excess of recommendations for protection of aquatic life (Schreier et al. 2003). Portions of three other streams (Bertrand Creek, Fishtrap Creek, and Atchelitz/Chilliwack/Semmihault) also receive stormwater from adjacent urban areas and are likely also contaminated. Pesticides and herbicides have been detected in both surface water and groundwater in Salish Sucker watersheds (Hall et al. 1991; Schreier et al. 2003). The list of compounds that could enter creeks from spraying, poor waste management, and accidental spills is enormous.

2.1.5 Threat 5: Sediment Deposition

Description
Sediment deposition is controlled by the balance between the rate of sediment delivery to the channel and capacity of the stream to mobilize and carry it downstream. Sediment delivery may be increased by direct discharges, storm drain runoff, or bank erosion accelerated by lack of riparian vegetation and/or increased peak flows (Waters 1995). All of these sources are likely to increase with urban, agriculture and mining development in a watershed.

Vulnerability (moderate concern)
Salish Suckers spawn in riffles between April and early July (Pearson & Healey, 2003) and are probably most susceptible to sedimentation in these habitats during this period. Salish Suckers are less likely to be found in reaches where land use within 200 m of the channel is predominantly urban (Pearson, 2004a); sediment inputs from storm sewer outfalls and its deposition on riffles may partially explain this.

Severity (moderate concern)
Sediment deposition and its negative effects on reproduction are moderate concerns in almost all Salish Sucker watersheds (Table 3). Chronic, large-scale releases from gravel pits have filled in pools and largely eliminated instream cover and food sources from a critical habitat reach in Pepin Brook.

2.1.6 Threat 6: Seasonal Lack of Water

Description
During late summer, when rainfall is sparse, Fraser Valley stream flows are maintained almost solely by groundwater. Stream hydrographs vary widely depending on surface soil permeability and water use. Watersheds with large unconfined aquifers or mountain tributaries fed by snow melt (e.g., Elk Creek) maintain steady flows of cold water throughout this critical period, while surface flows may cease completely in watersheds with impermeable surface soils (e.g., Bertrand Creek and tributaries). Unfortunately, the late summer low-flow period coincides with peak demand for water from wells and streams for irrigation and domestic use, which can lower water levels further. Common land use changes in the Fraser Valley also tend to exacerbate problems with lack of water. Gravel mining reduces the size of the aquifer contributing to base flow, urban development increases the area of impermeable surfaces, reducing infiltration to the aquifer, and drainage for agriculture lowers water tables, further reducing low flows. Beaver ponds are a stabilizing force, maintaining water levels in reaches that may otherwise dry out. Beaver dams can improve low flows by augmenting groundwater levels and via seepage through the dams (Stabler 1985, Gurnell 1998).

Vulnerability (minor concern)
The deep pool habitats preferred by Salish Suckers rarely dry out completely. Spawning and egg incubation occur in spring and early summer, when water is generally plentiful. Lack of

water is a potentially exacerbating factor for several other threats including hypoxia, toxicity, habitat fragmentation and introduced predators.

Severity (moderate concern)
Lack of water is a moderate concern range-wide. It is a major concern in three of the eleven watersheds, a minor concern in three and a moderate concern in the remaining five (Table 3).

2.1.7 Threat 7: Increased Predation

Description
Increased predation is most likely to arise from the introduction of new predators to Salish Sucker habitats. Such introductions are implicated in the extinction of numerous native fishes across North America (Miller et al. 1989; Richter 1997; Gido & Brown 1999).

Vulnerability (minor concern)
The impacts of introduced predators on Salish Sucker populations are unknown, but do not appear to be severe. Salish Suckers have coexisted with Brown bullheads, *Ameiurus nebulosis*, bullfrogs, *Rana catesbeiana,* and/or Largemouth bass, *Micropterus salmoides*, for at least ten years in various parts of the range (Pearson, unpublished data). All three likely prey on juvenile Salish Suckers, and Largemouth bass become large enough to consume adults. Their impacts probably vary with habitat attributes. All three of these predators thrive in warm water littoral zones. The Brown bullhead is also extremely tolerant of hypoxia (Scott & Crossman 1973). Other introduced fish species, such as Smallmouth bass *Micropterus dolomieu*, Black crappie *Pomoxis nigromaculatus* and Pumpkinseed sunfish *Lepomis gibbosus* are spreading in the region, through unauthorized introductions and subsequent range expansions (Hatfield & Pollard 2006). Introduced Smallmouth bass are implicated in the extirpation of small-bodied fish species from lakes in eastern Canada (Chapleau et al. 1997; Whittier et al. 1997; Vander Zanden et al. 1999; Whittier and Kincaid 1999; Findlay et al. 2000; MacRae and Jackson 2001). Introduced species may alter habitat use by Salish Suckers and exacerbate other habitat effects such as increased water temperatures or the frequency and severity of hypoxia. Alternatively, recovery efforts to increase habitat complexity may reduce impacts from introduced species by providing areas of refuge (Jackson et al. 2001).

Severity (moderate concern)
Introduced predators inhabit every stream known to contain Salish Suckers. The threat of effective, new predators being introduced is also ever present.

2.1.8 Threat 8: Riffle Loss to Beaver Ponds

Description
Beaver ponds have been shown to influence fish populations both positively and negatively (Hanson & Campbell 1963; Keast & Fox 1990; Lavkulich et al. 1999; Schlosser 1995), but the impacts of riffle loss through ponding has received little attention.

Vulnerability (minor concern)
As long as the relatively small amount of riffle habitat necessary for spawning remains intact, riffle loss to beaver ponds is unlikely to impact Salish Sucker populations, although other aspects of ponding are (Pearson 2004a). By stabilizing the otherwise highly variable environments of headwater streams (Hanson & Campbell 1963; Naiman et al. 1986), beaver pond creation is likely to benefit Salish Suckers. Indeed, during late summer low-flow periods, beaver ponds provide the only wetted habitat in a number of reaches (Pearson 2004a). Dams, however, also reduce water movement, increase hypoxia and act as barriers to escape from poor conditions.

Severity (minor concern)
Riffle loss to beaver ponds is a major concern in one watershed, a moderate concern in one other, and a minor concern in the rest (Table 3).

2.2 Summary of Threats Analysis

Salish Sucker populations appear to be most vulnerable to severe hypoxia and habitat loss. Hypoxia is widespread, degrades areas of otherwise suitable habitat, can kill large numbers of fish quickly, has numerous contributing factors, can easily go undetected, and is likely occurring with increasing frequency. Direct habitat destruction is likely the primary cause of historical decline in Salish Sucker populations. Large portions of all creeks surveyed have been channelized, in-filled, or repeatedly dredged. Damage continues to occur through municipal ditch-cleaning activities and unauthorized works on private land.

Habitat fragmentation is considered a moderate threat to the Salish Sucker, but is also poorly understood. Toxicity, sediment deposition and seasonal lack of water appear to be major threats in particular watersheds, but do not threaten the species across the range.

Introduced predators are considered a moderate threat. Although they are numerous, occur across the Canadian range, and are commonly implicated in decline and extinction of other native species, there are several documented instances of co-existence with the Salish Sucker for more than two generations. The threat of introduction of more effective, novel predators is, however, a concern. Riffle loss to beavers may limit spawning when riffles are rare but is considered a minor concern range-wide, although the potential role of recruitment limitation in limiting Salish Sucker populations remains unknown. Beaver ponding may have opposing influences on the Salish Sucker and another SARA-listed fish, the Nooksack Dace, in Pepin Brook. Riffle habitats critical to Nooksack Dace are destroyed by beaver dams, but the deep, marshy habitats favoured by adult Salish Suckers are created.

3. CRITICAL HABITAT

3.1 Identification of critical habitat

Critical habitat is defined in the *Species at Risk Act* (2002) section 2(1) as:

> *"…the habitat that is necessary for the survival or recovery of a listed wildlife species and that is identified as the species' critical habitat in a recovery strategy or in an action plan for the species."* [s. 2(1)]

SARA defines habitat for aquatic species at risk as:

> *"… spawning grounds and nursery, rearing, food supply, migration and any other areas on which aquatic species depend directly or indirectly in order to carry out their life processes, or areas where aquatic species formerly occurred and have the potential to be reintroduced."* [s. 2(1)]

For the Salish Sucker, critical habitat is identified to the extent possible, using the best information currently available. The critical habitat identified in this recovery strategy describes the geospatial area that contains the biophysical features, functions and attributes necessary for the survival or recovery of the species. The identified critical habitat includes all habitats within occupied watersheds considered to be high quality or potentially high quality for the Salish Sucker, and constitutes the habitat deemed to be necessary to achieve the population and distribution objectives.

The current area identified may not be sufficient to achieve the population and distribution objectives for the species and its description will need to be further refined. The schedule of studies outlines the activities required to identify additional critical habitat or refine the description of the existing critical habitat in order to support its protection.

3.1.1 Information and methods used to identify critical habitat

Critical habitat for the Salish Sucker was defined using in-stream habitat characteristics at the scale of the reach, a natural unit of stream habitat that ranges from hundreds to thousands of metres in length (Frissell et al. 1986). There are three reasons for adopting this scale. First, the reach scale corresponds to the distribution of subpopulations within watersheds and usually contains all habitat types used during the life cycle (Pearson 2004a). Second, the 'channel units' of critical habitat (riffles and pools) are dynamic and frequently move during flood events in these streams. Effective protection and management of critical habitat in these circumstances must allow for normal channel processes and must, therefore, occur at a spatial scale larger than the channel unit. The reach scale is the next largest in accepted stream habitat classifications (Frissell et al. 1986; Imhof et al. 1996) and by definition represents relatively homogenous segments of stream demarcated by distinct geomorphic or land use transitions. Third, the reach scale corresponds most closely to that of land ownership in these watersheds and, consequently, to most recovery actions.

The protocol used for identifying Salish Sucker critical habitat was consistent with guidelines for documenting habitat quality and use by species at risk (Rosenfeld & Hatfield 2006; Fisheries and Oceans Canada 2007) and the approach and results have been reviewed and approved by the Pacific Science Advise Review Committee (Pearson 2008). Specifically, area of deep pool habitat in each reach (a key habitat feature) was used to quantify carrying capacity and the degree of hypoxia was identified as the key variable in determining its quality. Its spatial configuration was mapped and a rough estimate was provided of the present amount that is of sufficient quality to support Salish Suckers. The supply of habitat was equated with population and distribution objectives and advice was provided on the feasibility of restoring additional habitat. All identified critical habitat is believed to be required to meet the population and distribution objectives. Advice was provided on the extent to which threats can lower the quality and quantity of critical habitat.

Defining width of riparian reserve strips

Riparian reserve strips are included in critical habitat for Salish Sucker. The required widths of riparian reserve strips vary among sites and should be defined in reach scale assessments. Riparian reserve strips must be sufficient to control sediment entry to the stream from overland flow, to prevent excessive bank erosion and to buffer stream temperatures. Reserve areas will also remove significant amounts of nitrate and phosphorous from groundwater, although their efficacy depends strongly on hydrogeologic conditions (Martin et al. 1999; Wigington et al. 2003; Puckett 2004). The effectiveness of a riparian reserve in preventing materials (sediment, nutrients, toxins, etc.) from entering a stream depends strongly on its longitudinal continuity and its lateral width (Weller et al. 1998). Consequently, riparian reserves in critical habitat reaches should be continuous and sufficiently wide. In open landscapes, such as agricultural fields, vegetation from reserve areas will collect windblown insects (Whitaker et al. 2000). Such insects, falling from riparian vegetation into the water constitute an important food source for drift-feeding fishes in headwater streams (Schlosser 1991; Allan et al. 2003;). More than 30 m of riparian vegetation may be required for full mitigation of warming (Brown & Krygier 1970; Lynch et al. 1984; Castelle et al. 1994), and siltation (Moring 1982; Davies & Nelson 1994; Kiffney et al. 2003), and for long-term maintenance of channel morphology (Murphy et al. 1986; Murphy & Koski 1989). At least 10 m are required to maintain levels of terrestrial carbon (i.e., leaf) and food (invertebrate) inputs similar to those of forested landscapes (Culp & Davies 1983). Reserves as narrow as 5 m provide significant protection from bank erosion and sediment deposition from overland flow (Lee et al. 2003; McKergow et al. 2003).

Failure to maintain an adequate riparian reserve as part of critical habitat is likely to cause population-level impacts. In habitats lacking sufficient flow or groundwater, absence of shade may increase water temperatures to harmful levels. Increased erosion due to poorer bank stability will cause sediment deposition in riffles, and impair spawning and incubation. Nutrient loading will be higher in reaches without adequate riparian vegetation (Martin et al. 1999; Dhondt et al. 2002; Lee et al. 2003) and is likely to contribute to hypoxia through eutrophication. Solar radiation in nutrient rich reaches lacking adequate riparian shading (Kiffney et al. 2003) will also contribute to eutrophication and hypoxia.

Specific research on the widths of riparian reserves required to protect key habitat attributes for Salish Sucker in particular has not been done, although this relationship has been investigated for other fish species. Mature Salish Suckers are benthic feeders (Scott & Crossman 1973) indicating that they are less dependant on insects of terrestrial origin than drift-feeding fishes like salmonids. They also appear tolerant of slightly higher water temperatures than salmonids (Wehrly et al. 2003), suggesting a reduced need for shading, but this may not be true under future climate warming scenarios. However, Salish Suckers are likely to be as vulnerable as salmonids to habitat degradation caused by sedimentation, loss of scope for natural channel movement, reduction in large woody debris supply, and invasive plant overgrowth of riffles fuelled by nutrient loading and riparian loss. Benthic insectivores, like Salish Suckers, are among the most sensitive fish species to loss of wooded riparian areas (Stauffer et al. 2000), probably due to the impacts of siltation and alterations to macroinvertebrate community structure (Kiffney et al. 2003; Allan 2004). Overall, there is little reason to believe that Salish Suckers require narrower or wider buffers than salmonids.

It should be noted that unidirectional transport of sediment in flowing waters means that riparian reserve strips upstream of critical habitat reaches are important in minimizing sedimentation and other impacts within instream critical habitat. For this reason stewardship programs should promote the establishment of continuous riparian reserve strips of native vegetation throughout the watershed, not just along critical habitat reaches.

Widths of riparian reserve strips included in critical habitat for Salish Sucker were assessed using a Geographic Information Systems (GIS)-based methodology adapted directly from and consistent with the British Columbia Riparian Areas Regulation (RAR, Reg. 837 under the *Fish Protection Act* [S.B.C. 1997, c. 21], Province of British Columbia 2006). The B.C. Ministry of Environment (B.C. MoE) and Fisheries and Oceans Canada (DFO) developed and implemented this methodology for determining riparian reserve widths required to maintain riparian function and protect fish habitat. The Riparian Areas Regulation (RAR) was developed under the provincial *Fish Protection Act* to protect "salmonids, game fish, and regionally significant fish" from the impacts of land development. In the absence of definitive data for a SARA-listed species, this is a reasonable standard to apply in the identification of critical habitat because it represents a benchmark and standard methodology to which both federal and provincial agencies responsible for management of species at risk have already agreed, and it forms the basis of the methodology employed. Further details of methods and an assessment of existing riparian vegetation in these areas can be found in Pearson (2008).

3.1.2 Identification of Critical Habitat: Geospatial

Critical habitat for the Salish Sucker consists of relatively homogenous segments of stream demarcated by distinct geomorphic or land use transitions, otherwise known as reaches, within the Salmon River, Bertrand Creek, Pepin Brook, Fishtrap Creek, Salwein Creek/Hopedale Slough, Atchelitz/Chilliwack/ Semmihault Creeks, Elk Creek/Hope Slough, Mountain Slough, Agassiz Slough and Miami River watersheds. Only those reaches that include more than 50 m of continuous pool with a water depth exceeding 70 cm under summer low flow conditions constitute critical habitat. Critical habitat within these reaches includes all the aquatic habitat features and attributes identified in section 3.1.3 and riparian reserve strips of native vegetation on both banks for the entire length of the reach. Riparian reserve strips are continuous and extend laterally (inland) from the top of bank to varying widths identified for each reach in Appendix 2. The width of the riparian reserve strip for each reach is equal to the widest zone of sensitivity (ZOS) calculated for each of five riparian features, functions and conditions: large woody debris supply for fish habitat and maintenance of channel morphology, localized bank stability, channel movement, shade, and insect and debris fall. The ZOS values are calculated using methods consistent with those used under the British Columbia Riparian Areas Regulation (Reg. 837) under the *Fish Protection Act* (S.B.C. 1997, c. 21).

