Morice Fish & Aquatic Habitat Review 2013

OFFICE OF THE WET'SUWET'EN

SkeenaWild CONSERVATION TRUST

Eclipse GIS

The author's opinions do not necessarily reflect the policies of the Office of the Wet'suwet'en.

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1.0 INTRODUCTION

1.1 Purpose

The purpose of this project is to document alterations and impacts to Wet'suwet'en land and resources, particularly in regard to anadromous and freshwater resident fish and their habitats in Morice watershed. Alterations and impacts resulting from development activities include both direct and indirect effects. The Morice watershed is located within Wet'suwet'en territory, and as such, Wet'suwet'en exercise land and stewardship rights, prerogatives, responsibilities, and authority. This project was undertaken by Office of the Wet'suwet'en (OW) in collaboration with SkeenaWild and Eclipse GIS.

Project objectives include:

- GIS-based high-level analysis of land and resource use and fish and their habitat centered on pressure indicators;
- Provide a basic understand the human-caused processes of change to the aquatic ecosystem in the Morice watershed at a high-level scale;
- Gain an understanding of natural disturbances at the watershed level;
- Provide results that support Wet'suwet'en decision-making in regard to guiding future activities such as planning, assessment, and monitoring activities;
- Enable integration of GIS analysis and results into current OW databases.

The purpose of this report is to document real and potential impacts resulting from an analysis using pressure and state indicators. This type of analysis is constrained by data limitations based on monitoring, uncertainty based on indicator thresholds, and the current lack of related state indicator data such as water quality and quantity.

1.2 Background

The Morice watershed is ranked as very high value and priceless by the Wet'suwet'en. The upper Morice watershed possesses spectacular wild land territory with intact and functioning cultural heritage, traditional use and knowledge that continues into the present, as well as, pristine water quality, important wildlife and their habitats, and valued anadromous and freshwater fish populations and their habitats.

The lower portion of the watershed has been changed due to human land and resource use economic activities. Consequently, the state of the environment and natural resources has changed and limits the Wet'suwet'en in their ability to exercise their constitutionally protected rights and has foreclosed on a variety of sustainable economic activities.

Presently, acquiring market access for oil and gas exports from the interior of BC and Alberta to the Pacific coast has prompted a "wild west" attitude by industry and government whereby multiple pipelines have been proposed through Wet'suwet'en territory, and in particular, the mid Morice watershed. Results of the proposed pipelines assessment indicate that major key components are in deep conflict with core Wet'suwet'en laws and values. Push back to these proposed pipelines from the Wet'suwet'en have included feast hall, territory, and office-based activities; this project is a small part of those larger efforts.

1.3 Wet'suwet'en Context

Canada and BC assert ownership to Wet'suwet'en territory as well; however to date, they have not provided evidence showing how or when they acquired ownership. The Wet'suwet'en have never relinquished or surrendered Wet'suwet'en title and rights to the lands and resources within Wet'suwet'en territory and continue to occupy and use the lands and resources and to exercise existing title and rights within the territory. The Wet'suwet'en have an inherent right to govern themselves and their territory according to their own laws, customs, and traditions. This was affirmed in the Supreme Court of Canada *Delgamuukw* decision.

The territories that could be directly and indirectly impacted by the proposed pipelines are integral to Wet'suwet'en identity, governance, traditional practices of hunting and gathering, and the passing on of traditional knowledge to future generations. Any impact to these vital aspects of Wet'suwet'en culture is an impact to Wet'suwet'en title.

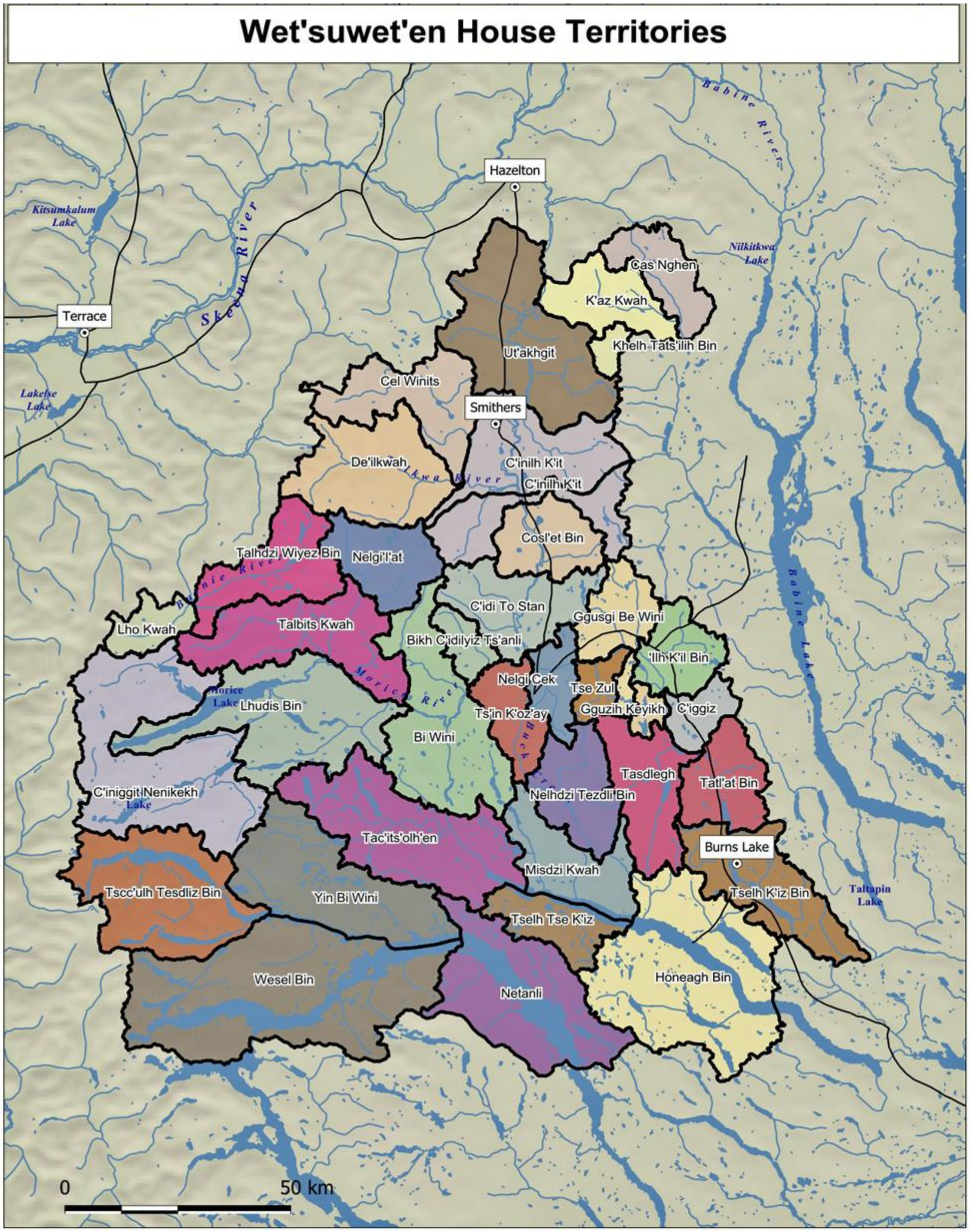

Figure 1. Wet'suwet'en House Territories.

2.0 WET'SUWET'EN

2.1 The Wet'suwet'en

The Wet'suwet'en are an Athabaskan matrilineal society organized into a number of exogamous clans. A clan is a group of people related by kinship based on common descent or historical alliance and belonging to a particular House identified by families and territories. The five Wet'suwet'en clans are:

- Gilsehyu (Big Frog)
- Laksilyu (Small Frog)
- Gitdumden (Wolf/Bear)
- Laksamshu (Fireweed)
- Tsayu (Beaver Clan)

In the feast hall they operate as four Clans with Laksamshu and Tsayu clans working together. Within each clan are a number of kin based groups known as Yikhs, often referred to as House groups. Each House group is an autonomous collective that has jurisdiction and ownership over one or more defined geographical areas known as the House territory.

Within the context of Wet'suwet'en society, this ownership is considered to be a responsibility rather than a right. Hereditary Chiefs are entrusted with the stewardship of a territory by virtue of the hereditary name they hold, and they are the caretakers of these territories for as long as they hold the name. It is the task of a head Chief to ensure that the House territory is managed in a responsible manner so that the territory will always produce enough game, fish, berries and medicines to support the subsistence, trade, and customary needs of House members. The House is a partnership between the people and the territory, which forms the primary unit of production supporting the subsistence, trade, and cultural needs of the Wet'suwet'en.

The rights and responsibilities of Chiefs to manage and harvest resources within the House territory on behalf of their House members continue to be validated in the feast or baht'lat, the central governance institution of the Wet'suwet'en. The resources from the territories are brought into the feast hall and distributed to witnesses by the host clan to validate their ownership of the territories and show respect for their guests.

2.2 Wet'suwet'en Territory Context

Wet'suwet'en territories sustained home places and resources for Wet'suwet'en House group members for approximately the last 10,000 years, with traditional use features or memories covering the landscape. Subsistence activities were tightly interwoven with the social structure, the local landscapes, and the broader regional environment. Detailed knowledge and understanding of the environment, the characteristic of each resource, and the seasonal variation in abundance and availability were necessary to the chiefs and House members for making decisions about what, where, and when different resources were to be harvested.

Over time, Wet'suwet'en ancestors developed systems of access, tenure, and resource management. A strong and adaptive semi-nomadic economy, pre-occupied with food gathering, was based around the summer salmon food fishery with dispersal into smaller family groups during the rest of the year to fish, hunt and gather on the House territories. These two modes of subsistence, the summer salmon fishery along with seasonal dispersal, delineated the culture. Intercultural relations were extensive, resulting in the forging of ties and alliances; these promoted trade occurrences and privileges, allowed technology and transfer thereof, facilitated cultural enrichment, and enhanced economic stability.

Trading was pervasive, with the major villages as trail hubs and an extensive trail network that connected the coastal areas with the Pacific slope, and homeplaces with resource gathering areas. The general cultural infrastructure was underpinned by this trail transportation framework, which linked together villages, homeplaces, and fishing, hunting, spiritual, and resource gathering locales. This transportation network is important in the present as well, as it connects the Wet'suwet'en to our ancient traditional heritage sites and features. Trails and associated cultural heritage features are considered culturally significant by the Wet'suwet'en, because knowledge of these brings awareness of and pride in their cultural heritage connection to place. This was their home and provided their livelihood.

2.3 Yintahk – Everything is Connected to the Land

The Wet'suwet'en do not merely live on the land, they are part of the land, they belong to it and they return to it. The Wet'suwet'en do not simply hunt, fish, and trap on their territories; rather, the Wet'suwet'en are decision-makers and stewards of the lands who actively engage in the management and preservation of their lands. Management of the lands is based on the intimate knowledge gained through personal experience as well as through the collective knowledge contained in the oral histories from generations past.

Figure 2. View across Morice River, Reach 2.

The Wet'suwet'en have a culturally specific term known as "yintahk". Yintahk means "everything is connected to the land". They do not see themselves as entities separate from nature or their territories; just as they own the land, they are owned by the land. The relationship can be characterized as a "conceptual gift exchange" whereby the land sustains the Wet'suwet'en, and when a Wet'suwet'en member passes, the ashes and dust are returned to the land to refresh its history and productivity.

The world view embodied in the term yintahk is used as a guiding principle in the daily lives of the Wet'suwet'en. Yintahk is based on the reciprocal stewardship of the land and all the life and spiritual energies it contains. As a culture that relies on the resources gathered from the territories, the principles of yintahk serve to instill a world view that strives to avoid the damaging forms of territorial resource exploitation. Obviously, damage to the territorial resources not only harms the land, it is counterproductive to the social, cultural, economic and physical well being of each and every Wet'suwet'en member, and will be viewed as an infringement to Wet'suwet'en title, rights and culture.

2.4 Cultural Context

Essentially, Wet'suwet'en possess an acute awareness of our past and pride in our culture today. There is a strong connection to the territory; this is our home. In briefly reviewing our cultural history since the time of Euro-Canadian contact in the area, through the transition period to the present, it is clear to see the social disruption that Wet'suwet'en people and culture have experienced as a marginalized people. Currently, these are important times for First Nations people. The lifeways, accomplishments, and artistic traditions of our people, who have survived the changes wrought by cultural interaction, depopulation, diffusion and colonialism, have never been of greater interest or influence than presently.

However, this is also a time when Wet'suwet'en culture and its heritage remain under a serious threat. Places with important ancestral and traditional connections have been disturbed and changed. Wet'suwet'en concerns about the land are inextricably linked to the complex social structures and customs characterizing the cultural fabric and governance structures; these concepts are not easily communicated to the non-Native community.

The Wet'suwet'en are challenged by the need to communicate our traditional ecological knowledge in a manner that is considered valid by resource management professionals and readily incorporated into land use and resource development planning and implementation processes. Different interpretations of landscape features and values, as well as many critical habitats used by the Wet'suwet'en for the collection of plant and animal resources for sustenance and ceremonial uses, have been adversely affected by resource development activities. One of the critical issues in this regard is the cultural imperative that sufficient resources are available at the House territory level to provide opportunities for house members to gather the resources they require and practice their culture. This is a central tenet of Wet'suwet'en governance or Inuk Nuat'en ("Our Own Law).

2.5 Morice Water Management Area

Water quality in the Morice watershed is integral to Wet'suwet'en livelihood and the spiritual connection they have with the area. Wet'suwet'en governance is based on the ability to retain a traditional livelihood from the health of the territories and a dynamic spiritual connection to these waters. This governance system is at the core of Wet'suwet'en title and rights.

In 2007, the Wet'suwet'en, in collaboration with BC, established the Morice Water Management Area (MWMA) as a component of the Morice Lands and Resource Management Plan (Morice LRMP). The Morice Water Management Area includes the upper part of Morice River, Reach 2, and the Morice drainage upstream, as well as the Burnie and upper Clore systems.

The Morice LRMP states, "The desired outcome is to ensure that the habitat and water quality supporting salmon and other fish is not negatively impacted." Beyond this, the goals intended for the Morice Water Management Area include:

- Water quality and quantity suitable to sustain the health and well being of the Wet'suwet'en; the intent being the protection of water quality, hydrologic integrity, and salmon habitat;
- Water quality that supports aquatic life at reference state;
- Sustainable water use practices;
- Integrated land and water resource planning that utilizes the Wet'suwet'en Territorial Stewardship Plan.

The Morice WMA was created to secure the integrity of Wet'suwet'en lands and water resources and represents a significant compromise by the Wet'suwet'en whose interests extend throughout the entire Morice watershed. The intent is to provide the maximum amount of security for sustaining water quality and quantity necessary for the health and well being of the Wet'suwet'en, as well as the protection of the salmon and other fish in the area and the aquatic life on which they depend. Losses to habitat or hydrological integrity are expected to be addressed promptly through restoration activities.

The Morice WMA makes clear what the Wet'suwet'en want in terms of aquatic and terrestrial resource planning and management. The Morice WMA overlies six Wet'suwet'en House territories and overlaps other land use zones, including four Protected Areas, many Area Specific Resource Management Zones, and some areas under General Management Direction as seen in Figure 3. The management of these other areas in conjunction with the MWMA is expected to enhance water quality and fish habitat protection.

Current proposed gas and oil market access pipeline projects will bisect the Morice Water Management Area. In effect, the projects propose to erode Wet'suwet'en land resource management planning initiatives and impinge on the right to protect and maintain the integrity of the territory.

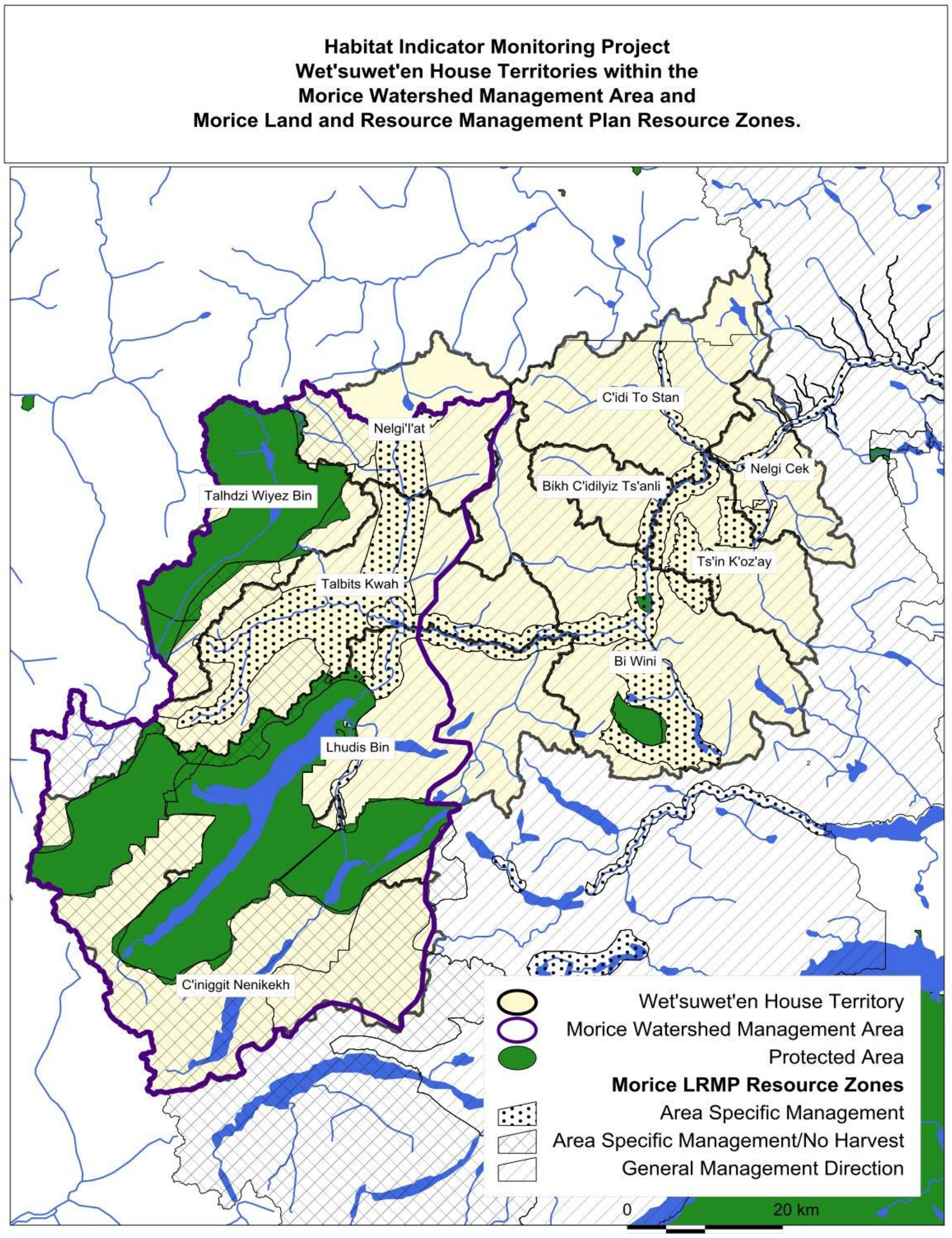

Figure 3. Wet'suwet'en House Territories within the Morice Watershed Management Area and Morice LRMP Zones.

3.0 MORICE WATERSHED

3.1 Environmental Setting

The Morice watershed is located in Wet'suwet'en territory, south of Houston, British Columbia. The watershed is bounded to the north by the Bulkley River drainage, to the west by the upper Kitimat and upper Zymoetz drainages, and to the east and south mainly by Nechako River tributaries.

The Morice Watershed is part of the Bulkley River basin and is fed by streams originating in both the Interior Plateau and the glaciated Coast Mountains. From the outlet of Morice Lake, the Morice River flows northeastward 80 km to join the Bulkley River near Houston, BC. The Bulkley River flows 150 km northwestward to enter the Skeena River at Hazelton, BC. The Skeena River flows 285 km downstream to Chatham Sound on the northeast Pacific Ocean.

The Morice River is a sixth order stream that drains a catchment area of 4,380 km^2 (comprising the southwestern portion of the Bulkley watershed. Elevations range from approximately 2,740 m to 560 m at the Bulkley confluence. Morice Lake (762 m) is the largest lake in the system and is the origin of the Morice River. Major tributaries include: Atna River, Nanika River, Thautil River, Gosnell Creek, Lamprey Creek, Owen Creek, and Houston Tommy Creek.

The contribution of high elevation snowmelt and ice melt runoff is important in maintaining adequate summer water levels in the mainstem and side channels of Morice and Nanika Rivers. Rainstorms in the fall and decreasing evapotranspiration yield moderate flows. The Morice River contributes on average, more than 90% of the flows to the Bulkley River at their confluence, and up to 99% of flows at certain times. There is a steep precipitation gradient from west to east, as well as from the high alpine to the valley bottom in the drainage. Annual total precipitation ranges from approximately 2,250 mm in the Coast Mountains to under 500 mm along the lower Morice River.

The Morice River mainstem is 80 km in length with a very low gradient (<0.2%) and no obstructions to anadromous fish passage over its length. Reach 1 is situated between the outlet of Morice Lake and the Thautil River and is a single-thread channel with a stable channel configuration. The substrate is mainly cobble with some gravels, deep pools, rock outcrops, and steep banks.

Reach 2 extends from the Thautil River downstream to Fenton Creek confluence. This reach is characterized as a wandering gravel bed river with one to several channels, frequent channel changes, gravel bars, forested islands, eroding banks, logjams, and a network of seasonally flooded channel remnants over the floodplain. The bedload of Reach 2 is coarse (over 97% is coarser than 2 mm), consisting mostly of gravel and cobbles, much of which originates from Thautil River. Reach 3 of the Morice River; which extends from Fenton Creek to the Bulkley River confluence, is a single thread channel that maintains a relatively stable channel configuration.

3.2 Morice Fisheries

The Morice watershed has high fisheries values and is a major producer of chinook, pink, sockeye, and coho salmon, and steelhead trout, which are fished by coastal and in-river aboriginal, commercial, and recreational fisheries.

3.2.1. Morice Sockeye

The Morice sockeye stock is composed of two sub-components: Nanika River spawners and Morice Lake and Atna Lake beach spawners. Morice sockeye are commonly termed Morice–Nanika sockeye as the majority spawn in Nanika River and rear in Morice Lake. Minor amounts of spawning occur in the Morice River; in the past, sockeye spawned at Owen and Lamprey lakes; however, these stocks are considered extirpated.

Historically, sockeye returning to the Morice Watershed numbered on the order of 50,000 to 70,000 fish and comprised as much as 10% of the total Skeena River escapement (Brett 1952). In 1954, the population collapsed and in the following twenty-year period, 1955–1975, an annual average of 4,000 sockeye returned to the watershed (DFO 1984). Average annual returns in the 1980s were 2,500 fish, while the annual average returns in the 1990s were 21,500 fish. This robust increase in the 1990s fell off in 2000. Returns to the Nanika appear to be decreasing; since 2000, escapements have ranged between 3,000 to 13,400 sockeye with an annual mean of slightly more than 8,400 sockeye.

Since the mid-1950s, Morice–Nanika sockeye abundance has mostly fluctuated at levels below historical escapements with low fry densities in relation to the juvenile sockeye rearing capacity in Morice Lake. Constraints to sockeye production stem from the high exploitation rates in the Alaskan, Canadian, and First Nation fisheries, as well as low production from the ultra-oligotrophic Morice Lake. The Morice Lake sockeye stock's spawning and rearing habitat is in its natural condition; it has not been impacted by development activities.

Morice–Nanika sockeye usually reach the mouth of the Skeena in late-June to mid-July with a peak in the first week of July (Cox-Rogers 2000). Peak migration of sockeye salmon through Moricetown Canyon is late-July and they are typically past Tsee Gheniinlii[1] in early to mid-August. The main sockeye run usually hold and school in Morice Lake before ascending the Nanika River to the 3 km reach downstream of Nanika Falls where the principal spawning grounds are located. Secondary Nanika River spawning grounds are scattered downstream to Glacier Creek. Shepherd (1979)[2] notes that Nanika River sockeye peak spawning occurs during the third week of September. Shepherd (1979) presents age data from 1965 to 1975 for Nanika River sockeye, which indicates the majority of spawners were five and six year old (90%), both having spent two years (86%) in freshwater. In all study years, egg retentions were low in Nanika sockeye spawners.

Figure 4. View across Morice Lake to sockeye beach spawning areas near Delta Creek.

Morice Lake sockeye spawners, who are thought to be composed exclusively of beach spawners, utilize scattered beach spawning grounds at the south end of the lake such as shown in Figure 3 above. Bustard and Schell (2002)[3] show the main beach spawning occurs for 3 km north of Cabin Creek.

Studies conducted in Atna Lake during 1980, indicated that approximately 400 sockeye shore spawners based on carcass recovery (Envirocon 1984)[4]. Most of these spawned in the northeast section, as

[1] Tsee Gheniinlii is the canyon and fishery on the Morice River downstream of Owen Creek confluence.

[2] Shepherd, B.G. 1979. Salmon studies associated with the potential Kemano II hydroelectric development: Volume 5 Salmon studies on Nanika and Morice River and Morice Lake. Dept. of Fish and Environ. Vancouver, BC.

[3] Bustard, D. and C. Schell. 2002. Conserving Morice Watershed fish populations and their habitat. Prepared for CFDC Nadina.
4Envirocon Ltd. 1984. Fish resources of the Morice River system: baseline information. Vol. 4. Environmental studies associated with the proposed Kemano Completion Hydroelectric Development. Aluminum Company of Canada. Vancouver, BC.

opposed to DFO observation in 1961 where most spawning appeared to be in the northwest section. Envirocon noted that the age distribution of Atna Lake sockeye differed from Nanika and other non-Morice Skeena stocks. The dominant group (58%) were 5_3's, (two years in freshwater and 3 years in the ocean). The primary difference is with the subdominant group (4_2's) representing approximately 29% of the run that had spent one year and three years in freshwater and the ocean respectively.

Nanika River sockeye are the only ones in the Morice system that have had consistent escapement estimates since the 1950s. Accurate beach spawning counts along Morice and Atna Lake shorelines are difficult due to turbidity and depth. Bustard and Schell (2002) suggest that Morice Lake beach spawning sockeye might comprise a significant component of the Morice sockeye run during some years. This is now corroborated by the Moricetown Canyon mark–recapture program that shows 35% of the total sockeye spawn in locations other than Nanika.

Finnegan (2006)[5] reports recent sockeye abundance estimates have been generated from the mark-recapture program that is located at Moricetown Canyon. Beach seining at Idiot Rock below the canyon and by dipnet at the fishway allows T-bar anchor tagging as shown in Figure 5. Recapture is at the fishway as shown in Figure 6 and tag recovery on the various spawning grounds. The aggregate escapement is determined from the Nanika River visual and swim surveys, and population estimation. The marked to unmarked ratio is determined in the upper Bulkley, on the Nanika River spawning grounds, and in Morice and Atna lakes to account for lake spawners (Finnegan 2006).

Figure 5. Seine tagging below the canyon.

Figure 6. Recapturing sockeye at the fishway.

Following emergence, sockeye fry emigrate from spawning beds into Morice Lake from late-May to late-July, usually prior to or coincident with peak annual flows (Shepherd 1979). Morice Lake serves as the freshwater rearing lake for sockeye spawned in the Nanika River, Morice Lake, and possibly an unknown amount from Atna Lake. Morice Lake sockeye juvenile studies were conducted primarily in the 1960s, 1970s, and early 1980s and reported on by Palmer (1986b) Crouter and Palmer (1965), Shepherd (1979) and Envirocon (1984a, 1984b) respectively. Shortreed et al. (1998, 2001) and Shortreed and Hume (2004) report on more recent sockeye juvenile sampling conducted in 1993 and 2002. Lake rearing habitat capacity and fry production relationships are presented in Cox-Rogers et al. (2004). The understanding of juvenile sockeye rearing and smolt production dynamics, such as age and growth, distribution and abundance, movement timing, and predation is still evolving in Morice Lake.

[5] Finnegan, B. 2006. Morice Lake Sockeye Program. Unpublished data. DFO, Stock Assessment, Smithers, B.C.

Due to the low nutrient input into Morice Lake, phytoplankton and zooplankton biomass levels are relatively low, resulting in very slow growth rates for sockeye fry. In contrast with other Skeena sockeye stocks, which spend one year in freshwater, over 85% of Nanika River sockeye spend two years in Morice Lake, and 90% return as four- (4_2's) and five- (5_3's) year-olds, with approximately 10% as six year-olds (Shepherd 1979). Age-0 fall fry are the smallest in any sockeye nursery lake in BC and the large percentage of two-year-old smolts in Morice Lake are indicative of its low productivity (Shortreed et al. 1998)[6]. Sockeye smolts migrate out of Morice Lake from late April to August with a peak migration in May (Shepherd 1979).