The combined length of critical habitat identified for the Salish Sucker in this recovery strategy is 145.74 km (of 329.1 km of surveyed stream channel). Maps showing the location of critical habitat and the width of riparian reserve strips for identified reaches are provided in Appendix 2.

The areas identified as critical habitat are those considered necessary to support the species survival and recovery and to reach the population and distribution objectives for Salish Sucker. Additional areas may be identified as critical habitat in subsequent action plans if new information determines that they are necessary to the survival and recovery of Salish Sucker.

3.1.3 Identification of Critical Habitat: Biophysical Functions Features and Their Attributes

Within the identified geographic boundaries, the critical habitat supports the following biophysical functions, features and attributes:

Deep Pool Habitat

Deep pool habitat is the biophysical feature that supports the life cycle functions of feeding and rearing for adult and juvenile Salish Suckers. Adults and larger juveniles (>70 mm) are concentrated in reaches containing long stretches of pool habitat that exceed 70 cm in depth at low flow (Pearson 2004a). As the primary habitat used for the majority of the life cycle, this feature is comprised of all deep pool habitats in reaches that contain more than 50 m of continuous channel and that have a depth exceeding 70 cm. The 50 m threshold was chosen because it is the minimum length of all reaches known to contain moderate or high densities of Salish Suckers (catch per unit effort > 1.8 individual per trap[2], Pearson, unpublished data). It also includes reaches that contain excellent physical habitat (i.e., meet the 50 m length threshold and 70 cm minimum depth), but where severe hypoxia appears to currently limit Salish Sucker numbers (i.e., this is habitat critical to recovery).

Essential attributes:

- A minimum depth of 70 cm is an essential attribute of deep pool habitat features.
- Dissolved oxygen levels of ≥ 4 mg/L
- Water temperatures between 6 and 23ºC
- Adequate quantity and quality of food supply (terrestrial and aquatic insects)
- Little or no additional sediment
- Few or no additional nutrients
- Few or no additional toxins

[2] Double ended cylindrical funnel traps 100 x 55 cm, 0.5” mesh, baited with dry cat food set for 24 h (see Pearson and Healey 2003).

Riffle Habitat

Riffle habitats are an essential feature of critical habitat used by Salish Suckers for spawning and incubation. Riffles tend to be rare (and potentially limiting) in the reaches occupied by high densities of Salish Suckers, which consist predominantly of headwater ponds and marshes (Pearson 2004a). Consequently, all riffle habitats within reaches containing more than 50 m of habitat with water depths exceeding 70 cm are identified as critical. In some reaches fish leave their ‘home’ reach to spawn (Pearson & Healey 2003). The riffles where this is known to occur are within identified critical habitat reaches, but other undocumented spawning sites outside identified critical habitat may exist.

Essential Attributes:

- Cobble or gravel substrate
- Dissolved oxygen levels of ≥ 4 mg/L
- Water temperatures between 6 and 23ºC
- Sufficient water flow to support riffles
- Adequate quantity and quality of food supply (terrestrial and aquatic insects)
- Little or no additional sediment
- Few or no additional nutrients
- Few or no additional toxins

Shallow Pool and Glide Habitats

Shallow pools and glides (moderately shallow sections of stream with even flow and little turbulence) less than 40 cm in depth are an essential feature of critical habitat that are used by young-of-the-year Salish Suckers (<70 mm fork length) as a nursery habitat for feeding and rearing, although they are occasionally captured in deeper water (Pearson 2004a). All shallow pool and glide habitats within reaches that contain more than 50 m of continuous habitat and water depths exceeding 70 cm are designated as critical as it is potentially limiting as nursery habitat.

Essential Attributes:

- A maximum depth of 40 cm is an essential attribute of shallow pool and glide habitat features.
- Dissolved oxygen levels of ≥ 4 mg/L
- Water temperatures between 6 and 23ºC
- Adequate quantity and quality of food supply (terrestrial and aquatic insects)
- Little or no additional sediment
- Few or no additional nutrients
- Few or no additional toxins

Riparian Habitats

Riparian habitats with native vegetation are an essential feature of critical habitat that maintain the instream habitat attributes necessary to support Salish Suckers’ use of these areas for biological functions of feeding, rearing and spawning. Native riparian vegetation is an essential attribute of riparian habitat features. Loss of riparian vegetation contributes to bank erosion, siltation, water temperature elevation, and nutrient inputs, all of which directly degrade instream critical habitat.

Failure to maintain an adequate riparian reserve as part of critical habitat is likely to cause population-level impacts. In habitats lacking sufficient flow or groundwater, absence of shade may increase water temperatures to harmful levels. Increased erosion due to poorer bank stability will cause sediment deposition in riffles, and impair spawning and incubation. Nutrient loading will be higher in reaches without adequate riparian vegetation (Martin et al. 1999; Dhondt et al. 2002; Lee et al. 2003) and is likely to contribute to hypoxia through eutrophication. Solar radiation in nutrient rich reaches lacking adequate riparian shading (Kiffney et al. 2003) will also contribute to eutrophication and hypoxia.

Essential Attributes:

- Native riparian vegetation
- Continuous for the entire length of the reach
- Extends laterally (inland) from the top of the bank to a width[3] equal to the widest zone of sensitivity, or ZOS (calculated using methods consistent with those used under the BC Riparian Areas Regulation), in order to ensure the following functions:
  - Protects the integrity of other aquatic features such as riffle and shallow pool habitat.
  - Provides large and small woody debris
  - Provides localized bank stability
  - Provides shade to buffer instream temperatures
  - Provides terrestrial insect input
  - Limits entry of added nutrients
  - Maintains natural channel morphology

Summary of Critical Habitat Features Functions and Attributes

Table 4 summarizes the essential functions, features and attributes of the Salish Sucker critical habitat identified in this recovery strategy:

[3] Width of riparian reserve strips associated with particular reaches is defined in the table of coordinates and critical habitat maps in Appendix 2.

Table 4. Summary of the functions, features and attributes of Salish Sucker critical habitat

Geospatial location	**Life Stage**	**Function**	**Feature (s)**	**Attribute(s)**
Reaches within Salmon River, Bertrand Creek, Pepin Brook, Fishtrap Creek, Salwein Creek/Hopedale Slough, Atchelitz/Chilliwack/ Semmihault Creeks, Elk Creek/Hope Slough, Mountain Slough, Agassiz Slough and Miami River watersheds	Adults and Juveniles (> 70 mm fork length)	Feeding and Rearing	*Deep Pool Habitat*	• Minimum water depth of 70 cm • Dissolved oxygen levels of ≥ 4 mg/L • Water temperatures between 6 and 23ºC • Adequate quantity and quality of food supply (terrestrial and aquatic insects) • Little or no additional sediment • Few or no additional nutrients • Few or no additional toxins
Reaches within Salmon River, Bertrand Creek, Pepin Brook, Fishtrap Creek, Salwein Creek/Hopedale Slough, Atchelitz/Chilliwack/ Semmihault Creeks, Elk Creek/Hope Slough, Mountain Slough, Agassiz Slough and Miami River watersheds	Juveniles (<70 mm fork length)	Feeding and Rearing	*Shallow Pool and Glide Habitat*	• Minimum water depth of 40 cm • Dissolved oxygen levels ≥ 4 mg/L • Water temperatures between 6 and 23ºC • Adequate quantity and quality of food supply (terrestrial and aquatic insects) • Little or no additional sediment • Few or no additional nutrients • Few or no additional toxins

Geospatial location	Life Stage	Function	Feature (s)	Attribute(s)
Reaches within Salmon River, Bertrand Creek, Pepin Brook, Fishtrap Creek, Salwein Creek/Hopedale Slough, Atchelitz/Chilliwack/ Semmihault Creeks, Elk Creek/Hope Slough, Mountain Slough, Agassiz Slough and Miami River watersheds	Adult	Spawning and incubation	*Riffle Habitat*	• Cobble or gravel substrates • Dissolved oxygen levels ≥ 4 mg/L • Water temperatures between 6 and 23ºC • Sufficient water velocity and flow to support riffles • Adequate quantity and quality of food supply (terrestrial and aquatic insects) • Little or no additional sediment • Few or no additional nutrients • Few or no additional toxins

Reaches within Salmon River, Bertrand Creek, Pepin Brook, Fishtrap Creek, Salwein Creek/Hopedale Slough, Atchelitz/Chilliwack/ Semmihault Creeks, Elk Creek/Hope Slough, Mountain Slough, Agassiz Slough and Miami River watersheds	Adult and juveniles	Spawning, incubation, feeding and rearing	*Riparian habitat*	• Native riparian vegetation
				• Continuous for the entire length of the reach
				• Extends laterally (inland) from the top of the bank to a width[4] equal to the widest zone of sensitivity, or ZOS (calculated using methods consistent with those used under the BC Riparian Areas Regulation), in order to ensure the following functions:
				    • Protects the integrity of other aquatic features such as riffle and shallow pool habitat.
				    • Provides large and small woody debris
				    • Provides localized bank stability
				    • Provides shade to buffer instream temperatures
				    • Provides terrestrial insect input
				    • Limits entry of added nutrients
				    • Maintains natural channel morphology

[4] Width of riparian reserve strips associated with particular reaches is defined in the table of coordinates and critical habitat maps in Appendix 2.

3.2 Activities Likely to Result in Destruction of Critical Habitat

The definition of destruction is interpreted as:

> *Destruction of critical habitat would result if any part of the critical habitat were degraded, either permanently or temporarily, such that it would not serve its function when needed by the species. Destruction may result from single or multiple activities at one point in time or from cumulative effects of one or more activities over time.*

Under SARA, critical habitat must be legally protected from destruction once it is identified. This will be accomplished through a s.58 Order, which will prohibit the destruction of the identified critical habitat unless permitted by the Minister of Fisheries and Oceans Canada pursuant to the conditions of SARA.

The Minister of Fisheries and Oceans invites all interested Canadians to submit comments on the potential use of a s.58 Order to protect the critical habitat of the Salish Sucker as soon as possible. Please note that, pursuant to s.58, any such Order must be operational within 180 days of the posting of the final version of the Recovery Strategy, or Action Plan, that identifies critical habitat.

The activities described in this table are neither exhaustive nor exclusive and have been guided by the Threats described in section 2.1 of the recovery strategy for the species. The absence of a specific human activity does not preclude, or fetter the department's ability to regulate it pursuant to SARA. Furthermore, the inclusion of an activity does not result in its automatic prohibition as it is destruction of critical habitat that is prohibited. Since habitat use is often temporal in nature, every activity is assessed on a case-by-case basis and site-specific mitigation is applied where it is reliable and available. In every case, where information is available, thresholds and limits are associated with attributes to better inform management and regulatory decision-making. However, in many cases the knowledge of a species and its critical habitat may be lacking and in particular, information associated with a species or habitats thresholds of tolerance to disturbance from human activities, is lacking and must be acquired.

Gaps in our understanding of the attributes of critical habitat features and the activities that could affect them will be a focus for research in one or more action plans.

Table 5. Activities likely to result in the destruction of critical habitat for Salish Sucker

Activity (Related Threat)	Affect – Pathway	Function Affected	Feature Affected	Attribute Affected
Over-application of Fertilizer (Hypoxia)	Nutrient loading in streams through excessive application of manure is the most common cause of the chronic late summer hypoxia that affects many reaches inhabited by Salish Suckers (Schreier et al. 2003).	Feeding, Rearing, Spawning and Incubation	Deep Pools Shallow Pools and Glides Riffles	Oxygen levels Nutrient levels
Drainage projects (Physical destruction of habitat and sediment deposition)	Dredging, dyking, and channelization directly destroy habitat, cause sediment deposition in riffles, and reduce base flow.	Feeding, Rearing, Spawning and incubation	Deep Pools Shallow Pools and Glides Riffles	Sediment levels Water flow Water levels Riffle structure
Urban storm drainage (Toxicity, sediment deposition and seasonal lack of water)	Storm drain systems that discharge directly to creeks are major sources of toxic contamination and sediment. They also reduce base flow by inhibiting groundwater recharge.	Feeding, Rearing, Spawning and Incubation	Deep Pools Shallow Pools and Glides Riffles	Sediment levels Toxicity levels Water flow Water levels
Riparian vegetation removal (Hypoxia and Sediment Deposition)	Loss of riparian vegetation causes increased erosion and sediment deposition, elevated water temperatures that can contribute to eutrophication and hypoxia, reduced supplies of terrestrially derived food, and increased nutrient loading.	Feeding, Rearing, Spawning and Incubation	Riparian Habitat Deep Pools Shallow Pools and Glides Riffles	Native riparian vegetation Bank stability Supply of woody debris Channel movement Shade Quantity and quality of terrestrial insects Water temperature Sediment levels Nutrient levels Oxygen levels Supply of terrestrial insects

Activity (Related Threat)	Affect – Pathway	Function Affected	Feature Affected	Attribute Affected
Mowing native vegetation (hypoxia and sediment deposition)	Mowing or removal of native vegetation in the riparian portion of critical habitat prevents the establishment of mature riparian vegetation and causes elevated erosion and sediment deposition, elevated water temperatures, reduced supplies of terrestrially derived food, and increased nutrient loading.	Feeding, Rearing, Spawning and Incubation	Riparian Habitat Deep Pools Shallow Pools and Glides Riffles	Native riparian vegetation Bank stability Supply of woody debris Channel movement Shade Quantity and quality of terrestrial insects Water temperature Sediment levels Nutrient levels Oxygen levels Supply of terrestrial insects
Livestock access to creeks (Hypoxia and sediment deposition)	Livestock damage habitat by trampling or causing erosion that clogs riffles with sediment. Access also contributes to nutrient loading.	Spawning and Incubation Feeding Rearing	Riffles Deep Pools Shallow Pools and Glides	Sediment levels Nutrient levels Oxygen levels Nutrient levels Oxygen levels
Excessive water withdrawal (Seasonal lack of water and hypoxia)	Water extraction (surface or ground), especially during dry periods, reduces flows and can contribute to hypoxia and drying of riffles needed for spawning.	Feeding Rearing Spawning and Incubation	Deep Pools Shallow Pools and Glides Riffles	Water levels Water flow Oxygen levels Water temperature Riffle structure

Activity (Related Threat)	Affect – Pathway	Function Affected	Feature Affected	Attribute Affected
Excessive sediment releases (Sediment deposition)	Sediment deposition in spawning substrate and inhibition of the flow of oxygen-rich water to eggs and larvae during incubation.	Spawning and Incubation	Riffles	Sediment levels Water flow Oxygen levels

Table 6 - Relative severity of the activities likely to destroy critical habitat for Salish Sucker by watershed. (Bert=Bertrand Creek; Pep=Pepin Brook; Fish=Fishtrap Creek; Salm=Salmon River; Salw=Salwein Creek/Hopedale Slough; Chill=Atchelitz/Little Chilliwack/Semmihault/Luckacuck Creeks; Miam=Miami River; Moun= Mountain Slough; Agas=Agassiz Slough; Hope = Elk Creek/Hope Slough; L.Cam=Little Campbell River)

Activity	Bert	Pep	Fish	Salm	Salw	Chill	Miam	Moun	Agas	Hope	L.Cam
Over application of fertilizer	+++	++	+++	+++	++	+++	+++	+++	++	+++	++
Drainage projects	++	+	+++	++	++	+++	+++	+++	+	+++	++
Urban storm drainage	+++	-	+++	-	-	+++	++	-	+++	++	+
Riparian vegetation removal	++	+	+++	++	+++	+++	+++	+++	++	+++	++
Livestock access to creeks	+	+	+	++	++	++	++	++	+	++	++
Excessive water withdrawal	+++	+	++	+++	+	++	++	++	++	++	++
Excessive sediment releases	+	+++	++	+	+	++	+	+++	+	++	+

+++	major concern	++	Moderate concern	+	minor concern	-	not a concern

3.3 Schedule of Studies to Identify Critical Habitat

This recovery strategy includes an identification of critical habitat to the extent possible, based on the best available information. Critical habitat areas and attributes that support life functions during the adult and spawning life stages have been identified. Further research is required to determine if all critical habitat has been identified and to refine our understanding of spawning areas as well as habitats used by juveniles, as per Table 7 below. At present, Salish Suckers are known to occur in 10 watersheds. Critical habitat areas, features and attributes that support functions required by adult and spawning life stages have been identified for these populations. Further research is required to locate and confirm additional spawning areas and critical habitat for juveniles.

Table 7. Schedule of studies to identify Salish Sucker critical habitat.