Since the early 1950s, a major theme of fisheries biologists involved in researching Morice sockeye has been identifying the factors limiting sockeye production. Over the last sixty years, enhancement efforts have focused on easing fish passage, increasing fry recruitment, understanding the trophic status of Morice Lake, and correlations among these factors. Currently, major factors limiting juvenile sockeye production are thought to be the lack of escapement and the relatively low intrinsic primary and secondary productivity of Morice Lake.

Morice sockeye salmon returning as adults from the sea to spawn and die provide a very important nutrient link between the marine and freshwater environment. These salmon accumulate over 90% of their biomass during the marine phase of their life cycle (Groot and Margolis 1991). Considerable research has highlighted the important role of anadromous salmon in importing marine–derived nutrients (MDN) to freshwater and riparian ecosystems. These subsidies support diverse food webs and increase the growth and survival of juvenile salmon during their freshwater residency (Scheuerell et al. 2005).

Figure 7. View upstream on Nanika River.

Recent research and reviews (Quinn 2005, Reimchen et al. 2003, Wilson and Halupka 1995) reveal that entire ecosystems benefit in direct and indirect ways from decomposing salmon. Wilson and Halupka (1995) term salmon a keystone species in recognition of salmon's special role enriching otherwise nutrient-poor systems. Different sockeye life history stages likely play different roles in the various habitats they occupy throughout their life cycle. The intrinsic importance of salmon to ecosystem functioning prompts concern for adequate escapement from an ecological perspective. The abundance of returning Morice sockeye spawners is critical to maintenance of fish populations rearing in streams and lakes. It follows that salmon are important components of numerous freshwater and marine food webs throughout their life history.

[6] Shortreed, K.S., J.M.B. Hume, K.F. Morton, and S.G. MacLellan. 1998. Trophic status and rearing capacity of smaller sockeye nursery lakes in the Skeena River system. Can. Tech. Rep. Fish. Aquat. Sci. 2240: 78p.

Decreased availability of salmon carcass material can significantly reduce the nutrient influx to natal streams and over time, diminish productivity. The resulting decrease in juvenile fish size can reduce overwinter and marine survival, reduce the number of returning adults, and further reduce stream and lake productivity (Bilby et al. 1996). Runs of adult Morice sockeye may continue to decline, returning fewer nutrients to already nutrient deficient streams and lakes, particularly if combined with overfishing of a now, less productive stock. Thus a negative feedback loop from nutrient–food chain impacts can be very significant to lake and stream rearing species. Understanding marine derived nutrient loss helps to explain the continuing decline of Morice–Nanika sockeye. It is clear that sockeye escapement needs to increase to enable primary and secondary production in Morice Lake.

The abundance, productivity, and carrying capacity status of Morice sockeye are rated as poor. The current decline of Morice–Nanika sockeye due to high exploitation rates and low-productivity issues in Morice Lake has deeply impacted the Wet'suwet'en and their culture. **The Wet'suwet'en Food, Societal, and Ceremonial (FSC) fishing moratorium of this stock is proof of their governance system, and any alteration or destruction to the fish and fish habitat is an infringement of Wet'suwet'en title and integrally associated traditional governance.** Recent Nanika-Morice sockeye stock returns have declined and are a cause for aboriginal and conservation concerns, which led to establishing the Morice_Nanika Sockeye Recovery Plan.

3.2.2 Morice Chinook

Morice River chinook salmon are an important Wet'suwet'en salmon stock, contributing approximately 30% of the total Skeena system chinook escapements in the 1990s. In the recent past, this stock has constituted as much as 40% of the total Skeena River chinook escapement (DFO 1984). In the late 1950s, an estimated escapement of 15,000 Morice River chinook spawners was recorded. From 1960 through to the mid 1980s, an average of 5,500 spawners returned, after which chinook spawner escapement increased. Between the mid-1980s and 2001, Morice River chinook spawners increased to the historic levels of the late 1950s returns (~15,000). From 2002 to 2011, average annual escapement decreased to 11,325 from a range of 4,800 to 18,000 chinook.

Adult chinook salmon begin their migration into the Morice River system about mid-July and spawn from August to October; peak spawning was observed by Shepherd (1979) to be mid-September, with die-off by mid-October. Approximately 80% of Morice chinook spawning occurs principally in the upper 2 km of the Morice River downstream of the lake outlet as shown in Figure 8.

Figure 8. Chinook Island and spawning dunes at Morice River.

Most of the riverbed at this site is characterized by a series of large gravel dunes oriented perpendicularly to the direction of flow. These dunes are constructed by chinook during redd excavation. This very unique feature is culturally significant to the Wet'suwet'en. Scattered minor spawning also occurs downstream to Lamprey Creek and in the Nanika River, downstream of the falls.

Morice chinook mostly spend less than one year in freshwater and return mainly as four or five-year-olds (85% in 1973 and 1974). In comparison with other Skeena chinook stocks, Shepherd (1979) notes the Morice River produces more six-year-olds than other systems in the Skeena (12% average versus 3% average) and fewer two and three-year-olds (3% versus 17%).

Chinook fry migrate or are displaced downstream upon emergence between mid-April and early-July, though typically peak emergence is in late-May to early-June. Survey results from Smith and Berezay (1983)[7] indicates that chinook fry overwinter throughout most of the Morice River mainstem. However, Reach 2 located between Thautil River and Fenton Creek is considered the most productive rearing area.

Morice River chinook spawning and rearing habitat is currently intact; however, were a spill or rupture from the proposed energy pipelines occur in Reach 2, this very productive chinook rearing habitat would be severely affected.

The Wet'suwet'en believe that there is a connection between our ancestors and the salmon that ensure community well-being and health. Wet'suwet'en laws regulating human behaviour toward the salmon strengthen the moral fibre and the whole social order of the society. Any change to the behaviour of the Chinook stock due to industrial activity, including oil and gas projects, will be an infringement to the Wet'suwet'en title and the integrally associated rights of Wet'suwet'en management and governance.

3.2.3 Morice Coho

Coho enter the Morice system in mid-August through to mid-September, generally holding in the mainstem, major tributaries, and in Morice Lake, and then, depending on water flow conditions, move with fall freshets into the tributaries to spawn. In years of below average stream flows, most coho spawners (85%) have been observed in the prime spawning grounds downstream of the lake outlet, with scattered spawning along Reach 2 side channels (Envirocon 1980). In these low flow years, often the only tributary streams with adequate flow for coho access and spawning are Gosnell Creek, the Thautil River, and Houston Tommy Creek.

In years with higher flows, other tributaries used for spawning include Owen Creek, McBride Creek, and Nanika River. Documented spawning areas occur in all tributary streams of the Morice River (Shepherd 1979); however, this is likely to depend on adequate adult escapement and fall freshets coinciding with the late October and November spawning period.

Since 1950, the relative contribution of coho from the Morice River system to Skeena coho escapement as a whole is approximately 6% (Bustard and Schell 2002). In reviewing the escapement data, a declining trend from the 1950s to the present is apparent in Morice system coho populations (DFO 2008). The decline is in absolute numbers as well as relative to the overall Skeena escapement. The highest ten-year period of abundance in escapement numbers, the 1950s, shows an annual average escapement of 10,700 fish. In the 1970s, the average annual escapement was approximately 4,300 fish, with the annual escapement diminishing to 518 fish in the 1980s, and it remained low in the 1990s with an average annual escapement of 672 fish. Since 1999, the aggregate coho escapement has steadily increased through to 2012, except for Gosnell coho, which have remained relatively depressed.

Coho fry emergence extends from April to July. Juveniles are widely distributed throughout the Morice mainstem, as well as in most of the tributaries and lakes in the system during years of suitable recruitment. Rearing in these streams occurs for one to two years. Habitat preferences are well defined

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[7] Smith, J.L. and G.F. Berezay. 1983. Biophysical reconnaissance of the Morice River system, 1979-1980. SEP Operations, Fisheries and Oceans Canada.

and include side channels, side pools, ponds and sloughs with instream cover providing an important key habitat component (Shepherd 1979).

Figure 9. Gosnell Creek coho spawning habitat, mountain pine beetle kill, and logging blocks.

Overwintering coho prefer side channels, which makes them susceptible to reduced winter flows and cold temperatures that may result in dewatering and freezing of their winter habitat. This is a major constraint for coho smolt production in the Morice River, where significant mortalities have been documented (Bustard 1983).

Morice coho habitat is somewhat stable with area specific impacts from forestry activities to rearing and spawning habitat that is a limiting factor to coho production. Coho abundance is rated as depleted and may require a recovery plan.

3.2.4 Morice Pink

Pink are the smallest salmon at maturity and posses a single age at maturity; they are exclusively two years old at spawning time. This means that odd-year and even-year stocks are genetically separate). In general, the odd and even-year lineages of pink salmon are more different genetically than stream populations over large areas. Morice even-year pink salmon have a moderately developed dominance, though abundance can vary exceptionally on an inter-annual basis.

The pink salmon life history is distinguished by an emphasis on marine habitat, only entering freshwater for spawning, egg incubation, and alevin development into fry. Overall, they have a relatively short life cycle with rapid growth. The critical periods up to adult survival include egg to fry, juvenile emigration, estuarine spring and summer feeding, ocean feeding, adult return migration, and escapement through the mixed stock fishery. There are too many unknown and complex factors, as well as a lack of information, for Morice pink salmon to partition survival in the marine, estuarine, and freshwater realms.

The Morice pink salmon run is significant among the larger pink producing systems in the Skeena watershed. The odd-year pink run to the Morice River has been expanding since construction of the Moricetown Canyon fishway in 1951 and was further augmented with the removal of key rocks by blasting at Hagwilget Canyon in 1959. Pink salmon were first seen in the lower Morice River in 1953 and had reached Owen Creek by 1961 and Gosnell Creek by 1975. By the mid-1980s, this steady expansion of habitat saw pink spawners colonizing the Nanika River spawning grounds.

Adult pink salmon usually migrate upstream into the Morice system in late August to early September. Pink spawning takes place through September with over 90% of the escapement spawning in Reach 2 side channels, particularly between Lamprey and Thautil. Small numbers of spawners have also been observed at Gosnell Creek, Nanika River, and in the mainstem downstream of the lake.

Winter observations of pink redds in heavily utilized side channels indicate that dewatering of redds, and probable losses of eggs and alevins with reduced flows, occurs more often at these sites than in the deeper main channel spawning areas. Upon emergence from gravels, pink fry migrate directly to the ocean, returning to spawn as two-year-old fish.

Currently, there are few Wet'suwet'en concerns regarding levels of pink salmon abundance or habitat issues. Future concerns do center on significant effects to pink migration and spawning habitat from proposed pipelines and potential spills.

3.2.5 Morice Steelhead

Wet'suwet'en harvest steelhead year-round in the Morice mainstem and major tributaries. Winter and spring steelhead catches through the ice are preferred as they are considered enjoyable fresh fish. Major Wet'suwet'en steelhead fisheries conducted in the Morice system are located at Tsee Gheniinlii (Morice Canyon), Bii Wenii C'eek the (Morice–Owen confluence), Lhet Lii'nun Teezdlii (outlet of Morice Lake) and Neenekeec (Nanika River); however, steelhead were fished throughout the system.

In recent years, the Bulkley-Morice likely accounts for 30% to 40% of the total escapement of Skeena steelhead, based on population estimates, genetic markers, and data from the Tyee Test Fishery (Beacham et al. 2000, Mitchell 2001). The significant summer-run of the Morice system moves into the river in mid-August and continues into the autumn (Whately et al. 1978). Overwintering appears to occur throughout the mainstem, particularly downstream of Gosnell Creek, with evidence that steelhead also utilize Morice Lake (Lough 1981, Envirocon 1984b). With the exception of Gosnell Creek, tributaries do not support overwintering steelhead due to insufficient discharge (Envirocon 1980, Tetreau 1999).

Figure 10. Steelhead holding and spawning habitat at the Thautil–Gosnell–Morice confluence area.

Steelhead spawning coincides with an increase in Morice River snowmelt flows and an increase in stream temperatures typically in late-May to early June. Results from Envirocon (1980) sampling surveys indicate widespread spawning distribution through the mainstem and tributaries. According to DFO stream survey maps, critical spawning habitat is in the upper Morice River and scattered downstream pockets to the Thautil confluence, as well as the lower reach of Gosnell Creek (DFO 1991b). Key spawning tributaries are Shea Creek, Owen Creek, upper Thautil River, and upper Lamprey Creek (Bustard and Schell 2002). Repeat spawners among Morice River steelhead comprise 6.6% of the total returns, with females outnumbering male repeat spawners by a ratio of 2:1 (Whately et al. 1978).

Steelhead fry emergence in the Morice mainstem occurs primarily between mid-August and mid-September, while emergence in some tributaries may occur as early as late-July, due to earlier spawning and warm water temperatures. Tredger (1981-87), Bustard (1992 and 1993), and Beere (1993) describe juvenile steelhead fry and parr distribution, densities, and size estimates from a network of index sites. Most Morice steelhead remain in freshwater for three (24%) or four (70%) winters prior to smolting, which is a longer freshwater residency time than in the six other summer-run steelhead rivers studied in the Skeena system (Whately 1978). Rearing occurs throughout the mainstem and tributaries, though

Thautil River and Owen, Lamprey, and Gosnell creeks account for most of the steelhead fry (85%) and parr (75%) sample catch (Envirocon 1984b).

3.2.6 Morice Lamprey

Skeena system Pacific lamprey are present in the r Lakelse, Kitsumkalum, Kispiox, Babine, and Bulkley watersheds. Within Bulkley system, lamprey are present throughout and especially in the Morice and upper Bulkley systems. Lamprey are anadromous and typically migrate upstream in mid to late July and spend a full year in the system prior to spawning the next summer. Spawning usually occurs in large to small streams, including side channels at the top end of riffles, where they construct noticeable redds and lay their eggs. Lamprey spawning habitat is similar to that used by salmon. Lamprey ammocoetes lie buried in the substrate for up to six years before transforming to an eyed, parasitic-form eel that travels downstream to the ocean.

As adults in the marine environment, lampreys are parasitic and feed on pelagic fish such as herring and salmon, as well as bottom fish. In turn, lamprey are prey for sharks, sea lions, and other relatively large marine life. After spending one to three years in near-shore marine areas, lampreys cease feeding and migrate upstream into their natal freshwater habitat.

Figure 11. Pre-spawn lamprey.

Lamprey are an important food fish for the Wet'suwet'en, who harvest them in the Bulkley mainstem, primarily at Hagwilget and Moricetown canyons with dipnets, and also on a variety of tributaries where traps are primarily used. Lamprey fisheries on Morice tributaries were conducted at Owen, Lamprey, Houston Tommy, and Gosnell creeks and Thautil River.