Study	Description	Timeframe
Surveys of additional areas for critical habitat features	Approximately 60 km of channel in watersheds containing populations needs to be surveyed to determine if critical habitat features (eg. deep pools) are present	2011 - 2014
Improve information used to identify juvenile critical habitat	Intensive trapping/seining in habitats near known spawning sites to gather more information on juvenile habitat use.	2012-2016
Identify spawning sites for all populations	Visual identification of spawning site use.	2011-2016

3.4 Knowledge Gaps in Salish Sucker Biology

Additional studies should address the following data needs related to specific threats to the Salish Sucker. This information will contribute to the protection of Salish Sucker populations and their critical habitats.

Table 8. Studies required to fill key knowledge gaps for the Salish Sucker.

Study	Description
Surveys for the presence/ absence of Salish Sucker in other area watersheds	Several of the currently known populations of Salish Sucker have been found since 2000. Surveys in other areas watersheds could reveal additional populations.
Characterize long-term population dynamics	Measure changes in abundance at the reach scale in watersheds where Salish Sucker are present.
Characterize impacts of introduced predators on mortality and habitat use by different life stages.	A variety of experimental and correlational approaches could be used to study the impacts of introduced predators. Those involving young-of-the-year and yearling Salish Suckers are of highest priority.
Potential connections among watersheds.	Assess the possibility and ecological consequences of connections among watersheds via Fraser River mainstem or during occasional floods.

4. RECOVERY

4.1 Recovery Feasibility

***Feasibility Criteria*[5]**

1) *Are individuals capable of reproduction currently available to improve the population growth or population abundance?*
   Yes. Breeding adults have been captured recently from all populations except that of the Little Campbell River, which is believed to have been extirpated.

2) *Is sufficient habitat available to support the species or could it be made available through habitat management or restoration?*
   Yes. Sufficient physical habitat exists to support target population sizes, but a large fraction of it (up to 40%) is seriously degraded by hypoxia and/or low water levels in late summer.

3) *Can significant threats to the species or its habitats be avoided or mitigated through recovery actions?*
   Yes. The largest threats, hypoxia and habitat loss can be avoided or mitigated.

4) *Do the necessary recovery techniques exist and are they demonstrated to be effective?*
   Yes. Monitoring of experimental habitat restoration projects has demonstrated that habitat creation and restoration are effective means of increasing population size and stability. Invasive weed control, riparian restoration, beaver management, and flow diversion have all been used successfully to reduce hypoxia in Salish Sucker habitat.

Feasibility Assessment
Recovery of Salish Sucker populations to levels ensuring long-term survival is both technically and biologically feasible. Given the restricted distribution of the species and the continued pressure on its habitats from a rapidly growing human population in the Fraser Valley it is likely that the species will remain at risk over the foreseeable future.

4.2 Recovery Goal, Objectives and Corresponding Approaches

4.2.1 Recovery Goal

Ensure the long-term viability of Salish Sucker populations throughout their natural distribution in Canada.

4.2.2 Recovery Objectives

1. Prevent extirpation of Salish Suckers in each of the 10 watersheds with extant populations by preventing net loss of reproductive potential.
2. Reach or exceed each of the following targets by 2020:
   a. occupation of all instream critical habitats,

[5] Draft Policy on the Feasibility of Recovery, Species at Risk Act Policy. January 2005.

   b. watershed-specific abundance targets for mature individuals,
   c. one or more source habitats with high density in each watershed.
3. Reintroduce the Salish Sucker to Little Campbell River, if extirpation is confirmed and reintroduction is feasible.

The objectives 2 and 3 are discussed in detail below.

Occupation of instream critical habitats

Rationale:
A high proportion of critical habitat is not currently occupied (Table 9), primarily due to severe hypoxia. Achieving interim population recovery targets requires that all critical habitat be occupied (see objective 2 below). In most cases, unoccupied areas could become habitable by improving water quality via increased water flow and/or reduced nutrient loading. Relatively simple measures including localized beaver control, fish-sensitive drainage maintenance practices or, in the case of Agassiz Slough, restoration of through-flow are likely to produce dramatic improvements quickly.

Target:
Occupation of critical habitat is defined as, Salish Sucker confirmed present in a reach (n>10 traps per reach; see Pearson & Healey 2003). The amount of critical habitat currently occupied and the amounts identified to support target abundances are presented in Table 9. The difference between the two columns represents the amount of habitat that requires some form of restoration.

Table 9. Occupied and total critical habitat for the Salish Sucker.

Watershed	Estimated length (km) of Currently Occupied Critical Habitat (year surveyed)	Total Critical Habitat Identified to Reach Recovery Targets (km)
Agassiz Slough	<1 (2005)	4.3
Atchelitz/Chilliwack/Semmihault	<16 (2004)	32.4
Bertrand Creek	>10 (2009)	15.0
Fishtrap Creek	Unknown* (1999)	6.5
Hope Slough/Elk Creek	Unknown* (2006)	23.6
Miami Creek	<1.8 (2002)	7.8
Mountain Slough	>7.5 (2008)	9.7
Pepin Brook	>7.5 (2004)	11.6
Salmon River	>10 (2008)	20.2
Salwein Creek/Hopedale Slough	<2.5 (2004)	10.8

* too few individuals were captured to assess occupancy

Watershed-specific abundance targets for mature individuals

Rationale:
Populations of Salish Sucker in the 10 watersheds where they occur are essentially independent of one another, with low probability of natural exchange of individuals

between watersheds. Natural exchange is limited by large distances of unsuitable habitat that separate populations. Natural recolonization of habitat from which a population has been extirpated (rescue effect) is therefore highly unlikely, especially if extirpation is due to progressive habitat or water quality degradation, rather than stochastic events. Each watershed, consequently, warrants a separate recovery target. Ideally, these targets would be based on robust population viability analyses, but the necessary demographic data is lacking for the Salish Sucker. Recommendations based on extensive literature reviews indicate that a minimum viable population size (MVP) of 7000 breeding adults (median value; range 2000-10000) will ensure long term persistence in the majority of vertebrates (Reed et al. 2003; Thomas 1990).

To assess Salish Sucker abundance Pearson (2004a) estimated density from catch-per-unit-effort in 84 reaches in four watersheds using an equation calibrated with capture-recapture data. Salish Suckers were present in 34 of these reaches, but density estimates exceeded 0.05 adult/m^2 in only seven of them. The maximum achievable population in each watershed was estimated by assuming this density occurs in all deep pool habitats within critical habitat reaches. The data suggest that if all deep pool areas in all critical habitat reaches supported this ‘medium density’ (Pearson 2004a), all populations would remain at or below the estimated median MVP for vertebrates (7000). This suggests that the maximum achievable population sizes are close to the minimum viable population sizes in these watersheds and that all suitable habitats should be designated critical. Enhancement of critical habitat to increase carrying capacity and construction/restoration of additional habitat is advisable in all watersheds to increase safety margins.

Target:
Watershed-specific abundance targets are presented in Table 10.

One or more source habitats with high density in each watershed

Rationale:
Available distribution data suggest that Salish Sucker populations within watersheds function as source-sink and/or metapopulation systems (Pearson 2004a). In metapopulation systems, subpopulations within watersheds are largely isolated from one another, connected only by occasional migrants (Forman 1995). Population growth may be positive in core (source) habitats of these subpopulations, but negative in surrounding (sink) habitats, even though a substantial portion of the population may reside in sink areas (Pullman 1988). Population persistence in such systems is dependent on the existence of one or more source habitats where population growth is positive and densities are high.

Target:
Source habitat for the Salish Sucker is defined based on a minimum catch-per-unit-effort of three adults/trap. Pearson (2004a) found only three examples among 84 reaches in 4 watersheds. In two more recently restored habitats in Pepin Brook with adequate

dissolved oxygen levels, however, this threshold has been achieved within three years (Pearson, unpublished data), implying that the goal is achievable.

Table 10. Area of deep pools and population targets for the Salish Sucker.

Watershed	Area of Deep Pool in Critical Habitat Reaches (m^2)	Population Target * (excludes young of year)
Agassiz Slough	39,200	2000
Atchelitz/Chilliwack/Semmihault	140,000	7000
Bertrand Creek	140,200	7,000
Fishtrap Creek	94,600	4700
Hope Slough/Elk Creek	159,700	8,000
Miami Creek	30,000	1500
Mountain Slough	88,700	4,400
Pepin Brook	24,000**	1200
Salmon River	165,000	8,200
Salwein Creek/Hopedale Slough	53,900**	2700

* See *Rationale* for methods used for determining targets. All numbers rounded to nearest hundred.
** Does not include several thousand square metres of habitat constructed since 2005.

Reintroduce the Salish Sucker to the Little Campbell River, if extirpation is confirmed and reintroduction is feasible

Rationale:

Re-establishment of extirpated populations is necessary to fully achieve the strategy's overall goal: "To ensure long-term viability of Salish Sucker populations throughout their natural distribution in Canada." This will only be feasible if extirpation is confirmed, sufficient habitat is available and threats (e.g., habitat quality and introduced alien predators) are sufficiently mitigated. The goal to have Salish Suckers occupy the full natural range is reasonable, given the species' restricted distribution in Canada.

4.2.3 Broad Strategies to Support the Recovery Objectives

Nine broad strategies have been identified in support of the recovery objectives:

1) Reduce incidence of severe hypoxia in instream critical habitats.
2) Protect existing habitat, restore lost or degraded habitat and create new habitat.
3) Increase the integrity and function of all riparian habitats.
4) Encourage stewardship among private landowners, local government and agencies, and the general public.
5) Reduce fragmentation of instream and riparian habitats.
6) Reduce toxic contamination of instream habitat.
7) Reduce sediment entry to instream habitats.
8) Assess impacts of predator introduction and prevent new introductions.
9) Assess feasibility of reintroducing the Salish Sucker into the Little Campbell River if extirpation from watershed is confirmed

In Table 11 these strategies are described in greater detail, prioritized and related to the recovery goal and objectives.

4.2.4 Evaluation

Ideally, monitoring and evaluation of a subset of populations should occur each year and the status of each population and watershed evaluated at least every five years. Performance measures for each objective and broad strategy are listed in Table 12. Details and priorities of strategy implementation will be provided in one or more action plans.

4.2.5 Effects on Other Species

Most recovery efforts will benefit co-occurring native species including Steelhead (*Oncorhynchus mykiss*), Cutthroat Trout (*Oncorhynchus clarkii clarkii*) and Coho Salmon (*Oncorhynchus kisutch*). In particular, Coho Salmon are likely to benefit because juveniles often share habitat with Salish Suckers (Pearson 2004a).

Many SARA-listed species are known to occur in streams and riparian areas supporting Salish Suckers. The Nooksack Dace (*Rhinichthys cataractae* sp., Pearson 2004a), Oregon Spotted Frog (*Rana pretiosa*, Haycock 2000), and Western Painted Turtle (*Chrysemys picta*) occupy aquatic areas in some Salish Sucker habitat. Nooksack Dace occur primarily in riffles and are seldom found in the same reaches as the Salish Sucker (Pearson 2004a). They are unlikely to be harmed by any of the activities described in this strategy and will benefit from many of them. American Beaver (*Castor canadensis*) control measures may be necessary in Pepin Brook to counteract inundation of riffles, the primary habitat of Nooksack Dace. This work would likely benefit the Salish Sucker preserving spawning riffles and by reducing hypoxia (currently a threat in the affected reaches) through increased water movement, although some loss of deep pool habitat will also occur. An action plan will consider habitat management jointly for the Salish Sucker and Nooksack Dace in the watersheds in which they co-occur.

Oregon Spotted Frogs occur in the same reaches as the Salish Sucker in Mountain Slough, near Agassiz and in Bertrand Creek, near Aldergrove. The frogs are likely to benefit from recovery activities described in this strategy, particularly those that increase oxygen levels in the water (Haycock pers. comm. 2005). Development of best management practices for instream works in habitats where Oregon Spotted Frogs and Salish Suckers coexist will be completed in cooperation with the Oregon Spotted Frog Recovery Team.

Western Painted Turtles occur in the same reaches as Salish Suckers in Salwein Creek, near Chilliwack. The turtles are likely to benefit from the creation and complexing of deep pool habitats for the Salish Sucker. A habitat enhancement project to benefit both species was initiated in Salwein Creek by members of both Recovery Teams in September 2009.

Many other SARA-listed species are known from riparian areas of Salish Sucker habitat, including the Pacific Water Shrew (*Sorex bendirii*), Red-legged Frog (*Rana aurora*), Western Toad (*Bufo boreas*), Mountain Beaver (*Aplodontia rufa*), Oregon Forestsnail

(*Allogona townsendiana*), Vancouver Island Beggarticks (*Bidens amplissim*a), and Great Blue Heron (*Ardea herodias fannini*). None are expected to be harmed by activities proposed in this recovery strategy, and most are expected to benefit from the protection and restoration of native riparian vegetation.

Table 11. Broad strategies, research activities and management activities to support the recovery objectives for the Salish Sucker.

Broad Strategy	Objectives	Threats Addressed	Priority	Specific Activities	Outcomes or Deliverables
1) Reduce incidence of severe hypoxia in instream critical habitats.	1, 2	Hypoxia	High	Assess extent, severity, causes and impacts of hypoxia in all watersheds. Work with stakeholders to eliminate sources of nutrient loading and to increase extent of riparian buffers adjacent to Salish Sucker streams. Work with municipalities to develop drainage maintenance and beaver management protocols that increase flow without degrading habitat. Develop and distribute public education materials on the impacts of hypoxia on fish and wildlife to landowners.	Late summer hypoxia maps completed for all watersheds. Increased dissolved oxygen levels in critical habitats susceptible to hypoxia.
2) Protect existing habitat, restore lost or degraded habitat and create new habitat.	1, 2	Physical destruction of habitat Habitat fragmentation	High	Assess benefits of habitat creation and enhancement to Salish Sucker populations. Identify high priority sites for protection, restoration or habitat creation. Work with stewardship groups and landowners to identify and implement habitat creation and restoration projects. Develop best management practices and work plans for critical habitat reaches that require drainage maintenance or beaver management. Develop guidelines for joint management where Salish Suckers and other listed species co-occur. Develop and distribute materials to landowners regarding the importance of habitat.	There are a variety of possible mechanisms to protect critical habitat and other habitats, only some of which are presented here. Habitat management plan developed for each occupied watershed. Protection of critical habitat through stewardship agreements, conservation covenants, acquisition or other mechanisms. Habitat creation/enhancement projects identified and implemented. Advice on Salish Sucker habitat requirements for local stewardship groups, agencies and consultants involved in habitat work. Educational materials developed and included in landowner contact programs and other public education applications.
3) Increase the integrity and function of all riparian habitats.	1, 2	Sediment deposition Physical destruction of	High	Conduct riparian assessments in all critical habitat reaches and make recommendations for reserve zones and other mitigative measures. Identify, prioritize and develop riparian planting	Riparian assessments completed as the basis for establishing defensible reserve zones to protect instream critical habitat. Riparian planting projects completed in

Broad Strategy	Objectives	Threats Addressed	Priority	Specific Activities	Outcomes or Deliverables
		habitat Toxicity Hypoxia		projects in cooperation with landowners, stewardship groups and government agencies. Develop and distribute public education materials to landowners on riparian reserve strips.	high priority areas. Educational materials developed and included in landowner contact programs and other public education applications.
4) Encourage stewardship among private landowners, local government and agencies, and the general public.	1, 2	All	Med	Give presentations and field tours on Salish Suckers and watershed ecology to local stewardship groups, school groups and others. Advise stewardship groups, agencies and consultants involved in habitat work on Salish Sucker habitat requirements.	Increased awareness of Salish Suckers and local stream ecology among public. Salish Sucker habitat features incorporated into instream works undertaken for other purposes.
5) Reduce fragmentation of instream and riparian habitats.	1, 2	Habitat fragmentation	Med	Assess the ability of different life stages to cross barriers such as beaver dams and perched or undersized culverts. Identify permanent/seasonal barriers and prioritize for mitigation. Identify, prioritize and develop riparian planting projects in cooperation with landowners, stewardship groups and government agencies.	Use of strategically located restoration projects to eliminate barriers and provide ‘stepping stones’ for dispersal to occupied habitats. Prioritize restoration projects available to local stewardship groups and agency staff involved in habitat work.
6) Reduce toxic contamination of instream habitat.	1, 2	Toxicity	Med	Estimate extent and severity of toxic contamination of creeks. Work with municipalities to identify, prioritize and develop projects to improve stormwater quality. Increase width and continuity of riparian reserves (see strategy 3) on agricultural lands. Develop and distribute public education materials on pesticide/herbicide impacts on fish and wildlife.	Stormwater treatment projects completed at high priority sites. Riparian planting projects completed in high priority areas. Educational materials developed and included in landowner contact programs and other public education applications.
7) Reduce sediment entry to instream habitats.	1, 2	Sediment deposition	Med	Estimate levels of sediment in riffles that are harmful to Salish Sucker spawning and incubation. Map, assess and prioritize mitigation for riffle sedimentation in all watersheds. Work with landowners, local government and stewardship groups to prevent, mitigate and restore	Recommendations for maximum levels of sedimentation in riffles for Salish Sucker habitat. Mitigation completed at high priority sites. Educational materials developed and included in landowner contact programs and

Broad Strategy	Objectives	Threats Addressed	Priority	Specific Activities	Outcomes or Deliverables
				sediment degradation of riffles. Develop and distribute public education materials on sediment impacts on fish and wildlife.	other public education applications.
8) Assess impacts of predator introduction and prevent new introductions.	1, 2	Increased predation	Low	Document distribution and density of introduced predators in each watershed. Evaluate susceptibility of different life stages to introduced predators. Develop and distribute public education materials on impacts of introduced predators on native species.	Maps of introduced predator distributions in each watershed. Educational materials developed and included in landowner contact programs and other public education applications.
9) Assess feasibility of reintroducing the Salish Sucker into the Little Campbell River if extirpation is confirmed.	3	Multiple threats of unknown severity	Low	Confirm extirpation and analyze causes and severity of current threats. Evaluate mitigation options. If extirpation is confirmed, estimate number of individuals necessary to establish a population. If extirpation is confirmed, evaluate options for obtaining fish or eggs for transplant.	Extirpation or presence of Salish Sucker in Little Campbell River confirmed Completed feasibility study if extirpation is confirmed. Contingent on feasibility study, the reestablishment of a viable Salish Sucker population in the Little Campbell River by 2020.