Lampreys are typically smoke dried, and then fully dried, frozen, canned, salted, or pickled. There are no absolute numbers regarding lamprey abundance, but Wet'suwet'en observations over the last two decades indicate moderate to high diminished returns, which has increased fishing effort and impacted sustenance regimes.

Lampreys are sensitive to environmental change in regards to water quality. An oil spill along their migration route, and nursery and spawning sites may lead to imminent extinction of the population. Wet'suwet'en management in their territories is to ensure this species survival remains intact for Food Social and Ceremonial purposes; any adverse change to this Wet'suwet'en mandate is an infringement to Wet'suwet'en title and governance.

3.2.7 Morice Resident Fish

Six resident fish species are predominant in Wet'suwet'en diets and these include lake trout, rainbow trout, Dolly Varden, bull trout, kokanee, and whitefish. Lake trout is a cold-water fish, usually frequenting deep lakes distributed in the Morice system. Lake trout presence is recorded in Atna Lake, McBride Lake, Morice Lake, Nanika Lake, and Owen Lake. Yellow listed resident fish include lake trout and Dolly Varden while bull trout are blue listed under the BC provincial list.

Lake trout are the top aquatic predator in most lakes where they are found. Lake trout may prey on kokanee and whitefish while in deep water, and aquatic insects and shore dwelling minnows while in shallow water. Usually, maturity occurs at age eleven with mature adults leaving lake waters to return in-river to spawn.

Lake trout are capable of reaching ages in excess of fifty years and achieving weights over 20 kg. Most lake trout populations in Wet'suwet'en territory have significantly reduced abundance due to road access and high angler effort. Due primarily to their large size and palatable flesh, they are prized by many anglers and are vulnerable to overexploitation; there are currently conservation concerns in McBride, and Owen lakes.

Rainbow trout are the most widely distributed and common fish living in both lakes and streams in Wet'suwet'en territories and are a mainstay of Wet'suwet'en fish catch. Dolly Varden are widely distributed in the upper cold water reaches of mountain streams in the Morice drainage territories. Dolly Varden are blue listed by the BC CDC as a species of concern due to loss of habitat.

Bull trout are common in the Morice watershed, and in many locations provide winter-long fresh fish catches to the Wet'suwet'en. Their distribution patterns indicate they are sensitive to water temperatures, preferring cold natal streams. Bull trout spawn in small to large tributary streams, and adults over-winter in larger rivers. Bull trout are a long-lived repeat spawning fish that can exceed twenty years of age and 10 kg in weight. Bull trout are a popular sport fish and are frequently harvested by sport anglers as by-catch during recreational fisheries targeted on summer-run steelhead, chinook, sockeye, and coho. As adults, they are an aggressive fish and vulnerable to over harvest by anglers. As territories in the western portion of the Morice drainage become more road accessible, Wet'suwet'en have noted diminished abundance of bull trout populations.

Figure 12. Redslide Creek–Nanika River confluence is a preferred bull trout area.

Kokanee are a landlocked form of sockeye salmon that are an important fish resource to the Wet'suwet'en at upper and lower Burnie Lakes, Shea Lake, and Morice Lake. Similar to lake trout and bull trout in Wet'suwet'en territories, kokanee are highly prized by anglers, as the deep red flesh is considered by many to be the tastiest and finest eating fish in the Morice watershed. Wet'suwet'en primarily used traps to catch kokanee; however, current harvest is typically by lake trolling.

Mountain whitefish, most commonly called whitefish, are widely distributed across the territory in streams and lakes and are an important food to Wet'suwet'en. In the Morice watershed, whitefish were and are harvested at various sites in the Bi Wenii (Owen), Ze'gel'h Kwa (Lamprey), Te't'aay Kwa (Thautil), Talbiits Kwa (Gosnell), Hlootsus Tez Dlee (McBride), Neenekeec (Nanika), and C'enenlee (Atna) systems.

As a matter of right and responsibility, Wet'suwet'en have a commitment to preserve the integrity, stability, and beauty of the biotic community for their members, and the general public at large. These values are in place for the health and ecosystem function in Wet'suwet'en Yintahk.

4.0 METHODOLOGY

Principal components of project methodology are as follows: acquisition of funding, formation of a steering committee, arrangements and agreement on methodology, discussion of challenges relating to data limitations and indicator thresholds, conducting and reviewing analysis, interpretation of analysis results, and report production.

It is important to note that this project utilized environmental indicators, in particular pressure indicators, in a pragmatic approach appropriate to basin and sub-basin scales. The indicators are from the classic Pressure–State–Response (PSR) conceptual model.[8] In a very general way, an indicator can be defined as a value, which provides information about a phenomenon. Typically, indicators have significance extending beyond the properties directly associated with the value. Indicators possess a synthetic meaning and are developed for a specific purpose. The PSR model is shown in Figure 13.

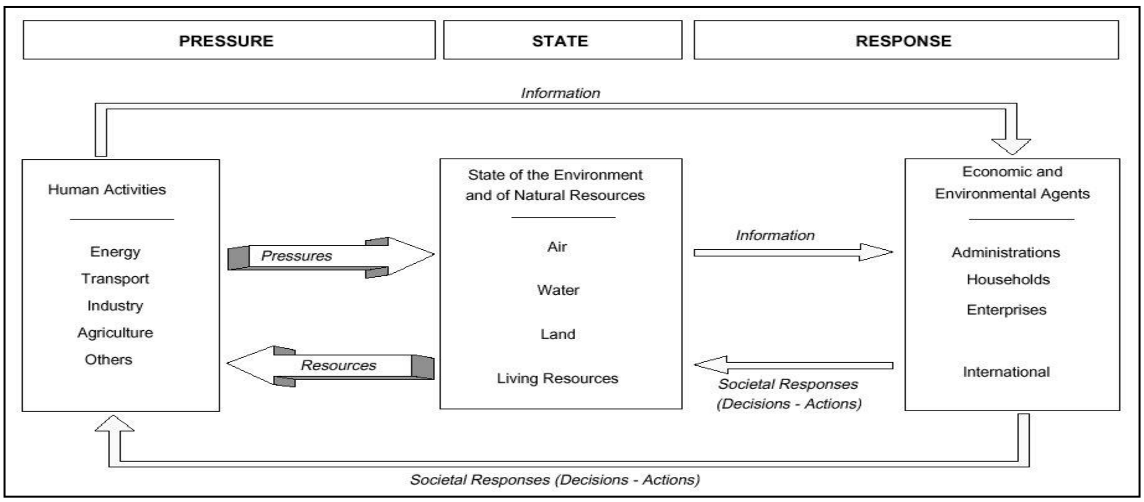


Figure 13. Pressure–State–Response conceptual model.

For the most part, data pertaining to state indicators for Morice watershed is either inadequate or non-existent and therefore tended to limit the overall analysis. An example of state indicators would be data related to water quality, water quality, abundance of selected fish, quantity or condition of their habitat, etc. In practice, the distinction between environmental conditions and the pressures can be ambiguous and the measurement of environmental conditions can turn out to be difficult and costly, particularly at small scales. Nevertheless, this project mostly uses the measurement of environmental pressures as a substitute for the measurement of environmental conditions.

Analysis of pressure indicators used widely-accepted thresholds, which are noted in the specific indicator methodology. Concerns regarding threshold levels are recognized and acknowledged. The focus of concerns is that indicator threshold levels were mostly established by the forest industry or forest industry regulatory agencies and are primarily based on opinion rather than science.

4.1 Pressure State Methodology

Keeping in mind Wet'suwet'en policy relevance, user utility, analysis, and measurability, the criteria for pressure indicator selection include:

- Providing a representative picture of pressures on the environment;
- Easy to interpret and able to show trends over time;

[8] http://www.fao.org/ag/againfo/programmes/en/lead/toolbox/Refer/gd93179.pdf

- Responsive to changes in the environment and related human activities;
- Applicable to regional environmental issues of national significance;
- Have a threshold or reference value against which to compare it so that users are able to assess the significance of the values associated with it;
- Be theoretically well founded in either cultural, technical, and scientific concepts;
- Data readily available or made available at a reasonable cost/benefit ratio;
- Adequately documented and of known quality;
- Updated at regular intervals in accordance with reliable procedures.

The pressure indicators selected and applied closely interrelate with the federal Wild Salmon Policy, with BC provincial regulations and policy, and the extensive forest development activity in Morice watershed. Each of these pressure indicators are relevant to stream and lake habitats and separately reported on in regard to GIS data, methodology, results, and discussion. The pressure indicators utilized for analysis include:

- Riparian Disturbance;
- Road Density;
- Total Land Cover Alteration;
- Stream Crossing Density.
- Fish Presence;
- Natural Disturbance.

4.2 Morice Analysis Areas

The results of the GIS analysis per indicator are reported out by analysis units including the Morice watershed, eighteen sub-watersheds and face units within the Morice watershed, the Morice Watershed Management Area, and the ten Wet'suwet'en House Territories within or partly within the Morice watershed. The Morice watershed boundary is 76 ha larger than the total area of all the sub-watersheds to accommodate the Wet'suwet'en House Territory boundaries.

4.2.1 Morice Water Management Area

The Morice Water Management Area (MWMA) is utilized in this analysis due to its importance to the Wet'suwet'en. Water quality in the Morice watershed is integral to Wet'suwet'en livelihood and the spiritual connection they have with the area. In 2007, the Wet'suwet'en, in collaboration with BC, established the Morice Water Management Area. The Morice Water Management Area is largely composed of the upper Morice watershed, though also includes the Burnie and upper Clore systems. MWMA is composed of 3,403.51 km^2.

4.2.2 Wet'suwet'en House Territories

Ten Wet'suwet'en House Territories lie within, or partly within the Morice watershed and analysis was conducted on all the territories. It is important when interpreting results that the reader does not get confused by the differing area and by the differing results. The area of the ten Wet'suwet'en House Territories within or partly within the Morice watershed is 5,902 km^2. The Morice watershed is 4,380 km^2. The 1,522 km^2 difference is attributed to additional territory falling outside Morice watershed including: Bi Winii, Ts'in K'oz'ay, Nelgi Cek, C'idi To Stan, Nelgi'I'at, and Talhdzi Wiyez Bin territories.

5.0 MORICE WATERSHED SALMON HABITAT ANALYSIS

5.1 Road Density

Roads have significant and widespread ecological impacts across multiple scales, often far beyond the area of the road "footprint". Road density is a useful indicator of human impact at all scales broader than a single local site because it integrates impacts of human disturbance from activities associated with roads and their use with direct road impacts. In the Morice watershed, the majority of road development is closely related to forestry activity.

Impacts from roads often create large and extensive departures from the natural conditions to which organisms are adapted, which increase with the extent and/or density of the road network. In the Columbia River Basin, road densities above 0.6 km per square km and their related effects have been well-documented and shown to be associated with declines in the status of salmonid species (USFWS 1999)[9]. To date, impact analysis on the effects of roads in Morice watershed has been scant; however, ESSA (2013)[10] recently completed a risk and vulnerability assessment reviewing Morice sockeye habitat.

Road densities have been widely correlated to salmon habitat degradation, and have been ranked as a high value indicator by the Wild Salmon Policy Habitat Working Group. It is apparent that it is difficult to settle on an appropriate and realistic road density threshold. Due to this factor, this analysis used interim thresholds that follow recommendations put forth by the Wild Salmon Policy that include:

- Low risk: road density < 0.40 km/km^2
- Moderate risk: road density 0.40 to < 1.2 km/km^2
- High risk: density >=1.2 km/km^2

5.1.1 Methodology

The following GIS spatial information was utilized in the analysis:

- FTEN (forestry roads)
- Digital Road Atlas (DRA)
- Landsat 7 – 2011/2012 imagery (15m panchromatic band)

No local forestry road layer was available from the Nadina Forest District. The road data from FTEN and DRA was amalgamated to create a single road network layer. The resulting road network was visually verified with 2012 Landsat imagery; this process added 325 km of mostly in-block roads. Area, road length, and road density were generated by the GIS System Manifold.

5.1.2 Results

The results of the road density indicator are reported out by analysis units including the Morice watershed, eighteen Morice sub-watersheds, the Morice Watershed Management Area, and the ten Wet'suwet'en House Territories.

5.1.2.1 Morice Watershed Road Density

The Morice watershed has a total road length of 2,019.52 km, resulting in a road density of 0.46 km/km^2 as shown in Table 1 and Figure 14 below.

Table 1. Road Density within Morice Watershed

Area (km^2)	Road Length (km)	Road Density (km/km^2)
4,379.62	2,019.52	0.46

[9] U.S. Fish and Wildlife Service (USFWS). 1999. Endangered and Threatened Wildlife and Plants; Determination of Threatened Status for Bull Trout in the Coterminous United States; Final Rule. Federal Register 64:58909-58933.
[10] ESSA Technologies. Porter et al. 2013. Morice Lake sockeye Conservation Unit: Habitat report cards.

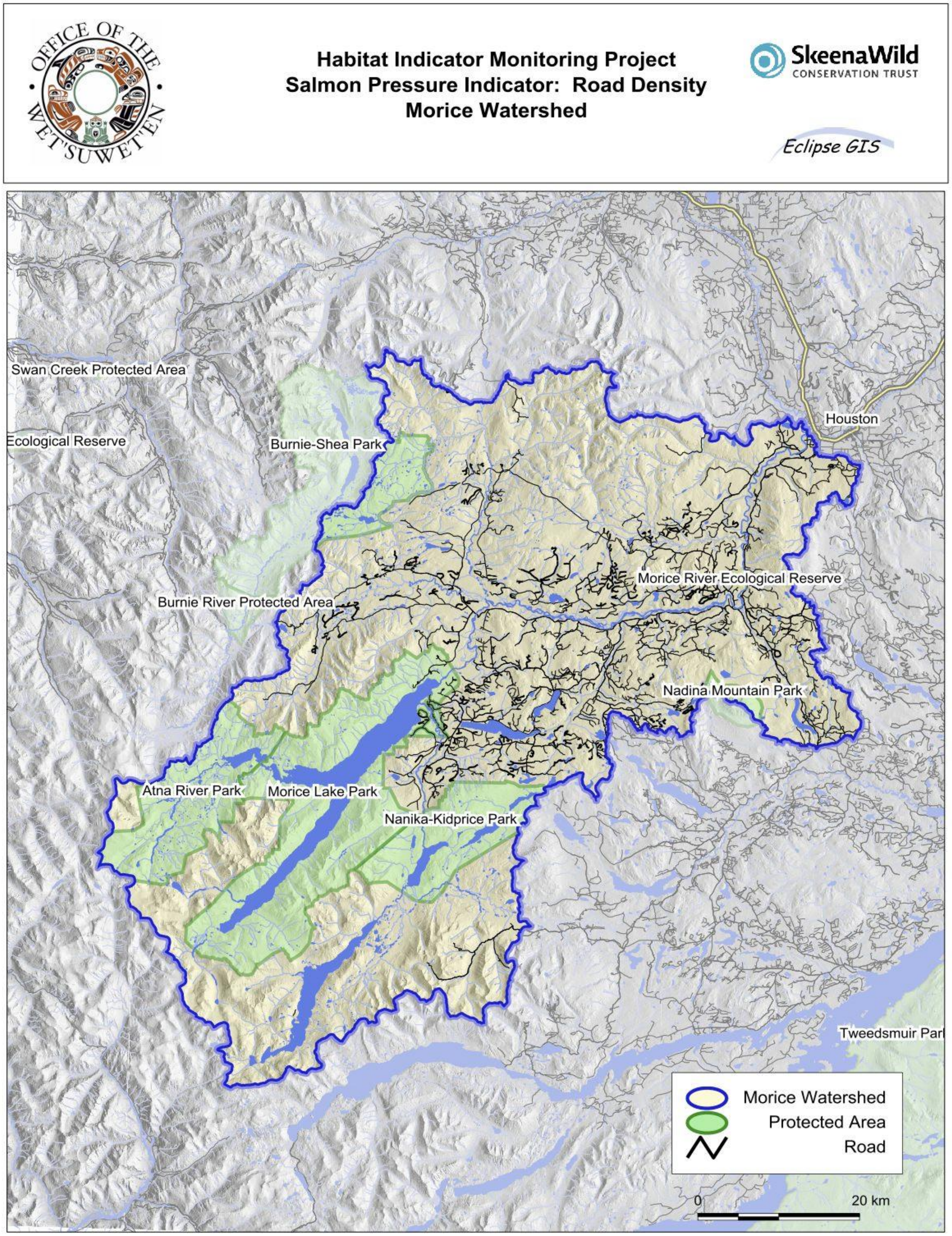


Figure 14. Road Density within the Morice Watershed.

5.1.2.2 Morice Watershed Management Area Road Density

The Morice Watershed Management Area contains 730.46 km of roads, with a road density of 0.21 km/km^2 as shown in Table 2 and Figure 15.

Table 2. Road Density within Morice Watershed Management Area.

Area (km^2)	Road Length (km)	Density (km/km^2)
3,403.51	730.46	0.21

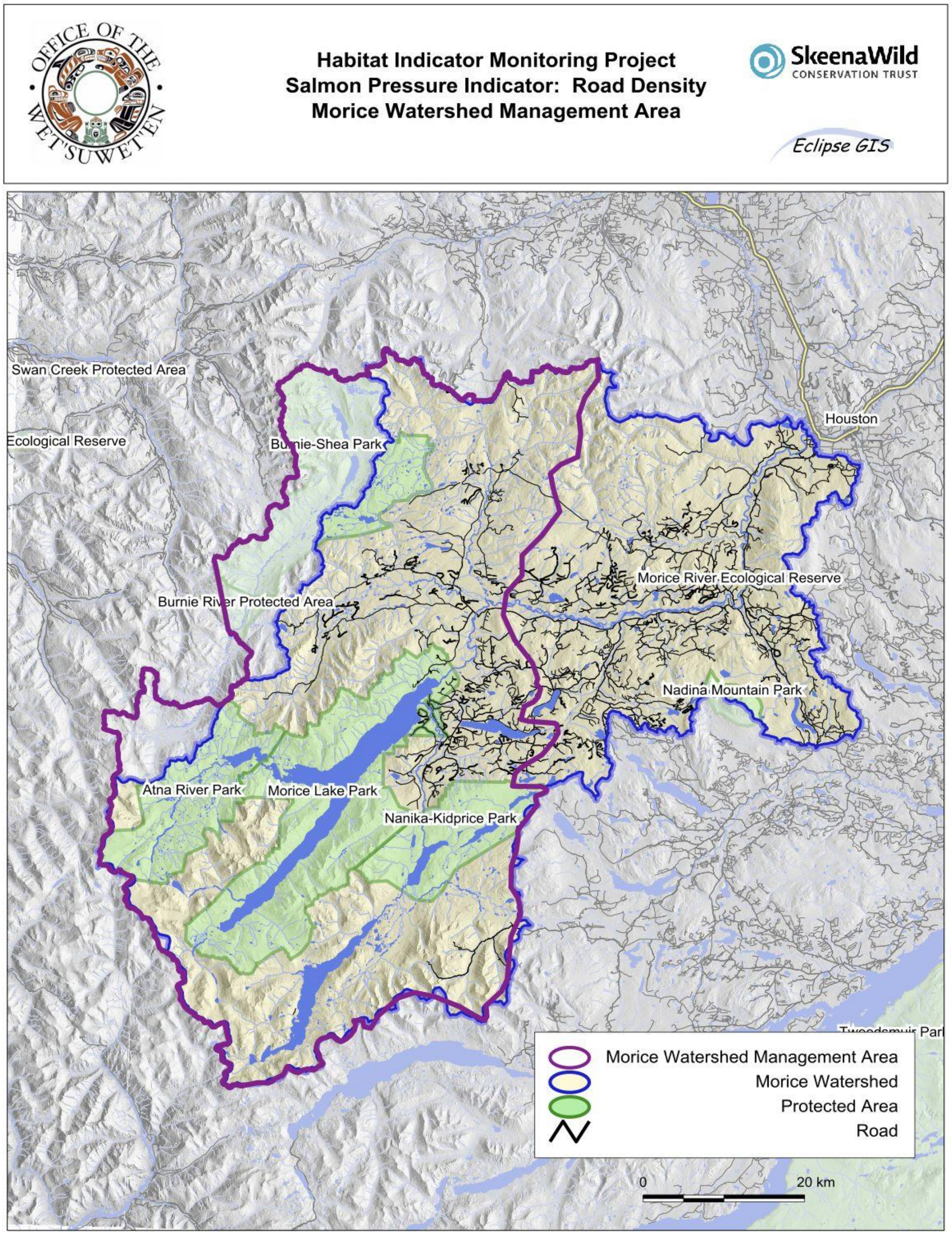


Figure 15. Road Density within Morice Watershed Management Area.

5.1.2.3 Wet'suwet'en House Territories Road Density

The ten Wet'suwet'en House Territories within the Morice watershed contain 3,160.25 km of roads with a road density of 0.54 km/km^2. The road density values across the House Territories ranges from 0.03 km/km^2 in Talhdzi Wiyez Bin to a value of 1.70 km/km^2 in Nelgi Cek as shown in Table 3 and Figures 16 and 17.

Table 3. Road Density within Wet'suwet'en House Territories

House Territory	Area (km^2)	Road Length (km)	Density (km/km^2)
Talhdzi Wiyez Bin	494.78	12.50	0.03
C'iniggit Nenikekh	1,293.94	36.50	0.03
Nelgi'l'at	387.11	55.02	0.14
Bikh C'idilyiz Ts'anli	142.48	40.42	0.28
Talbits Kwah	710.28	456.10	0.64
Lhudis Bin	989.37	755.17	0.76
C'idi To Stan	505.42	413.13	0.82
Bi Wini	883.29	767.93	0.87
Ts'in K'oz'ay	280.41	258.33	0.92
Nelgi Cek	214.98	365.13	1.70
Total	5,902.06	3,160.25	
Average Density			0.54

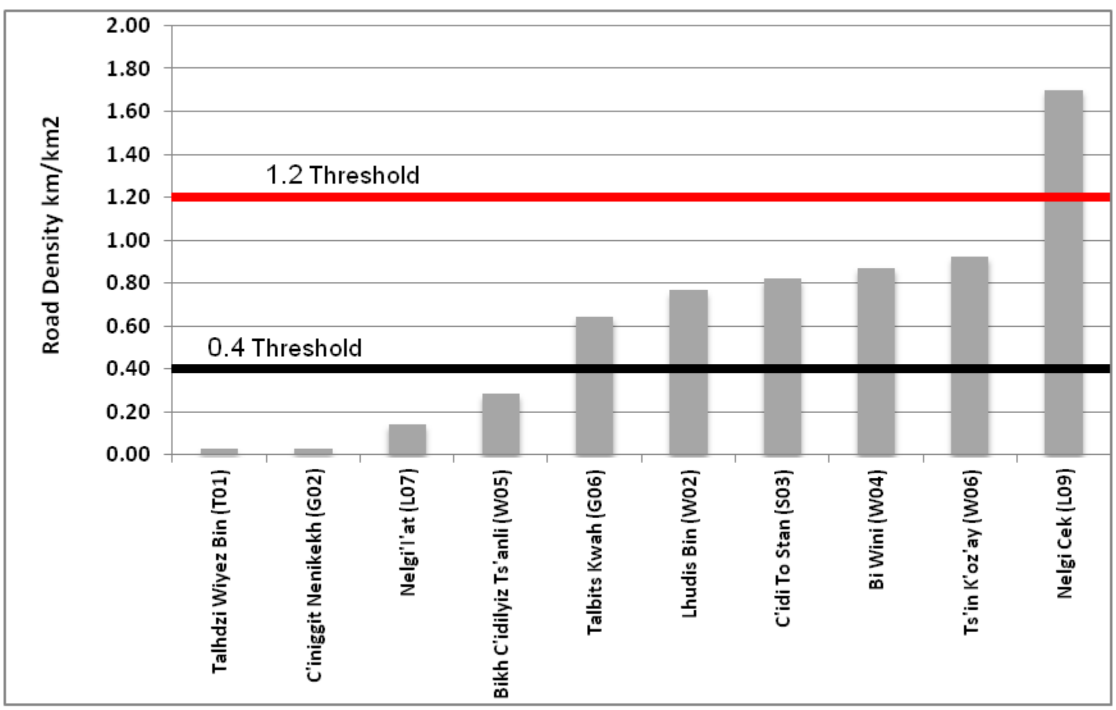


Figure 16. Road Density with Thresholds within Wet'suwet'en House Territories.

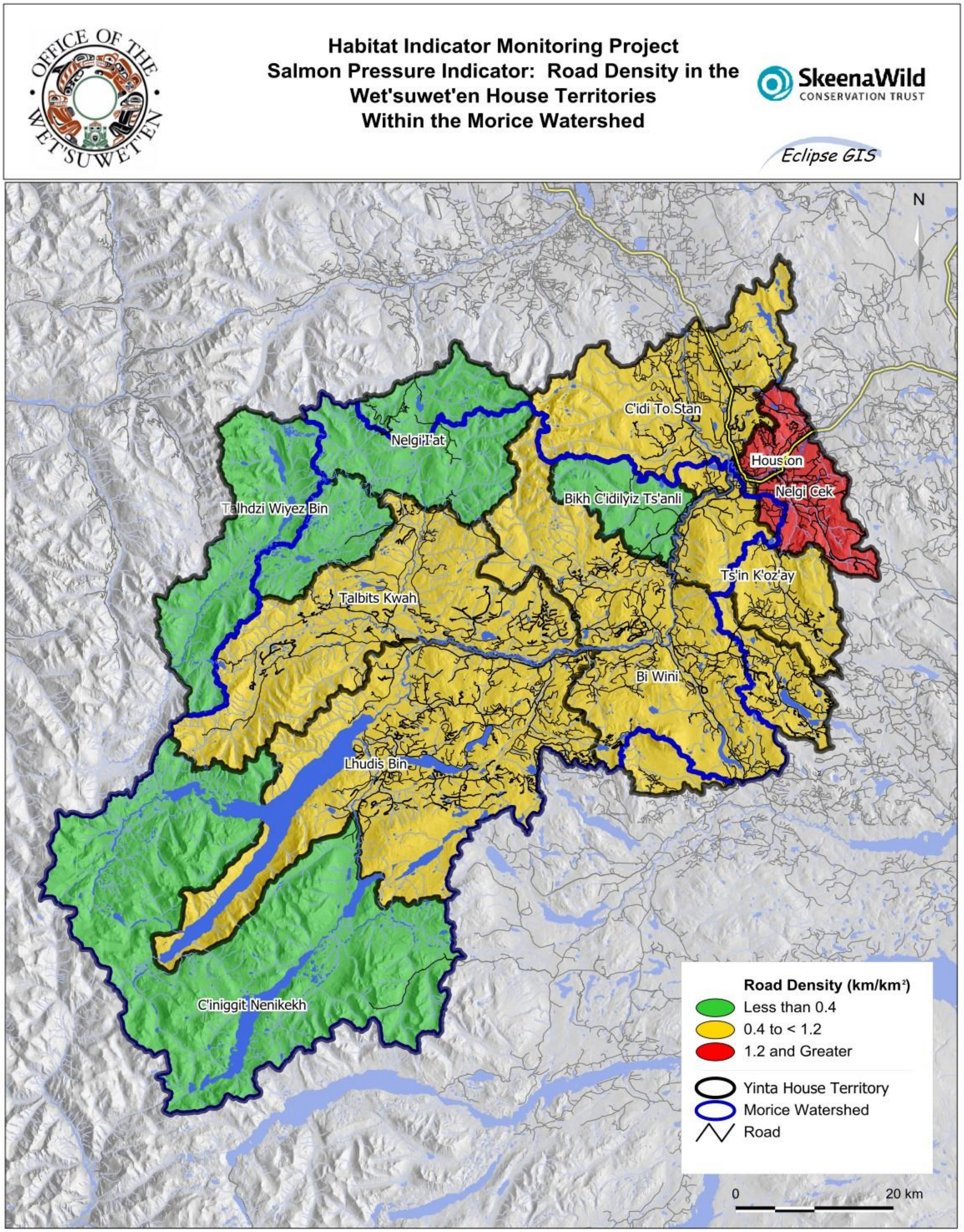


Figure 17. Road Density with Thresholds within Wet'suwet'en House Territories.

5.1.2.4 Morice Sub-watersheds Road Density

The road density within the eighteen Morice sub-watersheds is 0.46 km/km^2. The road density ranges from 0.0 km/km^2 in the Atna sub-watershed to 1.59 km/km^2 in the McBride sub-watershed as shown in Table 4 and Figures 18 and 19.