Table 12. Performance measures for evaluating the achievement of objectives and success of strategies.

Objectives	Process Performance Measure	Biological Performance Measure
1) Prevent extirpation of the Salish Sucker in each of the 10 watersheds with extant populations by preventing net loss of reproductive potential.	Abundance surveys completed in all watersheds.	Stable or increasing populations in all watersheds.
2) a. Occupation of all instream critical habitats by 2020.	Critical habitat identified and occupancy evaluated in all watersheds.	Proportion of instream critical habitat occupied.
2) b. Reach or exceed watershed-specific abundance targets for mature individuals by 2020.	Abundance surveys completed in all watersheds.	Estimated population size relative to target population[6]. Number of watersheds that yield an average catch-per-unit-effort of 1.8 or more adults per trap in critical habitat reaches.
2) c. One or more source habitats with high density in each watershed. by 2020.	Abundance surveys completed in all watersheds.	Number of watersheds with at least one reach where catch-per-unit-effort exceeds 3 adult Salish Suckers per trap.
3) Reintroduce the Salish Sucker to the Little Campbell River, if feasible.	Feasibility study complete.	Feasibility findings.

Strategies	Process Performance Measure	Biological Performance Measure
Reduce incidence of severe hypoxia in instream critical habitats.	Maps of critical habitat sites requiring increased water movement. Area of critical habitat benefiting from management efforts to increase water movement. Length and area of riparian habitat restored in each watershed.	Area and proportion of critical habitat with dissolved oxygen concentrations above 4 mg/L. Proportion of critical habitat with measurable flow. Estimated change in nutrient loading to ground and surface water in watersheds. Establishment or significant growth of Salish Sucker populations in critical habitat reaches with increased water movement.
Protect existing habitat, restore lost or degraded habitat and create new habitat.	Prioritized list of habitat requiring protection or restoration. Number of successful restoration/protection	Proportion of critical habitat restored and/or protected. Establishment or significant growth of Salish Sucker populations in critical habitat reaches containing protected,

[6] Direct estimation of density using capture-recapture methods is far too time consuming for use in monitoring ten populations spread over more than 100 km of channel. Consequently, catch-per-unit-effort is recommended as the performance measure. An average of 1.8 adults/trap (n>10 traps per reach), corresponds to a density of 0.05 adult/m^2 according to equations developed by Pearson (2004a), and is considered an appropriate target for proposed critical habitat at the watershed scale.

	projects completed. Length of critical habitat restored and/or protected.	created or enhanced habitat.
Increase the integrity and function of all riparian habitats.	Number of riparian assessments completed. Length and area of riparian habitat restored or enhanced in each watershed.	Length and proportion of critical habitat with greater than 5, 10, and 30 m of riparian reserve. Establishment or significant growth of Salish Sucker populations in critical habitat reaches with restored riparian reserve strips.
Encourage stewardship among private landowners, local government and agencies, and the general public.	Number of non-government organizations involved in recovery activities. Number of projects completed or agreements signed on private lands. Number of landowners and others contacted or involved in programs and consultations.	Length of critical habitat protected or restored on private land or with public involvement. Establishment or significant growth of Salish Sucker populations in critical habitat reaches on stewarded lands.
Reduce fragmentation of instream and riparian habitats.	Maps of permanent and seasonal barriers to movement in each watershed. Number of barrier remediation projects undertaken.	Quantity of habitat reconnected by removal of barriers. Establishment or significant growth of Salish Sucker populations in critical habitat reaches where habitat fragmentation has been addressed.
Reduce toxic contamination of instream habitat.	Identified sources of toxic contamination in each watershed. Mitigation of toxic contamination.	Area and proportion of critical habitat affected by toxic contamination. Establishment or significant growth of Salish Sucker populations in critical habitat reaches affected by toxic contamination.
Reduce sediment entry to instream habitats.	Identification of major sources of sediment entry to each watershed. Development and implementation of sediment mitigation plans.	Area and proportion of critical habitat affected by sediment deposition. Establishment or significant growth of Salish Sucker populations in critical habitat reaches where sediment deposition has been addressed.
Reduce impacts of introduced predators.	Maps of critical habitat occupied by introduced predators.	Proportion of critical habitat containing introduced predators. Correlation of establishment or growth of Salish Sucker population with introduced predator absence.
Assess feasibility of reintroducing the Salish Sucker into the Little Campbell River.	Feasibility study complete.	Successful reintroduction, if judged feasible.

4.3 Approaches to Recovery

An active adaptive management approach (Walters & Holling 1990) should be used in planning and implementing recovery. Whenever possible, management actions should be conducted as controlled experiments designed to inform ongoing strategy and action planning. Recovery planning and implementation should occur at the scale of individual watersheds because the populations are isolated from one another and face different suites of threats in each watershed.

4.4 Actions Already Completed or Underway

Experimental Habitat Restoration Projects
Experimental habitat restoration work targeting the Salish Sucker was initiated by University of British Columbia researchers in cooperation with local stewardship groups and landowners in 1999. Population size and habitat conditions have been monitored repeatedly at two sites in the Pepin Brook watershed (Pearson unpubl) Using this information, additional projects have been constructed in Salwein Creek and Hopedale Slough, Mountain Slough, Bertrand Creek, and the Salmon River by Dr. Mike Pearson, working in cooperation with DFO, the Township of Langley and the District of Kent. Monitoring should continue on these projects.

Integrated Channel Maintenance Pilot Projects
Agricultural drainage maintenance and fish habitat protection objectives have often been in conflict in the Fraser Valley. In 2003, the City of Chilliwack initiated a pilot project integrating drainage maintenance and fish habitat restoration in Salwein Creek, a Salish Sucker watershed. Hand maintenance protocols and shade from riparian zone plantings reduce the need for machine cleaning of waterways for drainage. When machine work is necessary to maintain drainage, additional habitat is constructed as part of the work. In 2004, DFO and the recovery implementation group helped expand the project to another Salish Sucker stream, Atchelitz Creek. A similar program is also underway with the District of Kent in portions of Mountain Slough and the Miami River. Expansion of this program to other watersheds and jurisdictions would be beneficial to the Salish Sucker and other native species.

Landowner Contact and Public Education Programs
Between 2000 and 2006, the Langley Environmental Partners Society and the Fraser Valley Regional Watersheds Coalition implemented landowner contact programs in cooperation with members of the Recovery Team in all watersheds currently inhabited by the Salish Sucker. Public information meetings were also held in each watershed. Colour display posters on Salish Suckers have also been given to stewardship groups in Chilliwack, Langley and Agassiz for use during public events. Since 2000, Dr. Mike Pearson has provided lectures and habitat enhancement site tours featuring the Salish Sucker and recovery efforts to local schools, universities and stewardship groups each year through the Langley Environmental Partners Society.

Native Plants Program
Since 2000, native plants and livestock fencing have been provided and installed for landowners of riparian habitats along reaches containing the Salish Sucker in Agassiz Slough, Mountain Slough, Miami River, Salmon River, Bertrand Creek, Pepin Brook, the Little Chilliwack River,

Elk Creek and Hope Slough. Much of this work has been done by community volunteers organized by three local stewardship groups (Langley Environmental Partners Society, Fraser Valley Regional Watersheds Coalition and Fraser Harrison Smart Growth) working in cooperation with Dr. Mike Pearson. Through various mechanisms, local governments such as the District of Kent and the Township of Langley have provided support and/or partnership for such projects.

4.5 Statement of When Action Plans Will Be Completed

Within five years of posting the final Salish Sucker recovery strategy on the SARA Public Registry, one or more action plans will be prepared for the Nooksack Dace and Salish Sucker.

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Appendix 1: Record of Cooperation and Consultation

The Salish Sucker is listed as a threatened species on Schedule 1 of the *Species at Risk Act* (SARA). As an aquatic species, the Salish Sucker falls under federal jurisdiction, and is managed by Fisheries and Oceans Canada (DFO).

DFO and the Province of British Columbia cooperated on the development of this draft document. Processes for coordination and consultation between the federal and British Columbian governments on management and protection of species at risk are outlined in the *Canada-B.C. Agreement on Species at Risk* (Government of Canada, 2005).

Consultation on the draft Recovery Strategy occurred through posting the draft Recovery Strategy online for comments and community open houses and workshops held in Chilliwack, Harrison Hot Springs and Aldergrove. Letters containing the consultation weblink and offering the opportunity for bilateral meetings or participation in workshops were sent to 29 First Nations and tribal councils. Four First Nations representatives participated in workshops but no other responses to letters were received. Invitations to four workshops held in January and February 2011 were distributed by email to representatives from municipalities, regional districts, provincial ministries, federal agencies, industry, agriculture, environmental non-governmental organizations and stewardship groups. Input from 88 workshop participants on the draft Recovery Strategy was collected through records of discussion and workbooks filled out by participants.

Over 2400 letters containing the consultation weblink, information on community open houses and maps of proposed critical habitat areas were sent to private landowners whose properties contained or were adjacent to proposed critical habitat. Public notices advertising community meetings were also placed in five area newspapers in English and three area newspapers in French. Over 230 people attended community open houses held in Chilliwack, Harrison Hot Springs and Aldergrove. Comments on the draft recovery strategy were gathered through records of discussions and feedback forms submitted by attendees. Other comments on the draft Recovery Strategy were received through online feedback forms, emails and letters submitted directly to DFO.

Key concerns raised by stakeholders were fears regarding the future impacts of the Recovery Strategy and proposed critical habitat on existing land use practices and private lands, drainage maintenance issues, questions around the value and importance of the Salish Sucker and comments on stakeholders' relationships with DFO. Most comments related to issues beyond the scope of the draft Recovery Strategy, which is based on the best available scientific information as required under SARA.

All feedback received was considered in the finalization of the Recovery Strategy. Suggestions and concerns related to the implementation of recovery for Salish Sucker will be considered in the action plan that will be developed for Salish Sucker and Nooksack Dace.

Appendix 2: Watershed Scale Maps and Coordinate Table for Salish Sucker Critical Habitat

The watershed scale maps below (pg 47-57) depict the location of reaches identified as Salish Sucker critical habitat as well as the widths of the riparian reserve strips of native vegetation included in critical habitat for each reach. Maps are based on data and maps included and described in Pearson (2008) and were generated using high-resolution colour orthophotos (2004) of the areas in question.

Each map shows stream reaches that have been identified as critical habitat for Salish Sucker within a particular watershed. Stream reaches have been labelled individually and the coordinates associated with the start and end points of each reach along the stream are shown in Table 12 below (pg 58-64).

As the legend for each map indicates, the pattern of the line identifying the stream reach as critical habitat indicates the width of the riparian reserve strip of native vegetation included in critical habitat for that reach. Riparian reserve strips of native vegetation extend inland from the top of the bank to the width indicated. Maps depict the locations along the watercourse of stream reaches identified as critical habitat; they do not indicate the location of the top of the bank or the boundary of the riparian reserve strip of native vegetation for reaches identified as critical habitat.

Table 12 below (pg 58-64) summarizes the width of the critical habitat feature identified as Riparian Reserve Strips of Native Vegetation for each reach identified as critical habitat for Salish Sucker. Riparian reserve strips of native vegetation are continuous and extend laterally (inland) from the top of the bank to the specified width on each bank.

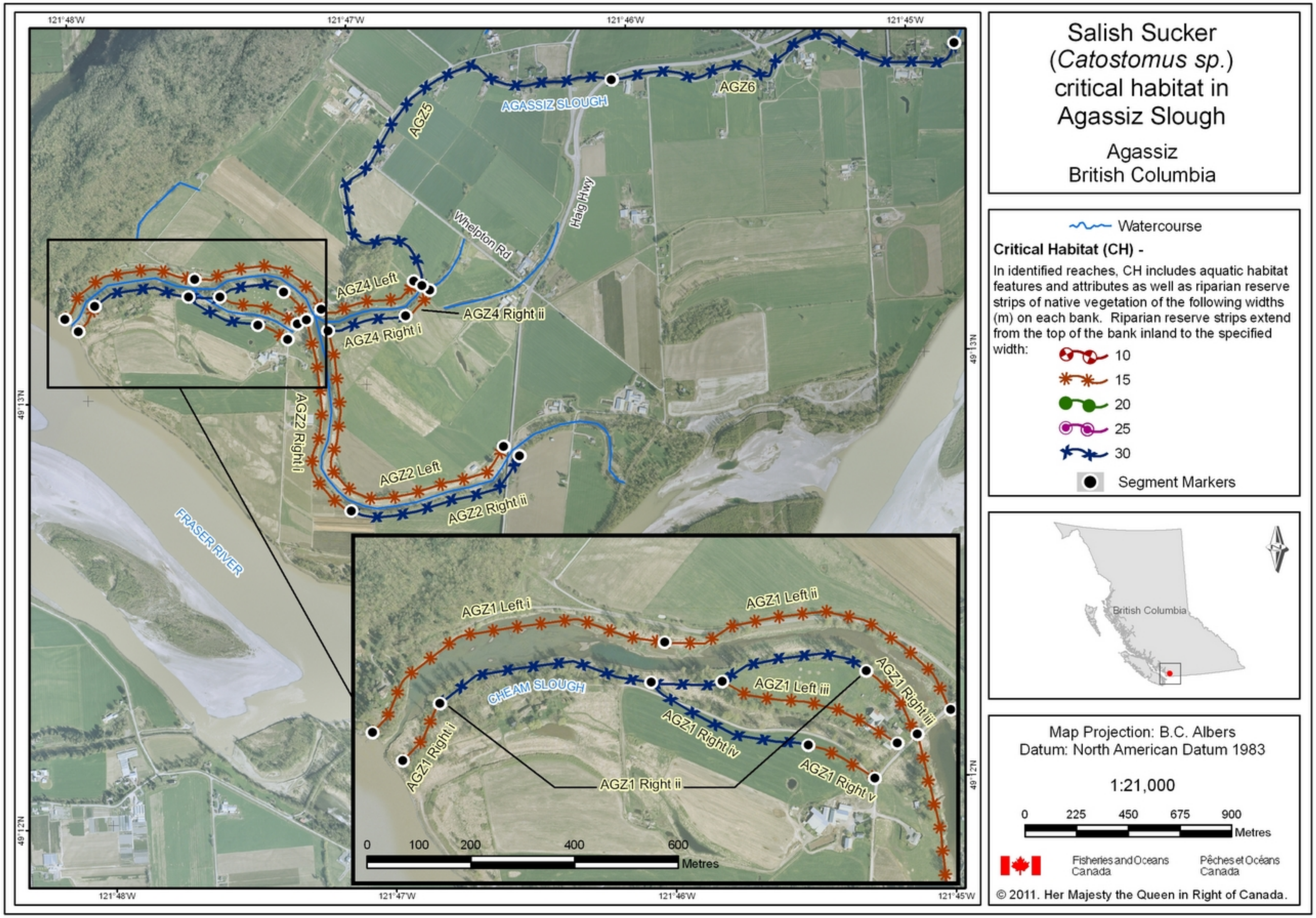

Figure 3 – Map of stream reaches containing critical habitat for Salish Sucker in the Agassiz Slough watershed