Table 4. Morice Sub-watersheds Road Density

Sub-watershed Unit	Area (km^2)	Road Length (km)	Road Density (km/km^2)
Crystal	62.45	15.4	0.25
Shea	194.98	43.8	0.22
Gosnell	279.45	115.3	0.41
Subtotals/Average	536.88	174.6	0.33
Atna	283.95	0.0	0.00
Houston Tommy	248.24	127.4	0.51
Lamprey	240.26	304.4	1.27
McBride	115.04	182.6	1.59
Nanika	889.67	125.2	0.14
Owen	212.37	196.9	0.93
Thautil	422.97	127.6	0.30
Morice	599.57	13.8	0.02
MR R1 East	71.72	80.5	1.12
MR R1 West	41.04	25.9	0.63
MR R2 North	206.19	262.4	1.27
MR R2 SE	101.57	117.3	1.15
MR R2 SW	61.64	60.8	0.99
MR R3 East	165.85	136.0	0.82
MR R3 West	182.00	80.2	0.44
Subtotals/Average	829.94	763.05	0.92
Total	4,378.93	2,015.64	
Average Density			0.46

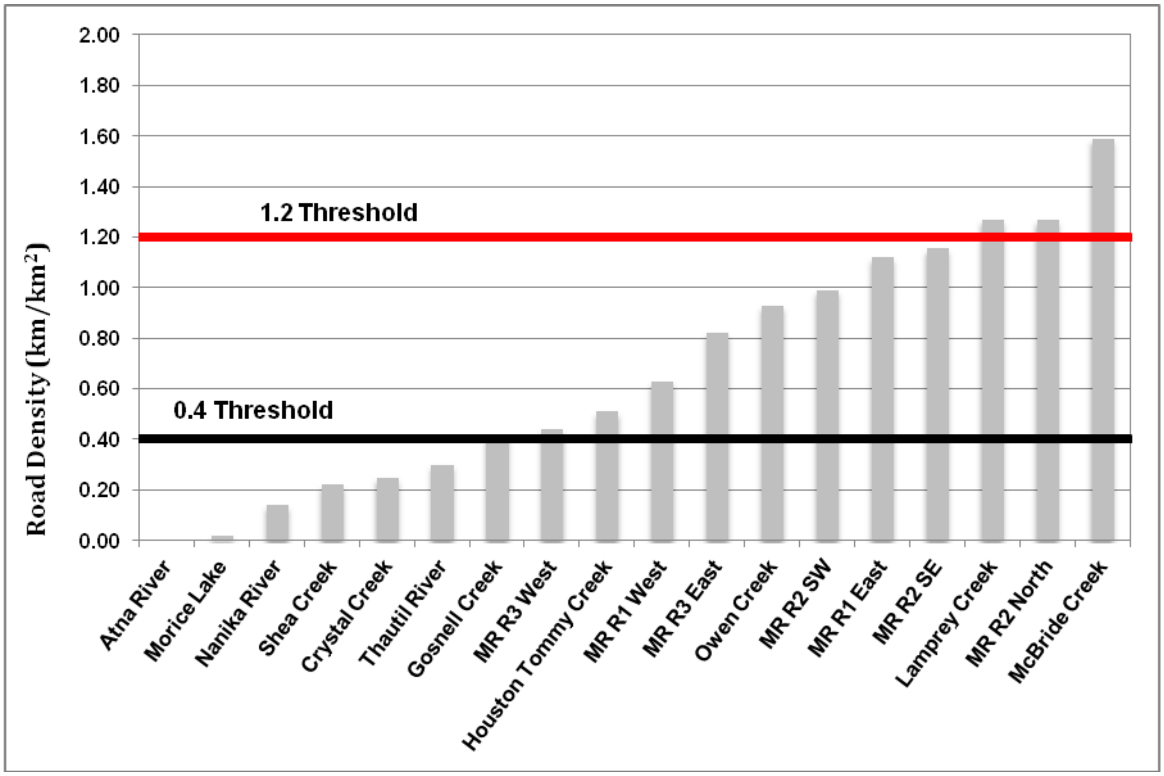


Figure 18. Road Density with thresholds in the Morice Sub-watersheds.

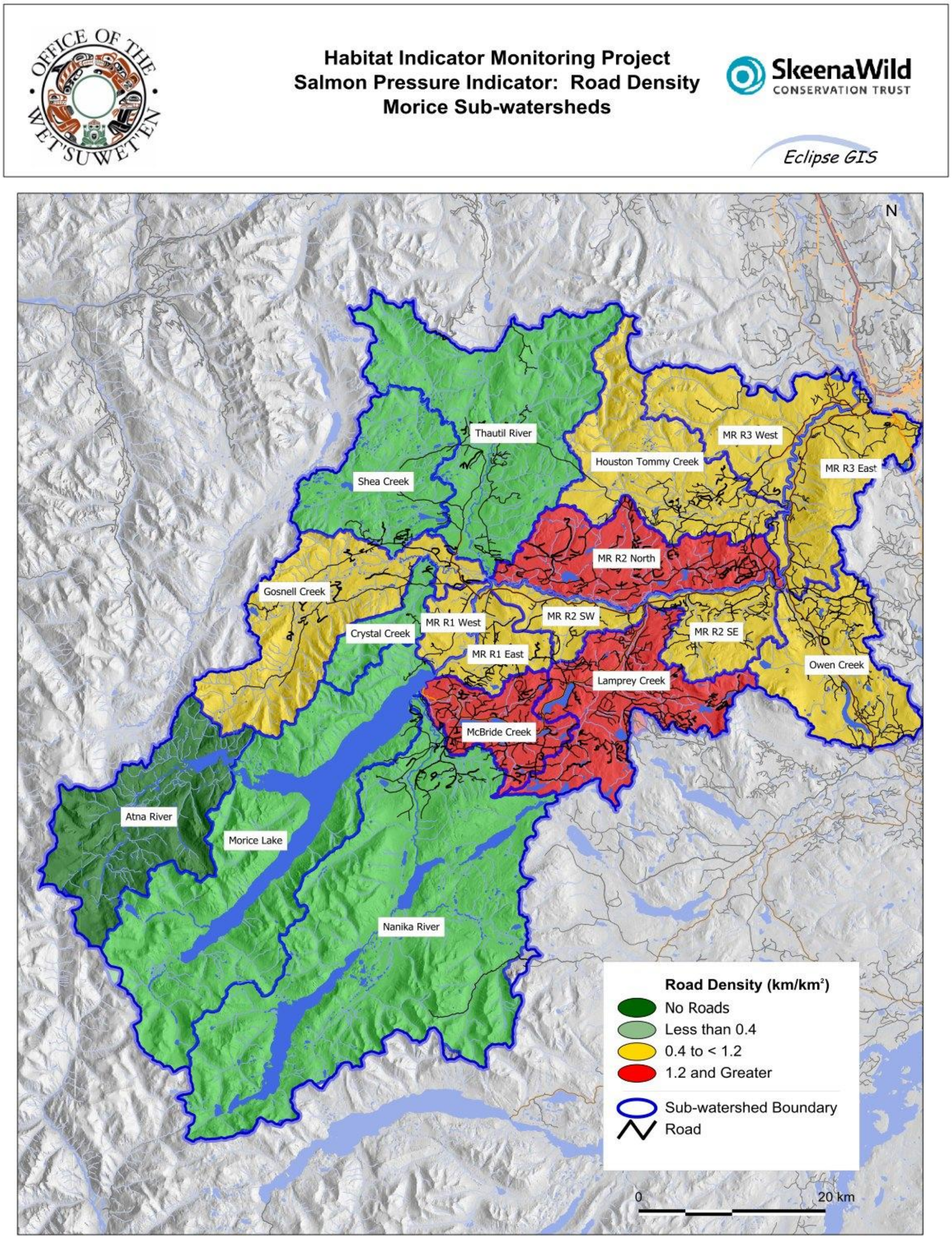


Figure 19. Road Density with Thresholds within the Morice Sub-watersheds.

5.1.3 Morice Watershed Road Density Impacts

The watershed is overlaid with 2019.5 km of roads. The results of the road density indicator reported out above show moderate risk at the watershed-level; this is phenomenal given that approximately 50% of the watershed has not been developed. Road density is ranked as a high value indicator in relation to salmon habitat degradation and declines in salmon populations and abundance.

Results at the sub-basin level as shown in Figure 19 indicate:

- Atna River is the only sub-basin unroaded;
- Morice Lake, Nanika River, Shea Creek, Crystal Creek, and Thautil River have less than 0.4 km/km^2 road density; however, it is important to note that road development is concentrated in small areas relative to the sub-basin scale;
- McBride Creek, Lamprey Creek, and Morice Reach 2 North sub-basins are densely roaded and highly impacted;
- Nine sub-basins including Gosnell Creek, Houston Tommy Creek, and the nine Morice River face units are overlaid with high road densities and are significantly impacted;

From the Wet'suwet'en House Territory perspective, the majority of Morice territories are overlaid with high road densities and are significantly impacted. Nelgi Cek territory located in the lower portion of Morice watershed includes a variety of road development other than forestry. The territory is highly impacted. The majority of roads are located in valley bottoms, which in the Morice generally support low-gradient, fish-bearing streams with a variety of high value habitat types that shape aquatic and riparian ecosystems.

Roads alter or modify soil density, temperature, water content, light levels, dust, surface waters, patterns of runoff, erosion and sedimentation, as well as adding heavy metals and nutrients to roadside environments that accumulate and reduce water quality. Increased road-derived fine sediments in stream gravel have been linked to decreased fry emergence, decreased juvenile densities, loss of winter carrying capacity, increased predation of fishes, and reduced benthic organism populations and algal production.

Roads often sever connections between streams and adjacent floodplain networks. Roads intercept groundwater flowpaths, in turn converting sub-surface flows to surface flows thereby increasing runoff. At high densities as seen in the majority of the Morice watershed, there is increased stream flows and increased sediment production resulting in altered water quality and quantity.

Analysis results indicate the majority of Morice watershed is considered at high risk in regard to road density due to industrial disturbance. It is recognized that various types of roads are deactivated and potentially do not contribute to adverse effects; but that is not always the case. Nevertheless, active and deactivated roads tend to affect fish habitat differently. Road density is correlated to stream crossing density, which is discussed in the following section.

5.2 Stream Crossing Density

Morice watershed contains more than a thousand streams crossed with closed bottom structures and hereafter noted as culverts. The number of stream crossings in the watershed is constantly increasing due to new road development. Stream crossings are considered to be the single most important habitat impact affecting fish. Other types of stream crossings in the Morice include bridges, box culverts (logs), fords, and corduroy. The number of stream crossings is related to the stream density and the road density.

The connectivity of diverse fish habitats for various fish life stages is fundamental to supporting fish abundance in Morice watershed's freshwater habitats. Tributary streams, lakes, offchannels, back channels, ponds, and sloughs all provide critical habitat. Ensuring that these components remain connected for the free migration of spawning adults and rearing juvenile fish is a critical component in maintaining healthy populations. The maintenance of healthy fish populations requires that streams crossed by roads and culverts, permits the free migration of spawning adult fish and rearing juveniles to upstream habitat.

The stream crossing density indicator is of interest to this high-level analysis, as it is closely related to the road density analysis presented above, as well as providing increased understanding of several correlated factors such as fish passage and habitat connectivity, sediment delivery, riparian connectivity, increased stream flows, and maintaining water quality.

Increased delivery of sediment to streams has long been recognized as one of the major environmental impacts of land development. Roads are often by far a greater source of sediment to watercourses than all other land-uses combined. Because sediment is delivered to the channel at the point that the road crosses the watercourse, there is interest and value in using stream crossing density of roads as a predictor of environmental impacts in Morice watershed.

Stream crossing density influences the efficiency of water delivery to the stream network through ditches. Higher densities can increase peak flows. It is important to note that culverts pass water very efficiently and thus increase flow rates at their outlets. During high water events, increased flows often scour the channel at the culvert outlet, thereby creating an outfall drop. During high water events, high streamflow through a culvert often produces a velocity barrier to fish passage.

Over the last two decades, stream crossing density indicator risk thresholds used in BC have been refined. Stream crossing density indicator risk thresholds used in this analysis are the same as those utilized by ESSA (2013) in their Morice sockeye conservation unit habitat status study. These thresholds are as follows in Table 5.

Table 5. Stream crossing density risk thresholds.

Threshold Category	Number of crossings/km^2
Low Risk	<0.20
Moderate Risk	>=0.20 to < 0.58
High Risk	>=0.58

5.2.1 Methodology

The following GIS spatial data was utilized in this analysis:

- Salmon presence and spawning data produced by SkeenaWild 2010-2012;
- Road Stream Crossings (BC Environment Culvert Assessment Project;
- Digital Road Atlas (DRA);
- Forest Tenure Roads (FTEN roads);
- Freshwater Atlas Streams (1:20,000);
- Freshwater Atlas Lakes (1:20,000);
- Modified Freshwater Atlas Assessment Watersheds;

- Wet'suwet'en House Territory boundaries;
- Morice Watershed Management Area boundary.

The road stream crossing data is derived from the BC Environment Culvert Assessment Project[11]. The potential number of streams crossed by culverts were calculated, and cross-referenced with a fish habitat model to assign fish habitat classes to the stream crossings. Fish habitat classes are represented as fish presence – either observed or inferred. The fish habitat model used to assess the stream crossing data is the same model used to calculate the Total Accessible Stream Length indicator.

Crossings that were determined unlikely to bear fish were removed. Only culverted fish stream crossings are included in this analysis. The stream crossing data does not include any culvert information collected by industry. The spatial overlay tool in Manifold GIS was used to assign analysis units to stream crossings. The resultant table was exported to excel where a pivot table was generated to summarize results.

5.2.2 Results

The results of the stream crossing density indicator is reported out by analysis units including the Morice watershed, the eighteen Morice sub-basins, the Morice Watershed Management Area, and the ten Wet'suwet'en House Territories.

5.2.2.1 Morice Watershed

The Morice watershed contains a potential 1,043 stream crossings as shown in Table 6 and Figure 20. 12.5% (130) of these crossings have confirmed fish presence and 87.5% (913) are designated with inferred fish presence. Within the Morice Watershed, nine salmon bearing streams are crossed with culverts as shown in Figure 21. The total stream crossing density is 0.24/km^2.

Table 6. Culverted stream crossing density in Morice watershed

Number of Stream Crossed by Culverts – Morice Watershed				
Area (km^2)	Fish Presence Observed	Fish Presence Inferred	Fish Streams Crossed	Stream Crossing Density
4,379.62	**130.0**	**913.0**	**1,043.0**	**0.24**

[11] Hillcrest Geographics. 2009. Fish Passage GIS Analysis, Methodology and Output Data Specifications. BC Ministry of Environment.