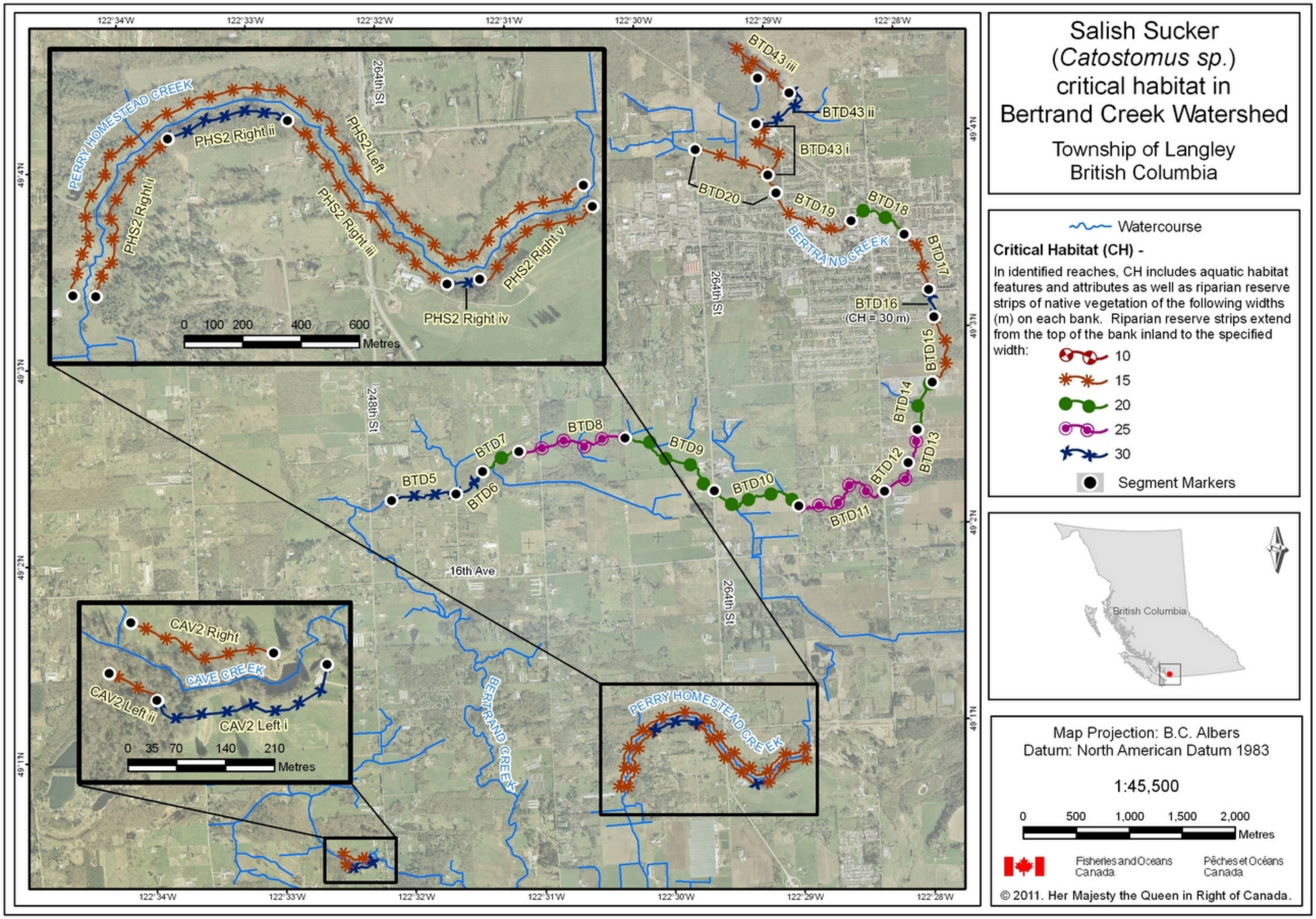

Figure 4 - Map of stream reaches containing critical habitat for Salish Sucker in the Bertrand Creek watershed

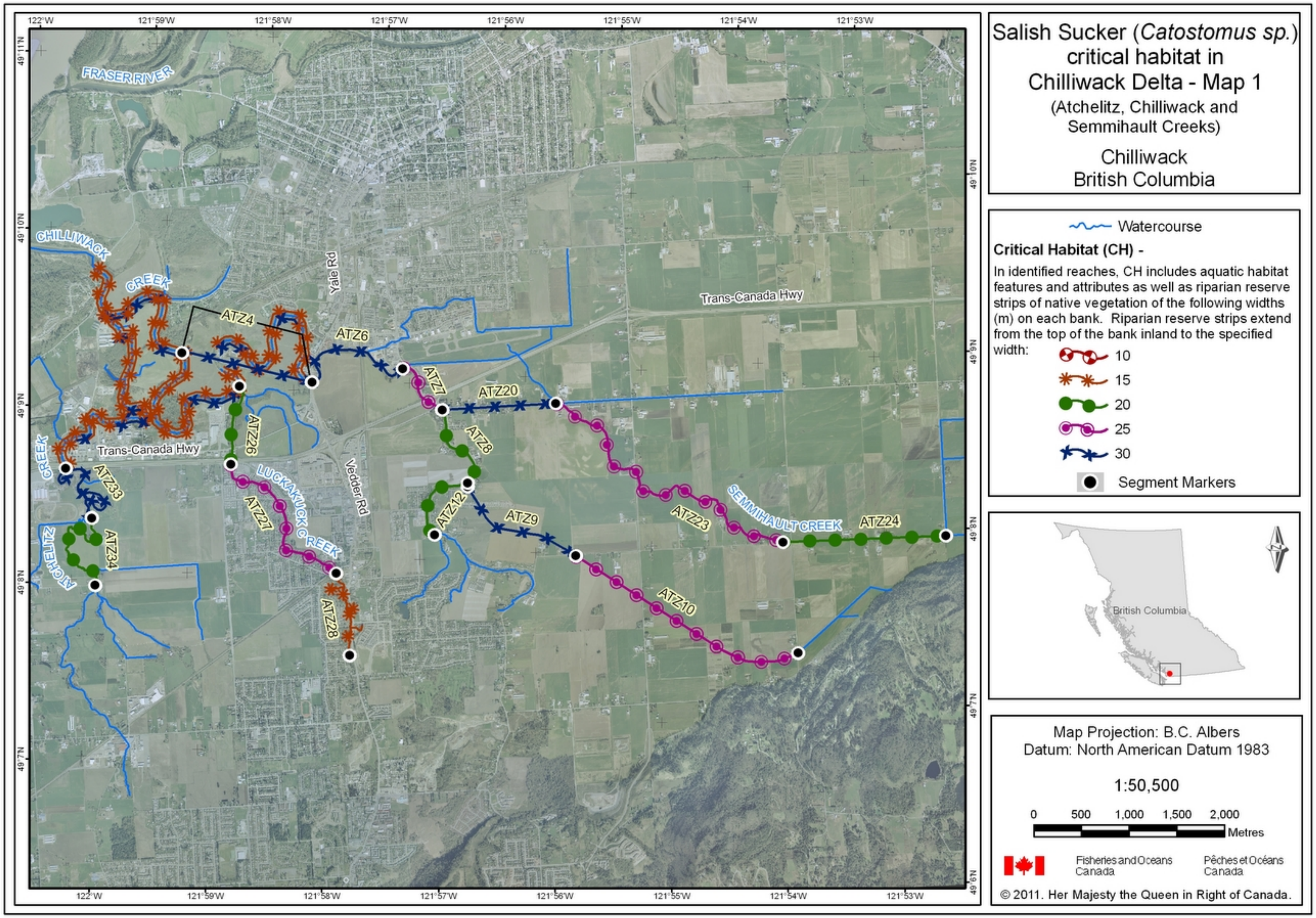

Figure 5 - Map of stream reaches containing critical habitat for Salish Sucker in the Chilliwack Delta watershed (Map 1)

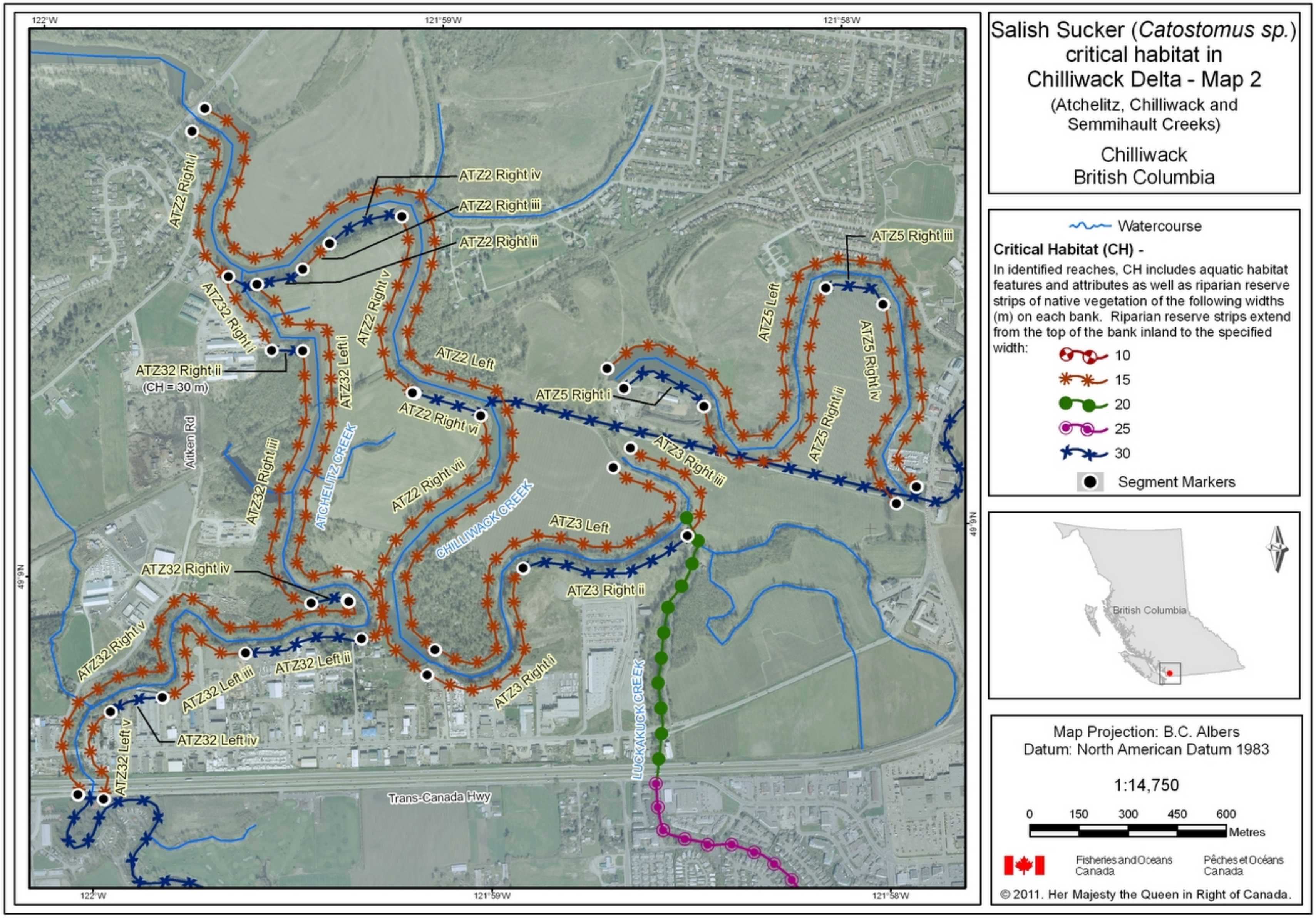

Figure 6 - Map of stream reaches containing critical habitat for Salish Sucker in the Chilliwack Delta watershed (Map 2)

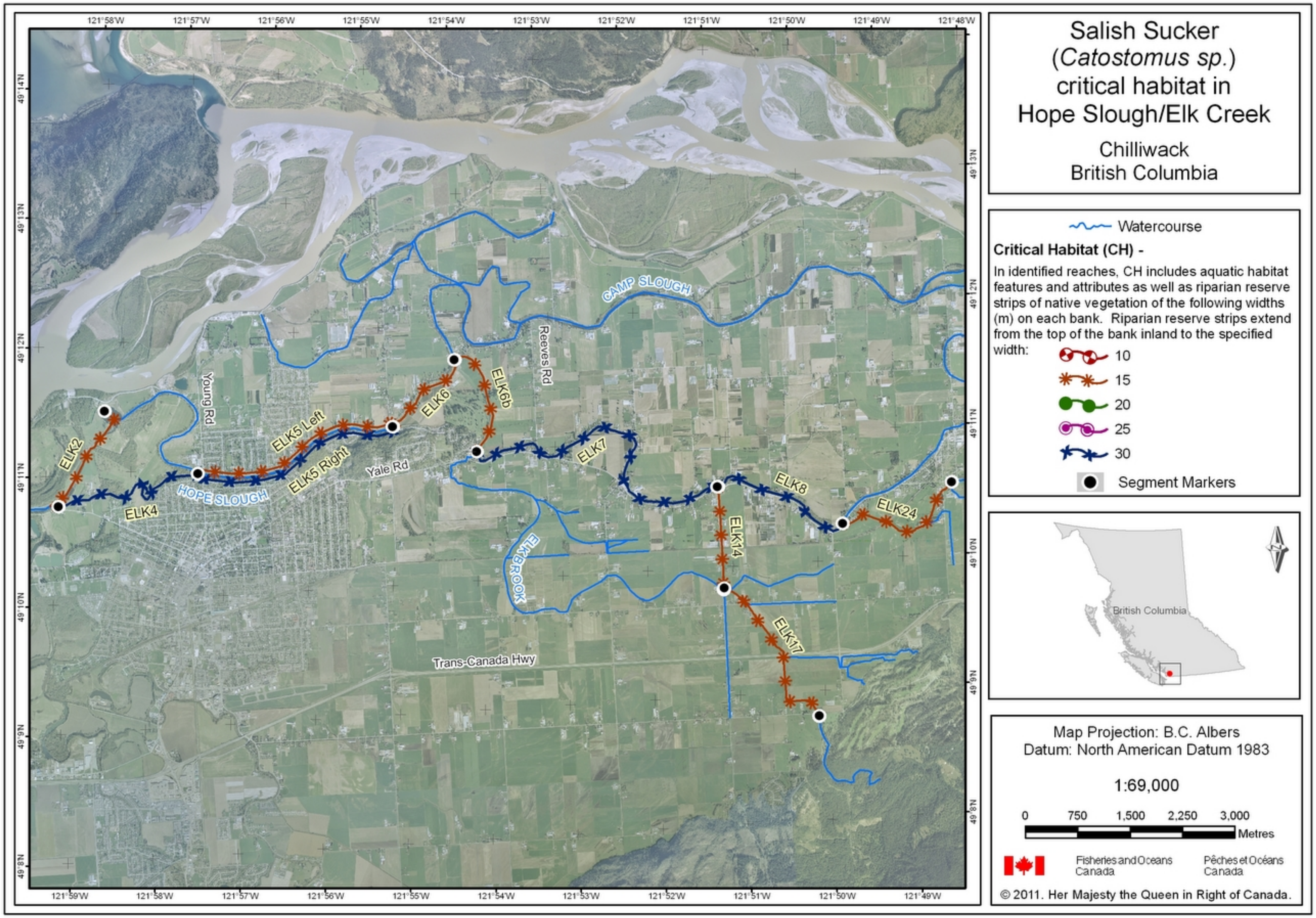

Figure 7 - Map of stream reaches containing critical habitat for Salish Sucker in the Hope Slough / Elk Creek watershed

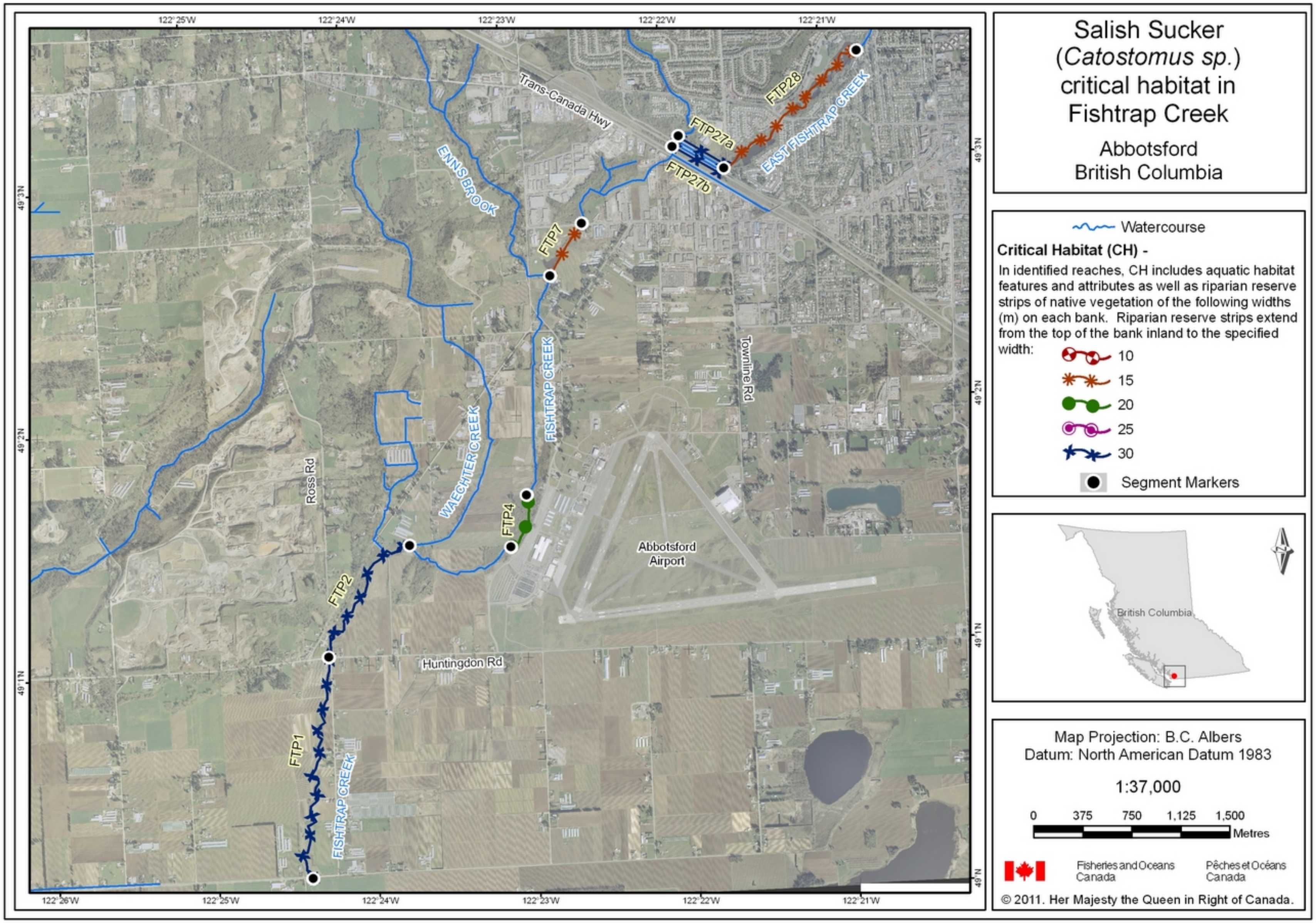

Figure 8 - Map of stream reaches containing critical habitat for Salish Sucker in the Fishtrap Creek watershed

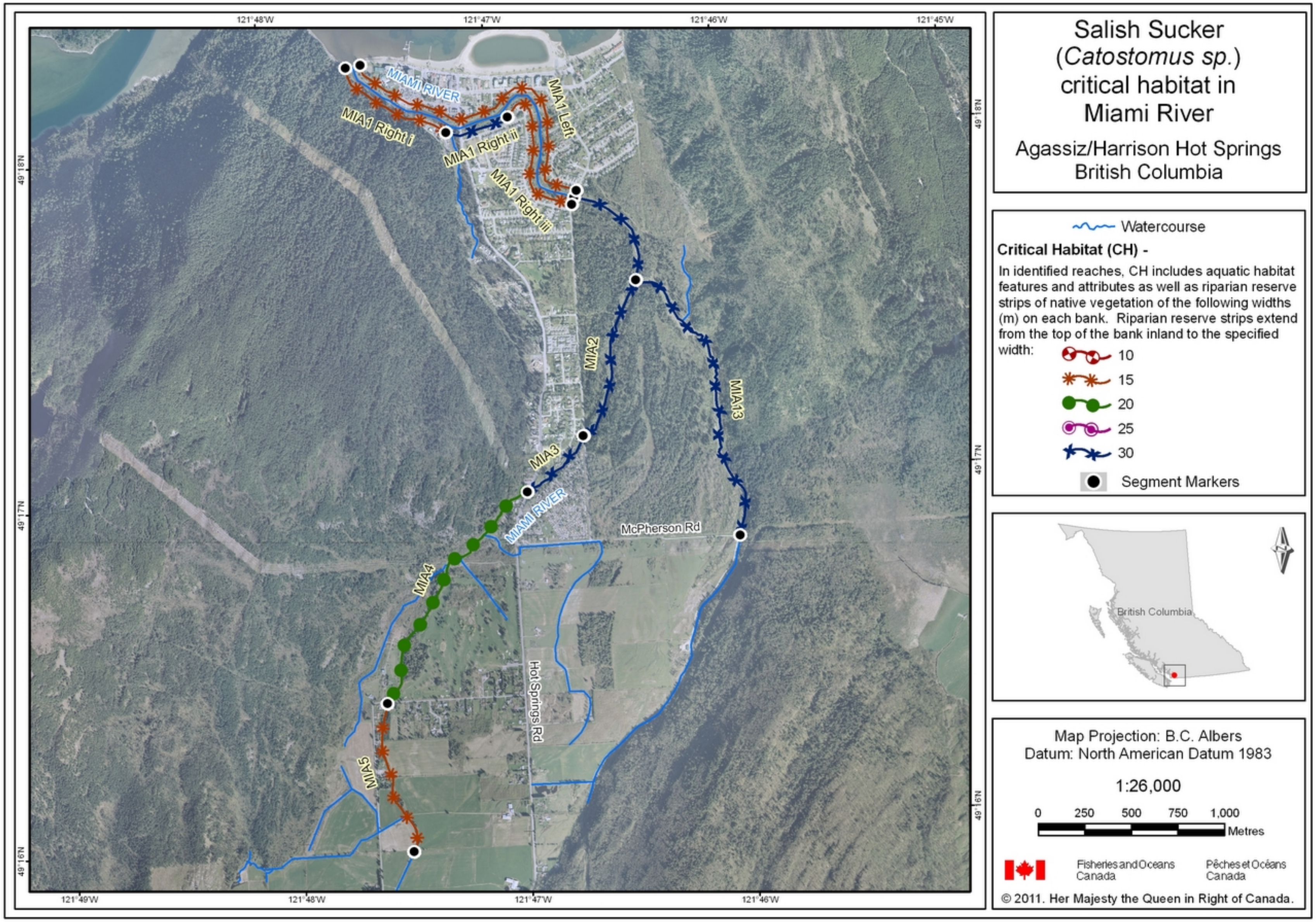

Figure 9 - Map of stream reaches containing critical habitat for Salish Sucker in the Miami River watershed

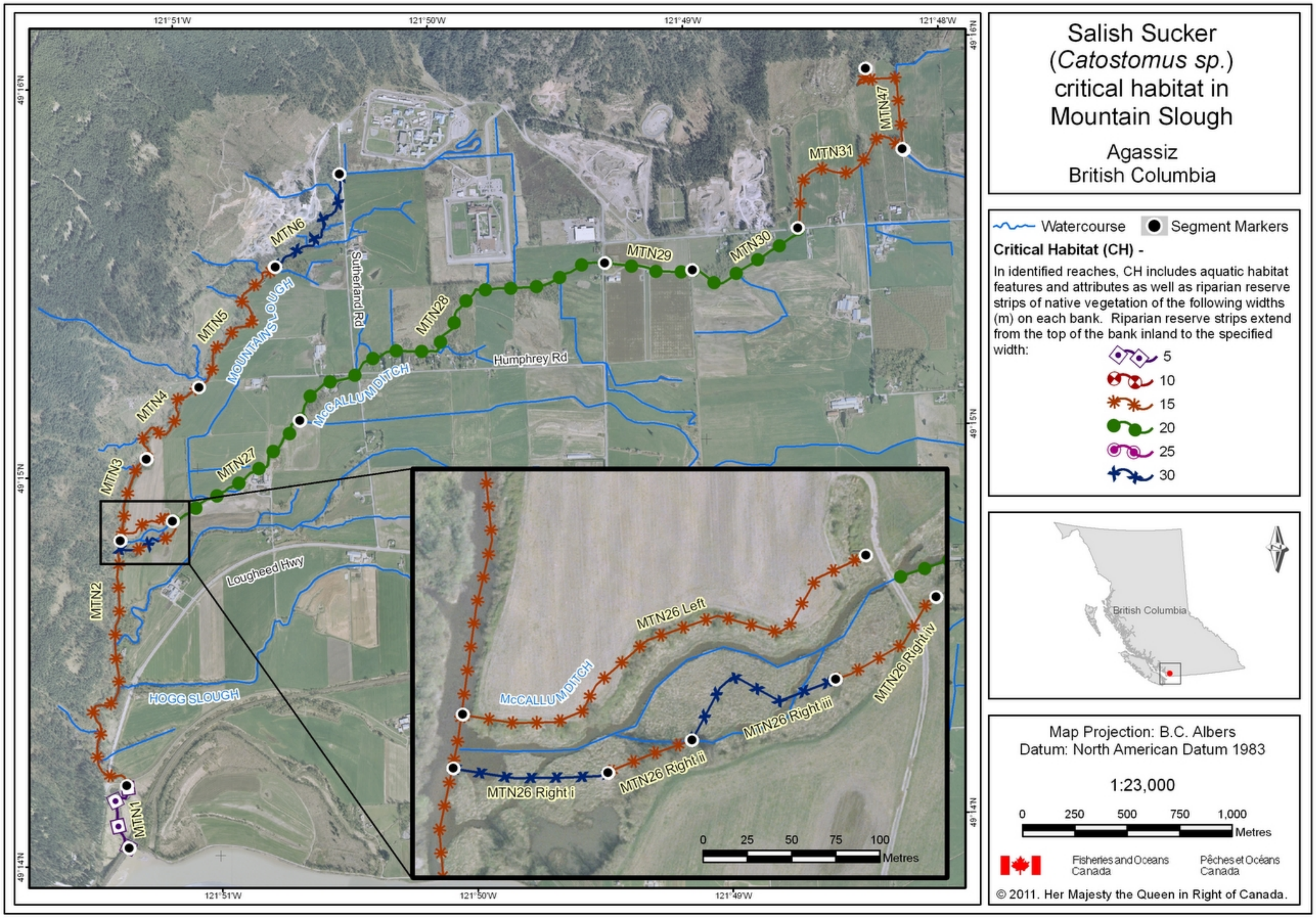

Figure 10 - Map of stream reaches containing critical habitat for Salish Sucker in the Mountain Slough watershed

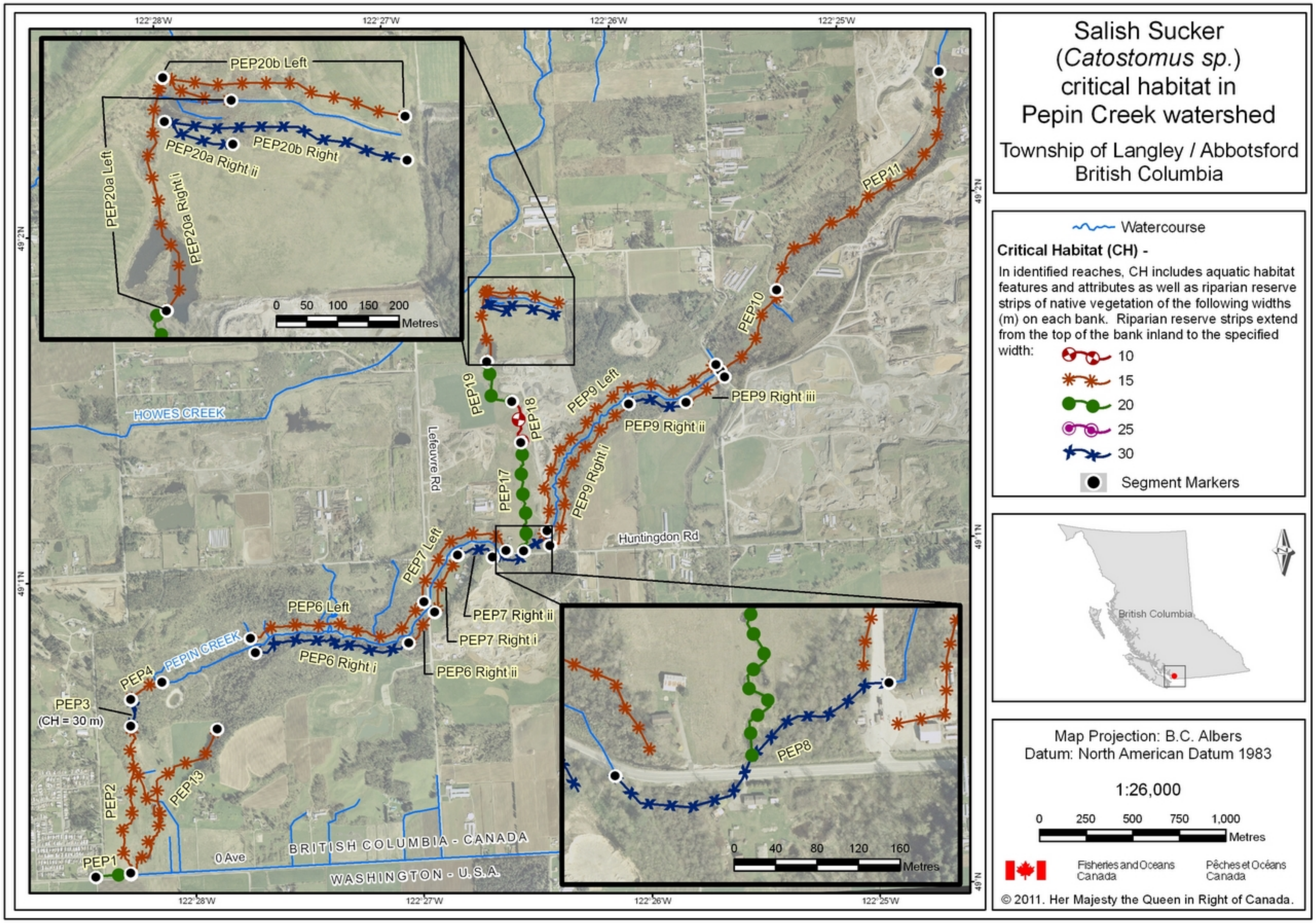

Figure 11 - Map of stream reaches containing critical habitat for Salish Sucker in the Pepin Creek watershed

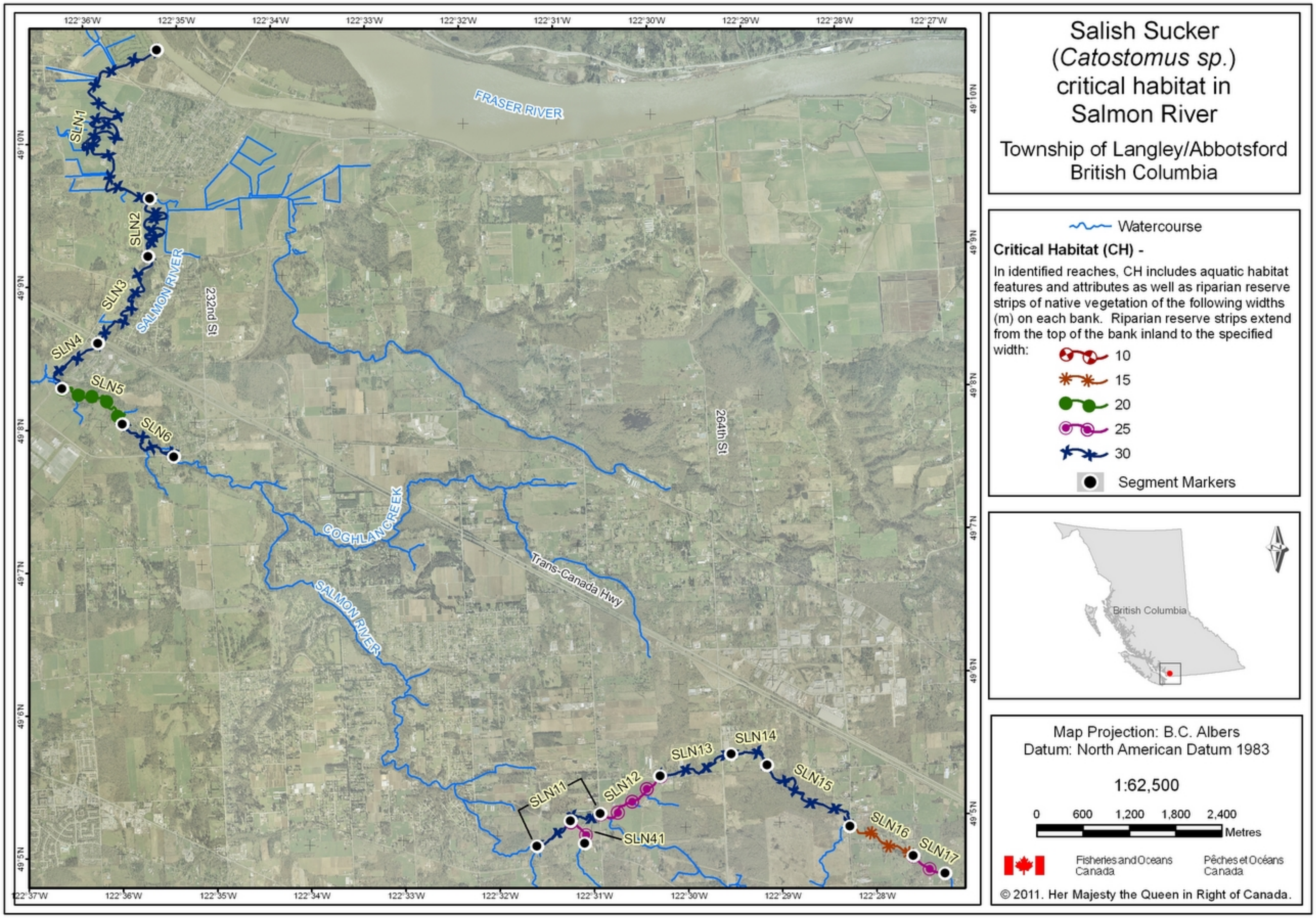

Figure 12 - Map of stream reaches containing critical habitat for Salish Sucker in the Salmon River watershed