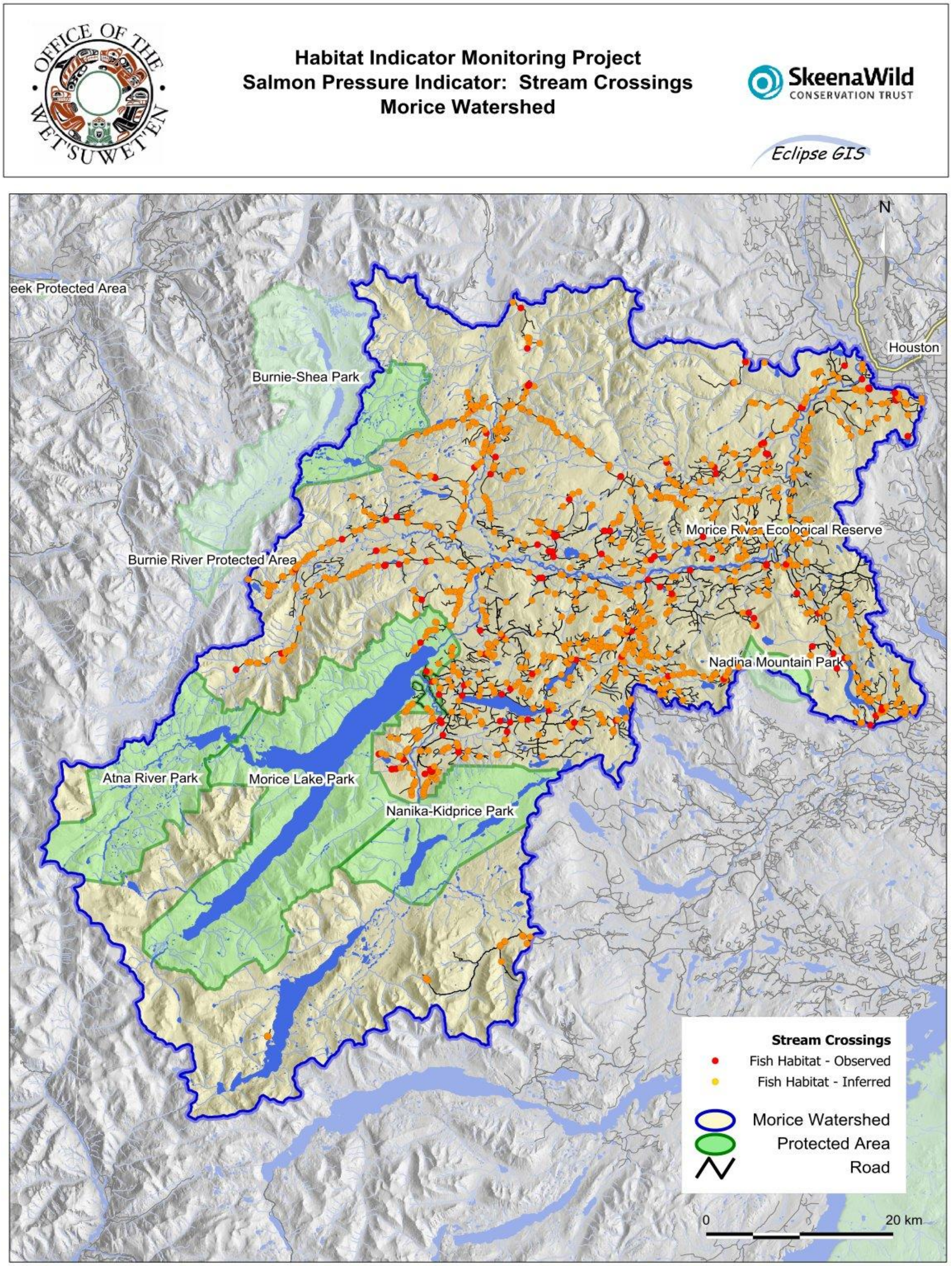


Figure 20. Culverted stream crossings in Morice watershed.

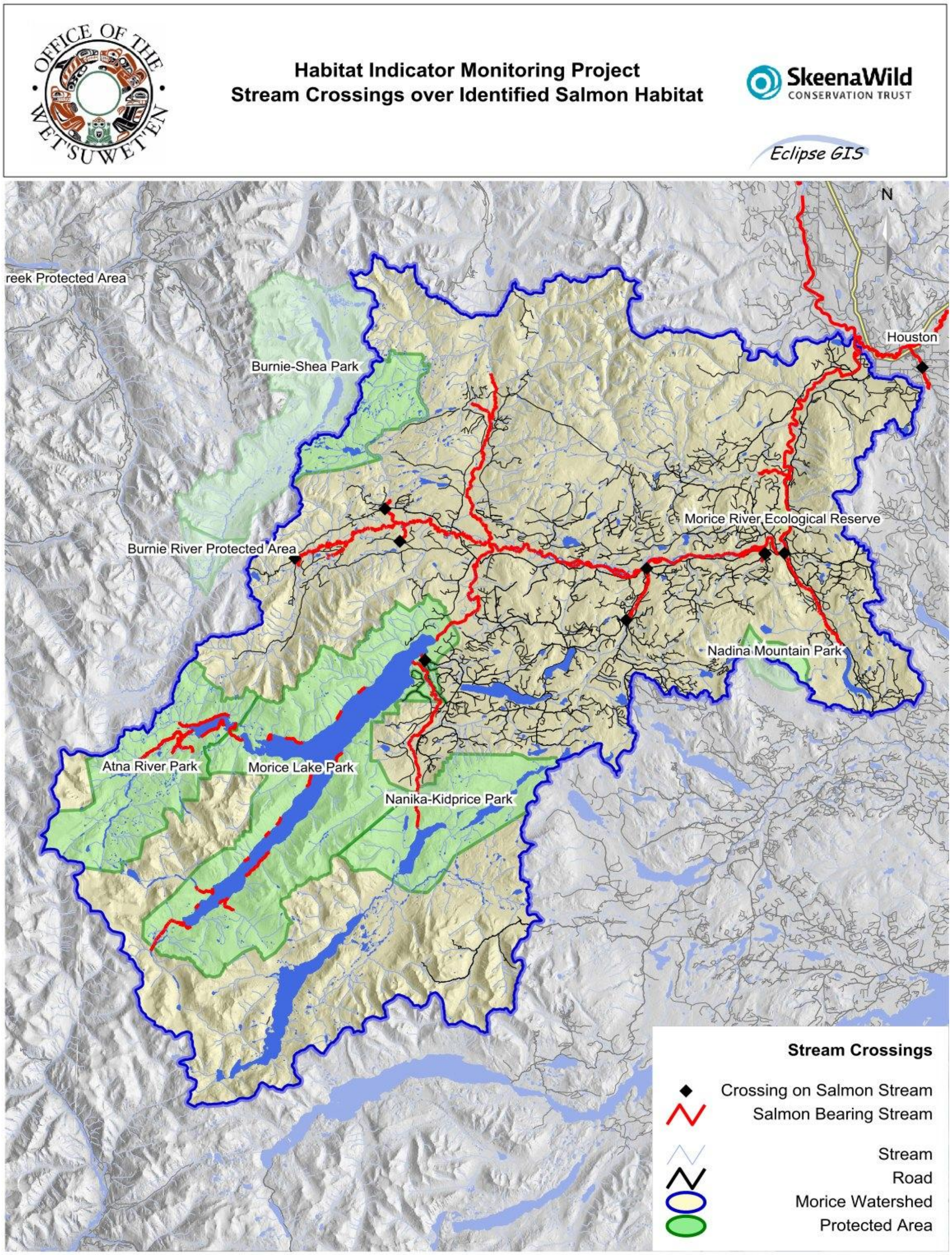


Figure 21. Salmon streams crossed by culverts in Morice watershed.

5.2.2.2 Morice Watershed Management Area

The Morice Watershed Management Area contains a potential 453 stream crossed by culverts as shown in Figure 22. 12.8 % or 58 of these culvert crossings have identified fish presence and 87.2% (395) are designated with inferred fish presence. The stream crossing density determined by the number of crossings/km^2 is 0.13/km^2.

Table 7. Stream Crossing Density in Morice Watershed Management Area

Number of Stream Crossed by Culverts – Morice Watershed Management Area				
Area (km^2)	Fish Presence Observed	Fish Presence Inferred	Fish Streams Crossed	Total Stream Crossing Density
3,403.51	**58.0**	**395.0**	**453.0**	**0.13**

The Morice Watershed Management Area contains three stream crossings directly over salmon bearing streams. These are located within the Gosnell and Shea sub-watersheds and are shown in Figure 21.

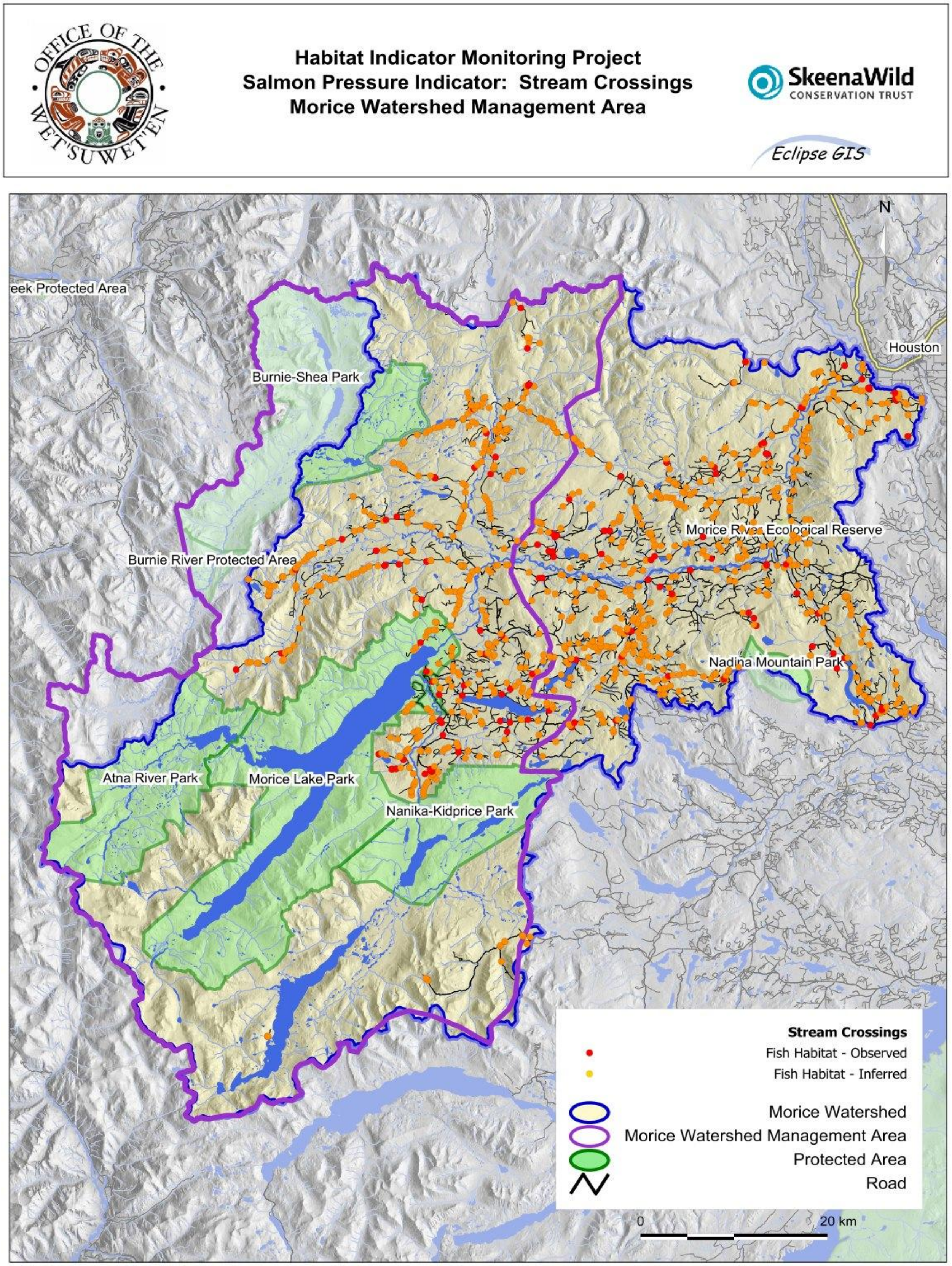


Figure 22. Streams crossed by culverts in Morice Watershed Management Area.

5.2.2.3 Wet'suwet'en House Territories within Morice Watershed

The ten Wet'suwet'en House Territories within the Morice watershed contain 1,587 potential stream crossed by culverts as shown in Table 8 and Figures 23 and 24. 13.7% (218) of these culverted stream crossings are situated in observed fish habitat and 86.3% (1,369) situated in inferred fish habitat. The stream crossing density for the House Territories ranges from 0.02/km^2 in the C'iniggit Nenikekh to 0.83/km^2 in the Nelgi Cek territory. The overall stream crossing density for the ten Wet'suwet'en Houses as determined by the number of crossings/km^2 is 0.31/km^2. Nine of the stream crossings are situated over salmon bearing streams.