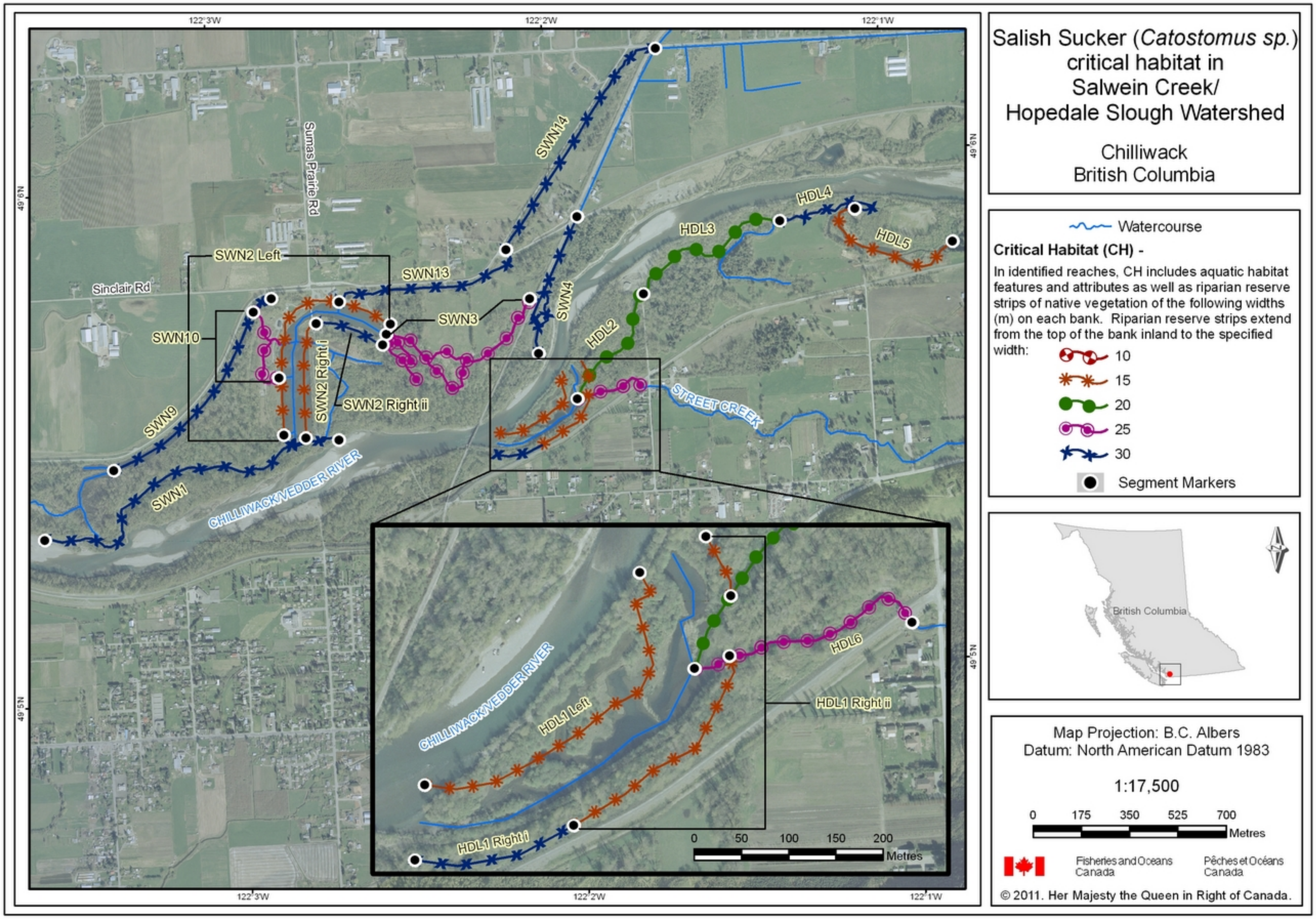

Figure 13 - Map of stream reaches containing critical habitat for Salish Sucker in the Salwein Creek / Hopedale Slough watershed

Table 13 - Widths of riparian reserve strips of native vegetation along reaches that have been identified as critical habitat for Salish Sucker. Riparian reserve strips are a feature of critical habitat that support life processes of Salish Sucker.

Watershed	Reach Code	Length of reach (m)	Reach Start Point (DMS)[7]		Reach End Point (DMS)[8]		Width of Riparian Reserve Strip of Native Vegetation (m)
			Lat DMS start	Long DMS start	Lat DMS end	Long DMS end	
Agassiz	AGZ1 Left i	661	49° 13' 11" N	121° 48' 2" W	49° 13' 15" N	121° 47' 36" W	15
Agassiz	AGZ1 Left ii	645	49° 13' 15" N	121° 47' 36" W	49° 13' 10" N	121° 47' 10" W	15
Agassiz	AGZ1 Left iii	363	49° 13' 15" N	121° 47' 36" W	49° 13' 8" N	121° 47' 15" W	15
Agassiz	AGZ1 Right i	134	49° 13' 11" N	121° 48' 2" W	49° 13' 14" N	121° 47' 58" W	15
Agassiz	AGZ1 Right ii	870	49° 13' 14" N	121° 47' 58" W	49° 13' 15" N	121° 47' 15" W	30
Agassiz	AGZ1 Right iii	160	49° 13' 15" N	121° 47' 15" W	49° 13' 10" N	121° 47' 10" W	15
Agassiz	AGZ1 Right iv	336	49° 13' 15" N	121° 47' 36" W	49° 13' 11" N	121° 47' 22" W	30
Agassiz	AGZ1 Right v	145	49° 13' 11" N	121° 47' 22" W	49° 13' 8" N	121° 47' 15" W	15
Agassiz	AGZ2 Left	1488	49° 13' 10" N	121° 47' 10" W	49° 12' 49" N	121° 46' 30" W	15
Agassiz	AGZ2 Right i	919	49° 13' 10" N	121° 47' 10" W	49° 12' 43" N	121° 47' 4" W	15
Agassiz	AGZ2 Right ii	829	49° 12' 43" N	121° 47' 4" W	49° 12' 49" N	121° 46' 30" W	30
Agassiz	AGZ4 Left	454	49° 13' 10" N	121° 47' 10" W	49° 13' 13" N	121° 46' 47" W	15
Agassiz	AGZ4 Right i	348	49° 13' 10" N	121° 47' 10" W	49° 13' 11" N	121° 46' 51" W	30
Agassiz	AGZ4 Right ii	159	49° 13' 11" N	121° 46' 51" W	49° 13' 13" N	121° 46' 47" W	15
Agassiz	AGZ5	2096	49° 13' 13" N	121° 46' 47" W	49° 13' 41" N	121° 46' 3" W	30
Agassiz	AGZ6	1686	49° 13' 41" N	121° 46' 3" W	49° 13' 43" N	121° 44' 50" W	30
Bertrand	BTD10	1065	49° 2' 13" N	122° 29' 33" W	49° 2' 7" N	122° 28' 54" W	20
Bertrand	BTD11	1133	49° 2' 7" N	122° 28' 54" W	49° 2' 11" N	122° 28' 14" W	25
Bertrand	BTD12	399	49° 2' 11" N	122° 28' 14" W	49° 2' 19" N	122° 28' 2" W	25
Bertrand	BTD13	356	49° 2' 19" N	122° 28' 2" W	49° 2' 29" N	122° 27' 57" W	25
Bertrand	BTD14	527	49° 2' 29" N	122° 27' 57" W	49° 2' 43" N	122° 27' 49" W	20
Bertrand	BTD15	718	49° 2' 43" N	122° 27' 49" W	49° 3' 3" N	122° 27' 47" W	15
Bertrand	BTD16	285	49° 3' 3" N	122° 27' 47" W	49° 3' 11" N	122° 27' 49" W	30
Bertrand	BTD17	616	49° 3' 11" N	122° 27' 49" W	49° 3' 29" N	122° 27' 59" W	15
Bertrand	BTD18	637	49° 3' 29" N	122° 27' 59" W	49° 3' 34" N	122° 28' 23" W	20
Bertrand	BTD19	916	49° 3' 34" N	122° 28' 23" W	49° 3' 43" N	122° 28' 57" W	15
Bertrand	BTD20	927	49° 3' 43" N	122° 28' 57" W	49° 3' 58" N	122° 29' 34" W	15
Bertrand	BTD43 i	779	49° 3' 49" N	122° 29' 1" W	49° 4' 5" N	122° 29' 5" W	15
Bertrand	BTD43 ii	671	49° 4' 5" N	122° 29' 5" W	49° 4' 14" N	122° 28' 49" W	30

[7] Reach start point indicates the location of the beginning of the reach in question along the watercourse.
[8] Reach end point indicates the location of the end of the reach in question along the watercourse.

Bertrand	BTD43 iii	1045	49° 4' 14" N	122° 28' 49" W	49° 4' 18" N	122° 29' 3" W	15
Bertrand	BTD5	653	49° 2' 15" N	122° 32' 3" W	49° 2' 16" N	122° 31' 32" W	30
Bertrand	BTD6	352	49° 2' 16" N	122° 31' 33" W	49° 2' 23" N	122° 31' 20" W	30
Bertrand	BTD7	450	49° 2' 23" N	122° 31' 20" W	49° 2' 28" N	122° 31' 2" W	20
Bertrand	BTD8	1141	49° 2' 28" N	122° 31' 2" W	49° 2' 31" N	122° 30' 13" W	25
Bertrand	BTD9	1105	49° 2' 31" N	122° 30' 13" W	49° 2' 13" N	122° 29' 33" W	20
Bertrand	CAV2 Left i	197	49° 0' 26" N	122° 32' 21" W	49° 0' 25" N	122° 32' 30" W	30
Bertrand	CAV2 Left ii	113	49° 0' 25" N	122° 32' 30" W	49° 0' 27" N	122° 32' 34" W	15
Bertrand	CAV2 Right	308	49° 0' 26" N	122° 32' 21" W	49° 0' 27" N	122° 32' 34" W	15
Bertrand	PHS2 Left	2655	49° 0' 44" N	122° 30' 22" W	49° 0' 52" N	122° 28' 56" W	15
Bertrand	PHS2 Right i	727	49° 0' 44" N	122° 30' 22" W	49° 1' 2" N	122° 30' 7" W	15
Bertrand	PHS2 Right ii	494	49° 1' 2" N	122° 30' 7" W	49° 1' 3" N	122° 29' 45" W	30
Bertrand	PHS2 Right iii	838	49° 1' 3" N	122° 29' 45" W	49° 0' 44" N	122° 29' 20" W	15
Bertrand	PHS2 Right iv	119	49° 0' 44" N	122° 29' 20" W	49° 0' 45" N	122° 29' 14" W	30
Bertrand	PHS2 Right v	476	49° 0' 45" N	122° 29' 14" W	49° 0' 52" N	122° 28' 56" W	15
Chilliwack Delta - Map 1	ATZ10	2656	49° 7' 58" N	121° 55' 39" W	49° 7' 21" N	121° 53' 48" W	25
Chilliwack Delta - Map 1	ATZ12	877	49° 8' 25" N	121° 56' 33" W	49° 8' 8" N	121° 56' 51" W	20
Chilliwack Delta - Map 1	ATZ20	1193	49° 8' 50" N	121° 56' 44" W	49° 8' 50" N	121° 55' 45" W	30
Chilliwack Delta - Map 1	ATZ23	3330	49° 8' 50" N	121° 55' 45" W	49° 7' 59" N	121° 53' 52" W	25
Chilliwack Delta - Map 1	ATZ24	1706	49° 7' 59" N	121° 53' 52" W	49° 7' 58" N	121° 52' 28" W	20
Chilliwack Delta - Map 1	ATZ26	858	49° 9' 2" N	121° 58' 28" W	49° 8' 36" N	121° 58' 34" W	20
Chilliwack Delta - Map 1	ATZ27	1848	49° 8' 36" N	121° 58' 34" W	49° 7' 57" N	121° 57' 43" W	25
Chilliwack Delta - Map 1	ATZ28	1508	49° 7' 57" N	121° 57' 43" W	49° 7' 29" N	121° 57' 39" W	15
Chilliwack Delta - Map 1	ATZ33	1645	49° 8' 38" N	121° 59' 59" W	49° 8' 21" N	121° 59' 48" W	30
Chilliwack Delta - Map 1	ATZ34	1507	49° 8' 20" N	121° 59' 47" W	49° 7' 58" N	121° 59' 48" W	20
Chilliwack Delta - Map 1	ATZ4	1392	49° 9' 15" N	121° 58' 56" W	49° 9' 2" N	121° 57' 50" W	30
Chilliwack Delta - Map 1	ATZ6	1392	49° 9' 2" N	121° 57' 50" W	49° 9' 5" N	121° 57' 3" W	30

Chilliwack Delta - Map 1	ATZ7	679	49° 9' 5" N	121° 57' 3" W	49° 8' 50" N	121° 56' 44" W	25
Chilliwack Delta - Map 1	ATZ8	990	49° 8' 50" N	121° 56' 44" W	49° 8' 24" N	121° 56' 33" W	20
Chilliwack Delta - Map 1	ATZ9	1428	49° 8' 24" N	121° 56' 33" W	49° 7' 58" N	121° 55' 39" W	30
Chilliwack Delta - Map 2	ATZ2 Left	2954	49° 9' 44" N	121° 59' 38" W	49° 8' 49" N	121° 59' 7" W	15
Chilliwack Delta - Map 2	ATZ2 Right i	532	49° 9' 44" N	121° 59' 38" W	49° 9' 30" N	121° 59' 34" W	15
Chilliwack Delta - Map 2	ATZ2 Right ii	200	49° 9' 30" N	121° 59' 34" W	49° 9' 30" N	121° 59' 24" W	30
Chilliwack Delta - Map 2	ATZ2 Right iii	116	49° 9' 30" N	121° 59' 24" W	49° 9' 32" N	121° 59' 20" W	15
Chilliwack Delta - Map 2	ATZ2 Right iv	284	49° 9' 32" N	121° 59' 20" W	49° 9' 35" N	121° 59' 7" W	30
Chilliwack Delta - Map 2	ATZ2 Right v	608	49° 9' 35" N	121° 59' 7" W	49° 9' 17" N	121° 59' 7" W	15
Chilliwack Delta - Map 2	ATZ2 Right vi	257	49° 9' 17" N	121° 59' 7" W	49° 9' 14" N	121° 58' 56" W	30
Chilliwack Delta - Map 2	ATZ2 Right vii	957	49° 9' 14" N	121° 58' 56" W	49° 8' 49" N	121° 59' 7" W	15
Chilliwack Delta - Map 2	ATZ3 Left	1473	49° 8' 49" N	121° 59' 7" W	49° 9' 8" N	121° 58' 37" W	15
Chilliwack Delta - Map 2	ATZ3 Right i	607	49° 8' 49" N	121° 59' 7" W	49° 8' 59" N	121° 58' 53" W	15
Chilliwack Delta - Map 2	ATZ3 Right ii	523	49° 8' 59" N	121° 58' 53" W	49° 9' 1" N	121° 58' 29" W	30
Chilliwack Delta - Map 2	ATZ3 Right iii	343	49° 9' 1" N	121° 58' 29" W	49° 9' 8" N	121° 58' 37" W	15
Chilliwack Delta - Map 2	ATZ32 Left i	1481	49° 9' 29" N	121° 59' 32" W	49° 8' 53" N	121° 59' 18" W	15
Chilliwack Delta - Map 2	ATZ32 Left ii	362	49° 8' 53" N	121° 59' 18" W	49° 8' 52" N	121° 59' 35" W	30
Chilliwack Delta - Map 2	ATZ32 Left iii	486	49° 8' 52" N	121° 59' 35" W	49° 8' 49" N	121° 59' 48" W	15
Chilliwack Delta - Map 2	ATZ32 Left iv	190	49° 8' 49" N	121° 59' 48" W	49° 8' 47" N	121° 59' 57" W	30
Chilliwack Delta - Map 2	ATZ32 Left v	347	49° 8' 47" N	121° 59' 57" W	49° 8' 38" N	121° 59' 59" W	15

Chilliwack Delta - Map 2	ATZ32 Right i	252	49° 9' 29" N	121° 59' 32" W	49° 9' 22" N	121° 59' 27" W	15
Chilliwack Delta - Map 2	ATZ32 Right ii	122	49° 9' 22" N	121° 59' 27" W	49° 9' 21" N	121° 59' 22" W	30
Chilliwack Delta - Map 2	ATZ32 Right iii	812	49° 9' 21" N	121° 59' 22" W	49° 8' 57" N	121° 59' 25" W	15
Chilliwack Delta - Map 2	ATZ32 Right iv	148	49° 8' 57" N	121° 59' 25" W	49° 8' 57" N	121° 59' 18" W	30
Chilliwack Delta - Map 2	ATZ32 Right v	1530	49° 8' 57" N	121° 59' 18" W	49° 8' 38" N	121° 59' 59" W	15
Chilliwack Delta - Map 2	ATZ5 Left	2153	49° 9' 16" N	121° 58' 37" W	49° 9' 3" N	121° 57' 54" W	15
Chilliwack Delta - Map 2	ATZ5 Right i	384	49° 9' 16" N	121° 58' 37" W	49° 9' 13" N	121° 58' 22" W	30
Chilliwack Delta - Map 2	ATZ5 Right ii	851	49° 9' 13" N	121° 58' 22" W	49° 9' 25" N	121° 58' 5" W	15
Chilliwack Delta - Map 2	ATZ5 Right iii	262	49° 9' 25" N	121° 58' 5" W	49° 9' 23" N	121° 57' 54" W	30
Chilliwack Delta - Map 2	ATZ5 Right iv	658	49° 9' 23" N	121° 57' 54" W	49° 9' 3" N	121° 57' 54" W	15
Elk	ELK14	1473	49° 10' 37" N	121° 51' 7" W	49° 9' 50" N	121° 51' 7" W	15
Elk	ELK17	2615	49° 9' 50" N	121° 51' 7" W	49° 8' 48" N	121° 50' 5" W	15
Elk	ELK2	1902	49° 10' 46" N	121° 58' 52" W	49° 11' 29" N	121° 58' 16" W	15
Elk	ELK24	2077	49° 10' 17" N	121° 49' 41" W	49° 10' 33" N	121° 48' 22" W	15
Elk	ELK4	2489	49° 10' 57" N	121° 57' 13" W	49° 10' 46" N	121° 58' 52" W	30
Elk	ELK5 Left	2994	49° 11' 14" N	121° 54' 54" W	49° 10' 57" N	121° 57' 13" W	15
Elk	ELK5 Right	3052	49° 11' 14" N	121° 54' 54" W	49° 10' 57" N	121° 57' 13" W	30
Elk	ELK6	1402	49° 11' 43" N	121° 54' 7" W	49° 11' 14" N	121° 54' 54" W	15
Elk	ELK6b	1716	49° 11' 43" N	121° 54' 7" W	49° 11' 0" N	121° 53' 55" W	15
Elk	ELK7	4846	49° 11' 0" N	121° 53' 55" W	49° 10' 37" N	121° 51' 7" W	30
Elk	ELK8	2151	49° 10' 37" N	121° 51' 7" W	49° 10' 17" N	121° 49' 41" W	30
Fishtrap	FTP1	1986	49° 0' 8" N	122° 24' 25" W	49° 1' 3" N	122° 24' 15" W	30
Fishtrap	FTP2	1243	49° 1' 3" N	122° 24' 15" W	49° 1' 29" N	122° 23' 42" W	30
Fishtrap	FTP27a	420	49° 3' 6" N	122° 21' 55" W	49° 2' 59" N	122° 21' 37" W	30
Fishtrap	FTP27b	430	49° 3' 5" N	122° 21' 55" W	49° 2' 59" N	122° 21' 37" W	30
Fishtrap	FTP28	1512	49° 2' 59" N	122° 21' 37" W	49° 3' 26" N	122° 20' 45" W	15
Fishtrap	FTP4	460	49° 1' 28" N	122° 23' 4" W	49° 1' 40" N	122° 22' 58" W	20
Fishtrap	FTP7	470	49° 2' 34" N	122° 22' 45" W	49° 2' 47" N	122° 22' 32" W	15
Miami	MIA1 Left	1783	49° 18' 15" N	121° 47' 35" W	49° 17' 50" N	121° 46' 38" W	15

Miami	MIA1 Right i	673	49° 18' 15" N	121° 47' 35" W	49° 18' 3" N	121° 47' 10" W	15
Miami	MIA1 Right ii	358	49° 18' 3" N	121° 47' 10" W	49° 18' 5" N	121° 46' 56" W	30
Miami	MIA1 Right iii	837	49° 18' 5" N	121° 46' 56" W	49° 17' 50" N	121° 46' 38" W	15
Miami	MIA13	1697	49° 17' 35" N	121° 46' 23" W	49° 16' 49" N	121° 46' 0" W	30
Miami	MIA2	1564	49° 17' 50" N	121° 46' 38" W	49° 17' 8" N	121° 46' 39" W	30
Miami	MIA3	445	49° 17' 8" N	121° 46' 39" W	49° 16' 59" N	121° 46' 55" W	30
Miami	MIA4	1446	49° 16' 59" N	121° 46' 55" W	49° 16' 24" N	121° 47' 35" W	20
Miami	MIA5	852	49° 16' 24" N	121° 47' 35" W	49° 15' 58" N	121° 47' 31" W	15
Mountain	MTN1	382	49° 14' 2" N	121° 51' 21" W	49° 14' 12" N	121° 51' 21" W	5
Mountain	MTN2	1370	49° 14' 12" N	121° 51' 21" W	49° 14' 50" N	121° 51' 19" W	15
Mountain	MTN26 Left	297	49° 14' 50" N	121° 51' 19" W	49° 14' 52" N	121° 51' 7" W	15
Mountain	MTN26 Right i	68	49° 14' 50" N	121° 51' 19" W	49° 14' 49" N	121° 51' 16" W	30
Mountain	MTN26 Right ii	36	49° 14' 49" N	121° 51' 16" W	49° 14' 50" N	121° 51' 14" W	15
Mountain	MTN26 Right iii	119	49° 14' 50" N	121° 51' 14" W	49° 14' 51" N	121° 51' 9" W	30
Mountain	MTN26 Right iv	74	49° 14' 51" N	121° 51' 9" W	49° 14' 52" N	121° 51' 7" W	15
Mountain	MTN27	825	49° 14' 52" N	121° 51' 7" W	49° 15' 6" N	121° 50' 35" W	20
Mountain	MTN28	1820	49° 15' 7" N	121° 50' 35" W	49° 15' 28" N	121° 49' 21" W	20
Mountain	MTN29	425	49° 15' 28" N	121° 49' 21" W	49° 15' 26" N	121° 49' 1" W	20
Mountain	MTN3	425	49° 14' 50" N	121° 51' 19" W	49° 15' 2" N	121° 51' 12" W	15
Mountain	MTN30	621	49° 15' 26" N	121° 49' 1" W	49° 15' 32" N	121° 48' 36" W	20
Mountain	MTN31	847	49° 15' 32" N	121° 48' 36" W	49° 15' 43" N	121° 48' 10" W	15
Mountain	MTN4	590	49° 15' 2" N	121° 51' 12" W	49° 15' 13" N	121° 50' 59" W	15
Mountain	MTN47	623	49° 15' 43" N	121° 48' 10" W	49° 15' 56" N	121° 48' 17" W	15
Mountain	MTN5	836	49° 15' 13" N	121° 50' 59" W	49° 15' 30" N	121° 50' 39" W	15
Mountain	MTN6	630	49° 15' 30" N	121° 50' 39" W	49° 15' 44" N	121° 50' 23" W	30
Pepin	PEP1	191	49° 0' 8" N	122° 28' 26" W	49° 0' 9" N	122° 28' 17" W	20
Pepin	PEP10	560	49° 1' 31" N	122° 25' 35" W	49° 1' 44" N	122° 25' 19" W	15
Pepin	PEP11	1633	49° 1' 44" N	122° 25' 19" W	49° 2' 21" N	122° 24' 33" W	15
Pepin	PEP13	1432	49° 0' 9" N	122° 28' 17" W	49° 0' 33" N	122° 27' 52" W	15
Pepin	PEP17	669	49° 1' 1" N	122° 26' 29" W	49° 1' 20" N	122° 26' 29" W	20
Pepin	PEP18	263	49° 1' 20" N	122° 26' 29" W	49° 1' 27" N	122° 26' 30" W	10
Pepin	PEP19	344	49° 1' 27" N	122° 26' 30" W	49° 1' 35" N	122° 26' 36" W	20
Pepin	PEP2	926	49° 0' 9" N	122° 28' 17" W	49° 0' 34" N	122° 28' 15" W	15
Pepin	PEP20a Left	494	49° 1' 35" N	122° 26' 36" W	49° 1' 45" N	122° 26' 31" W	15
Pepin	PEP20a Right i	377	49° 1' 35" N	122° 26' 36" W	49° 1' 46" N	122° 26' 36" W	15
Pepin	PEP20a Right ii	117	49° 1' 46" N	122° 26' 36" W	49° 1' 45" N	122° 26' 31" W	30
Pepin	PEP20b Left	376	49° 1' 46" N	122° 26' 35" W	49° 1' 43" N	122° 26' 17" W	15
Pepin	PEP20b Right	376	49° 1' 46" N	122° 26' 35" W	49° 1' 43" N	122° 26' 17" W	30

Pepin	PEP3	155	49° 0' 34" N	122° 28' 15" W	49° 0' 39" N	122° 28' 15" W	30
Pepin	PEP4	206	49° 0' 39" N	122° 28' 15" W	49° 0' 42" N	122° 28' 6" W	15
Pepin	PEP6 Left	1124	49° 0' 47" N	122° 27' 42" W	49° 0' 52" N	122° 26' 55" W	15
Pepin	PEP6 Right i	927	49° 0' 47" N	122° 27' 42" W	49° 0' 48" N	122° 27' 1" W	30
Pepin	PEP6 Right ii	197	49° 0' 48" N	122° 27' 1" W	49° 0' 52" N	122° 26' 55" W	15
Pepin	PEP7 Left	648	49° 0' 52" N	122° 26' 55" W	49° 1' 1" N	122° 26' 36" W	15
Pepin	PEP7 Right i	341	49° 0' 52" N	122° 26' 55" W	49° 1' 2" N	122° 26' 48" W	15
Pepin	PEP7 Right ii	307	49° 1' 2" N	122° 26' 48" W	49° 1' 1" N	122° 26' 36" W	30
Pepin	PEP8	327	49° 1' 1" N	122° 26' 36" W	49° 1' 3" N	122° 26' 22" W	30
Pepin	PEP9 Left	1597	49° 1' 3" N	122° 26' 22" W	49° 1' 31" N	122° 25' 35" W	15
Pepin	PEP9 Right i	1007	49° 1' 3" N	122° 26' 22" W	49° 1' 27" N	122° 26' 1" W	15
Pepin	PEP9 Right ii	351	49° 1' 27" N	122° 26' 1" W	49° 1' 27" N	122° 25' 45" W	30
Pepin	PEP9 Right iii	240	49° 1' 27" N	122° 25' 45" W	49° 1' 31" N	122° 25' 35" W	15
Salmon	SLN1	5102	49° 10' 37" N	122° 35' 13" W	49° 9' 35" N	122° 35' 22" W	30
Salmon	SLN11	1163	49° 4' 55" N	122° 31' 35" W	49° 5' 7" N	122° 30' 54" W	30
Salmon	SLN12	1063	49° 5' 7" N	122° 30' 54" W	49° 5' 22" N	122° 30' 15" W	25
Salmon	SLN13	1079	49° 5' 22" N	122° 30' 15" W	49° 5' 30" N	122° 29' 29" W	30
Salmon	SLN14	604	49° 5' 30" N	122° 29' 29" W	49° 5' 24" N	122° 29' 6" W	30
Salmon	SLN15	1726	49° 5' 24" N	122° 29' 6" W	49° 4' 57" N	122° 28' 15" W	30
Salmon	SLN16	1013	49° 4' 57" N	122° 28' 15" W	49° 4' 43" N	122° 27' 36" W	15
Salmon	SLN17	494	49° 4' 43" N	122° 27' 36" W	49° 4' 35" N	122° 27' 16" W	25
Salmon	SLN2	1910	49° 9' 35" N	122° 35' 22" W	49° 9' 11" N	122° 35' 25" W	30
Salmon	SLN3	1830	49° 9' 11" N	122° 35' 25" W	49° 8' 35" N	122° 35' 59" W	30
Salmon	SLN4	1020	49° 8' 35" N	122° 35' 59" W	49° 8' 17" N	122° 36' 24" W	30
Salmon	SLN41	400	49° 5' 5" N	122° 31' 13" W	49° 4' 55" N	122° 31' 5" W	25
Salmon	SLN5	1751	49° 8' 17" N	122° 36' 24" W	49° 8' 1" N	122° 35' 46" W	20
Salmon	SLN6	1081	49° 8' 1" N	122° 35' 46" W	49° 7' 46" N	122° 35' 14" W	30
Salwein	HDL1 Left	491	49° 5' 28" N	122° 2' 12" W	49° 5' 37" N	122° 1' 58" W	15
Salwein	HDL1 Right i	150	49° 5' 28" N	122° 2' 12" W	49° 5' 29" N	122° 2' 5" W	30
Salwein	HDL1 Right ii	341	49° 5' 29" N	122° 2' 5" W	49° 5' 37" N	122° 1' 58" W	15
Salwein	HDL2	481	49° 5' 33" N	122° 1' 57" W	49° 5' 45" N	122° 1' 44" W	20
Salwein	HDL3	652	49° 5' 45" N	122° 1' 44" W	49° 5' 52" N	122° 1' 19" W	20
Salwein	HDL4	437	49° 5' 52" N	122° 1' 19" W	49° 5' 53" N	122° 1' 6" W	30
Salwein	HDL5	604	49° 5' 53" N	122° 1' 6" W	49° 5' 49" N	122° 0' 49" W	15
Salwein	HDL6	265	49° 5' 33" N	122° 1' 57" W	49° 5' 34" N	122° 1' 46" W	25
Salwein	SWN1	1379	49° 5' 20" N	122° 3' 34" W	49° 5' 30" N	122° 2' 40" W	30
Salwein	SWN10	411	49° 5' 37" N	122° 2' 50" W	49° 5' 45" N	122° 2' 54" W	25
Salwein	SWN13	720	49° 5' 46" N	122° 2' 39" W	49° 5' 51" N	122° 2' 8" W	30

Salwein	SWN14	945	49° 5' 51" N	122° 2' 8" W	49° 6' 13" N	122° 1' 40" W	30
Salwein	SWN2 Left	777	49° 5' 30" N	122° 2' 48" W	49° 5' 42" N	122° 2' 31" W	15
Salwein	SWN2 Right i	483	49° 5' 30" N	122° 2' 48" W	49° 5' 45" N	122° 2' 44" W	15
Salwein	SWN2 Right ii	295	49° 5' 45" N	122° 2' 44" W	49° 5' 42" N	122° 2' 31" W	30
Salwein	SWN3	1402	49° 5' 42" N	122° 2' 31" W	49° 5' 45" N	122° 2' 3" W	25
Salwein	SWN4	719	49° 5' 38" N	122° 2' 4" W	49° 5' 54" N	122° 1' 55" W	30
Salwein	SWN9	877	49° 5' 27" N	122° 3' 20" W	49° 5' 47" N	122° 2' 51" W	30