Table 8. Culverted Stream Crossing Density in Wet'suwet'en House Territories within Morice Watershed

House Territory	Area (km^2)	Salmon Bearing Streams	Fish Presence Observed	Fish Presence Inferred	Fish Streams Crossed	Stream Crossing Density
Talhdzi Wiyez Bin	494.78		0	16	16	0.03
C'iniggit Nenikekh	1,293.94		0	24	24	0.02
Nelgi'I'at	387.11		24	5	29	0.07
Bikh C'idilyiz Ts'anli	142.48		8	24	32	0.22
Talbits Kwah	710.28	3	37	226	263	0.37
Lhudis Bin	989.37	2	48	355	403	0.41
C'idi To Stan	505.42		25	192	217	0.43
Bi Wini	883.29	3	46	264	310	0.35
Ts'in K'oz'ay	280.41		17	97	114	0.41
Nelgi Cek	214.98	1	13	166	179	0.83
Total	5,902.06	9	218	1369	1587	
Average Stream Crossing Density						0.31

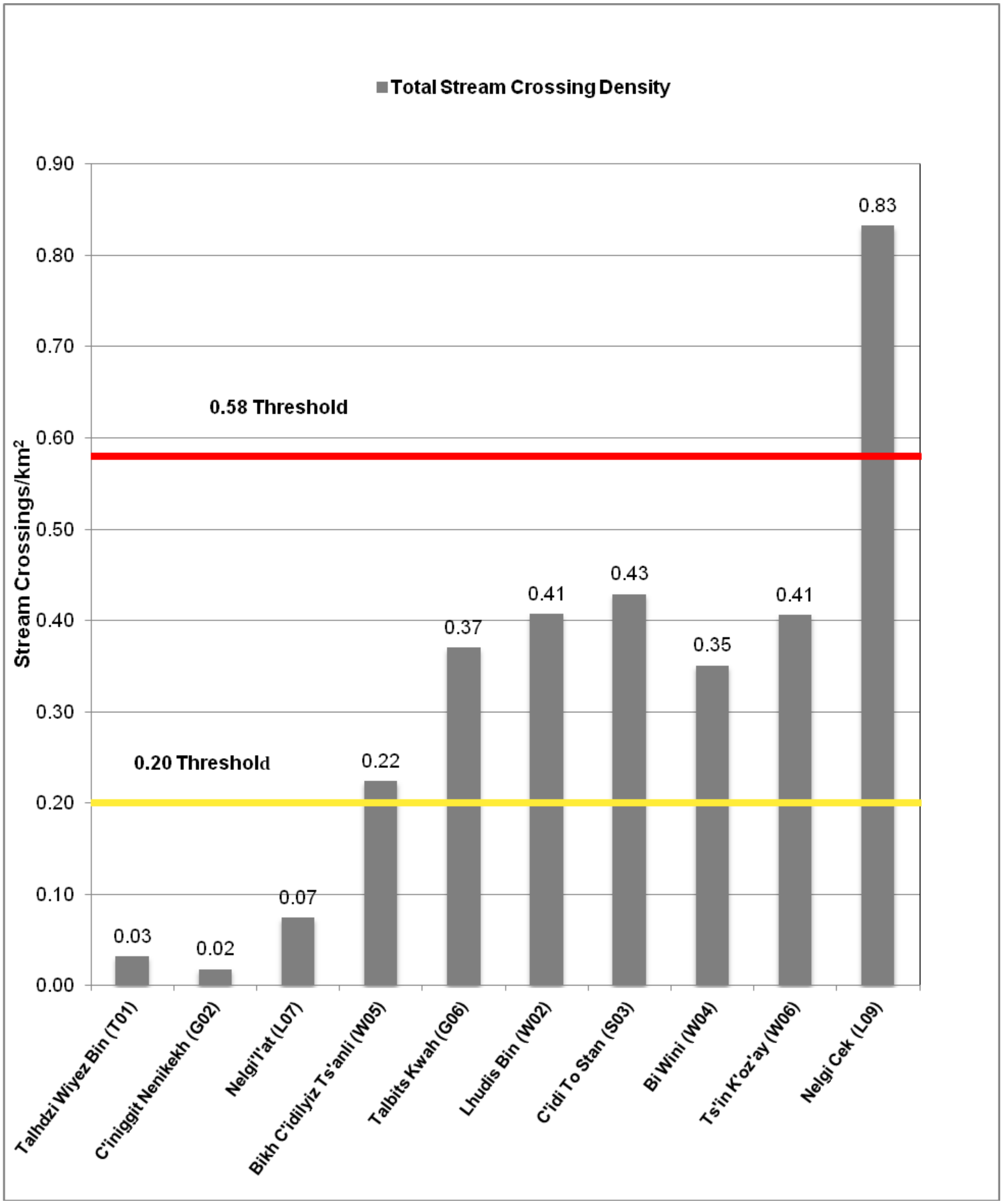


Figure 23. Stream Crossing Density in Wet'suwet'en House Territories within Morice Watershed with interim Thresholds.

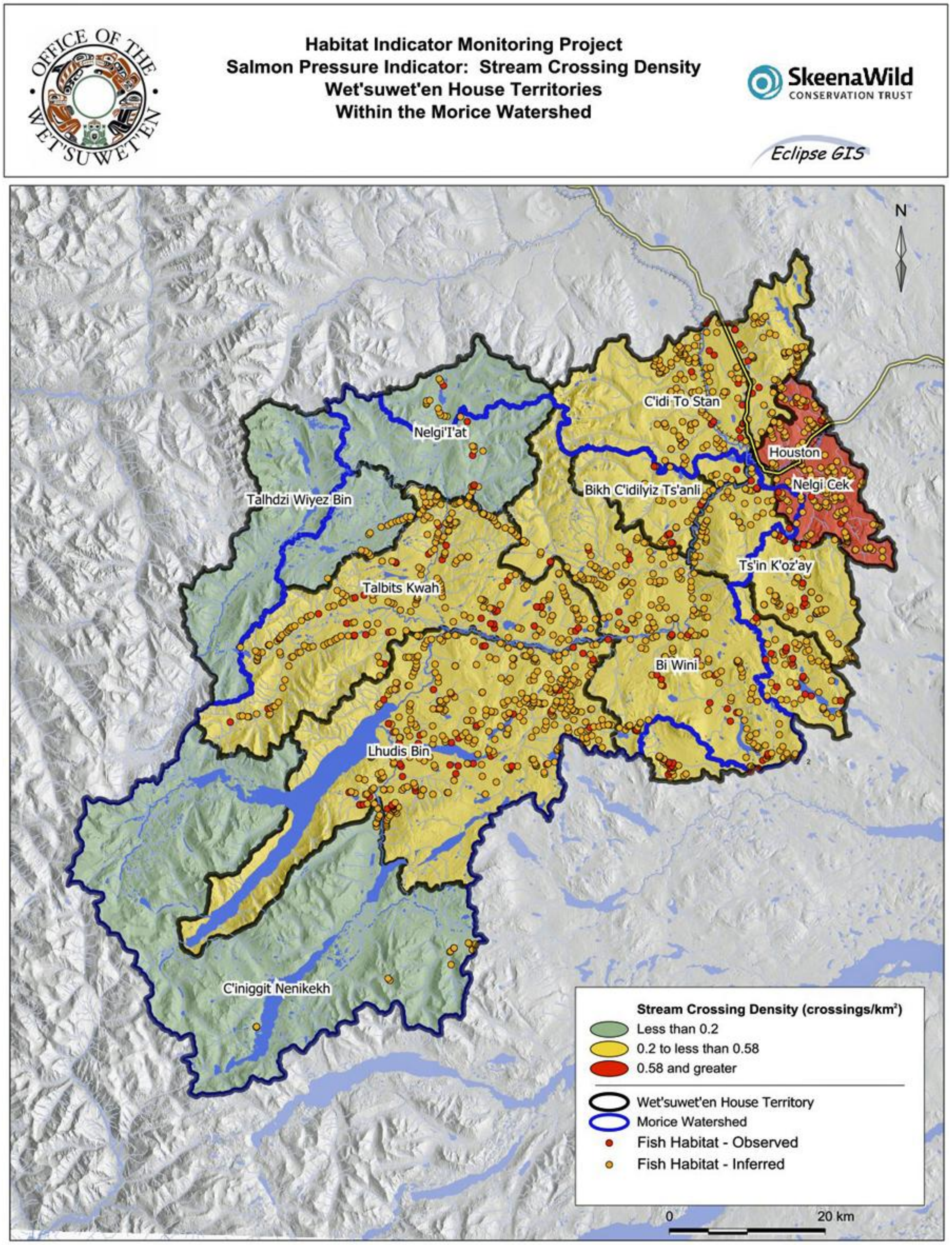


Figure 24. Wet'suwet'en Territories Culverted Stream Crossings and Density.

5.2.2.4 Morice Sub-watersheds

The eighteen sub-watersheds within the Morice watershed contain a total of 1,040 potential stream crossings as shown in Table 9 and Figures 25 and 26. 12.5% (129) of these culverted stream crossings are located in observed fish habitat and 87.6% (911) situated over inferred fish habitat. The stream crossing density is determined by the number of crossings/km$^{2.}$ The stream crossing densities for the sub-watersheds range from 0.0/km^2 in the Atna River sub-watershed to 0.76/km^2 in the Morice River Reach 1 West sub-watershed. The aggregate stream crossing density for the Gosnell sub-watershed is 0.22 crossings/ km^2.

Table 9. Culverted Stream Crossing and Density in Morice sub-watersheds.

Sub-watershed Unit	Area (km^2)	Salmon Bearing Streams	Fish Presence Observed	Fish Presence Inferred	Total Stream Crossings	Stream Crossing Density
Crystal Creek	62.5		2	5	7	0.11
Shea Creek	195	1	4	24	28	0.14
Gosnell Creek	279.4	2	10	71	81	0.29
Gosnell Subtotal	536.9	3	16	100	116	0.22
Lamprey Creek	240.3	2	13	166	179	0.75
Atna River	283.9		0	0	0	0.00
McBride Creek	115		13	51	64	0.56
Nanika River	889.7		16	71	87	0.1
Owen Creek	212.4	1	10	58	68	0.32
Thautil River	423		9	103	112	0.26
Morice Lake	599.6		1	9	10	0.02
Houston Tommy Creek	248.2	0	4	58	62	0.25
MR R1 East	71.7		3	26	29	0.4
MR R1 West	41		0	31	31	0.76
MR R2 North	206.2		18	76	94	0.46
MR R2 SE	101.6	2	6	20	26	0.26
MR R2 SW	61.6		2	35	37	0.6
MR R3 East	165.8		9	70	79	0.48
MR R3 West	181.9		9	37	46	0.25
Subtotal	829.9	5	47	295	342	0.41
Total	4,378.90	8	129	911	1,040.00	
Average Stream Crossing Density						0.24

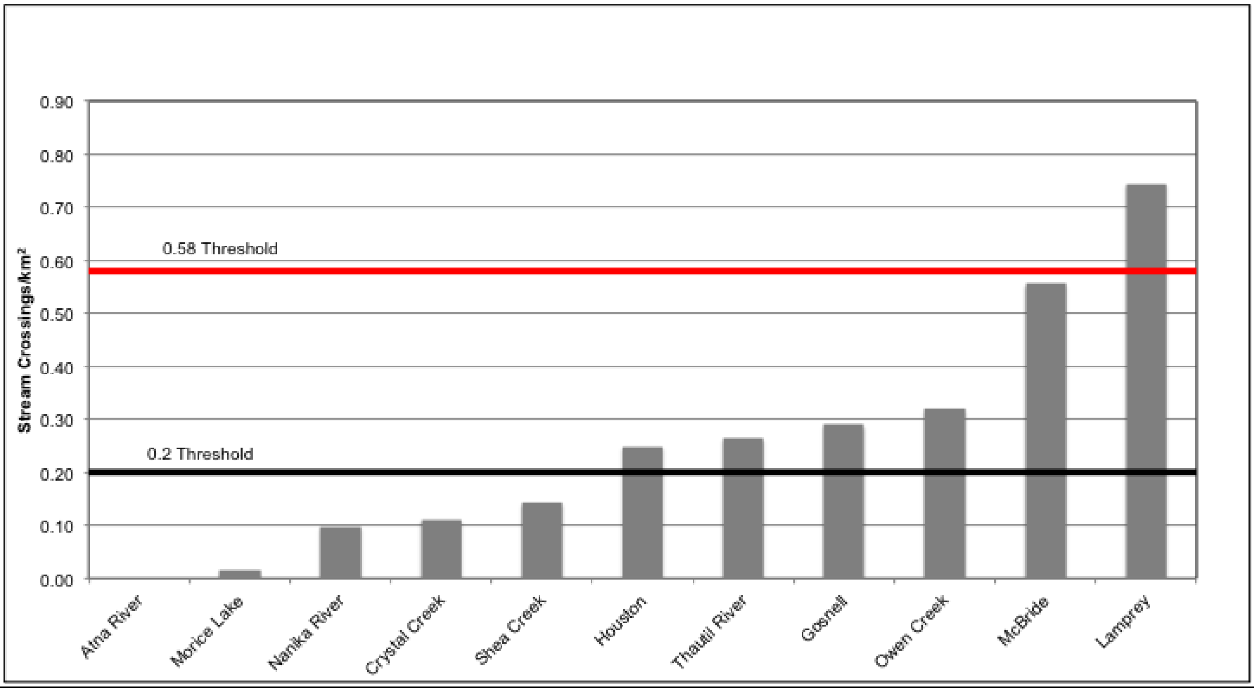


Figure 25. Culverted Stream Crossing Density within Morice Sub-watersheds.

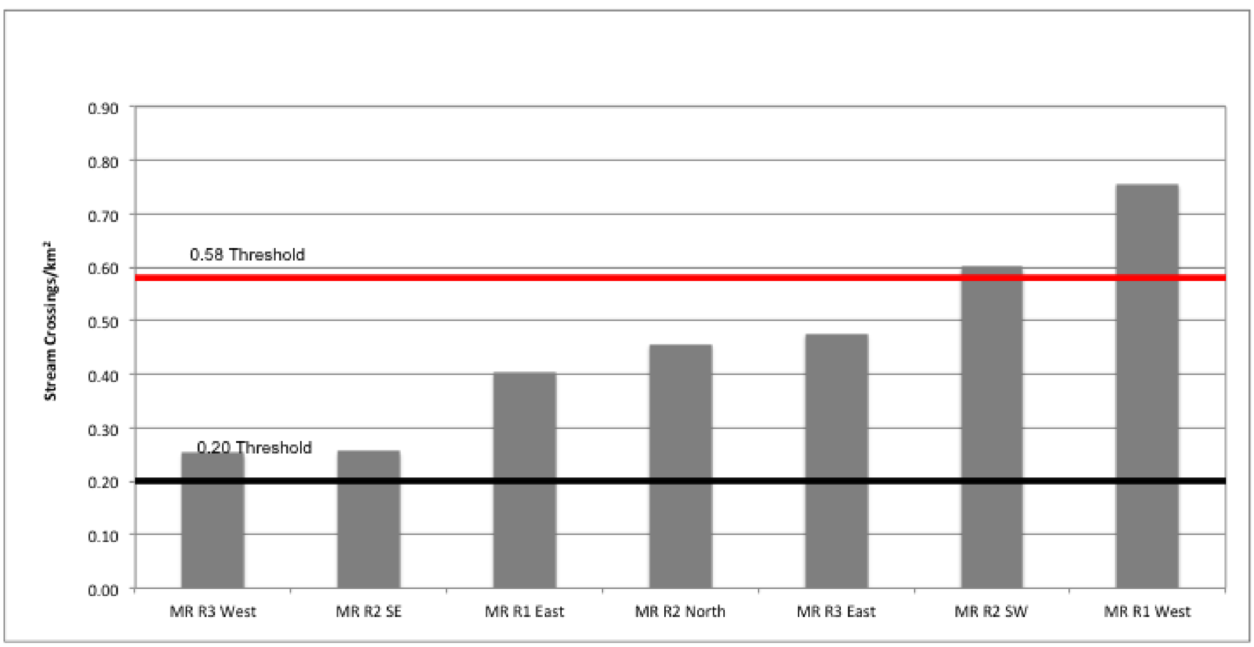


Figure 26. Culverted Stream Crossing Density within Morice River Face Units.

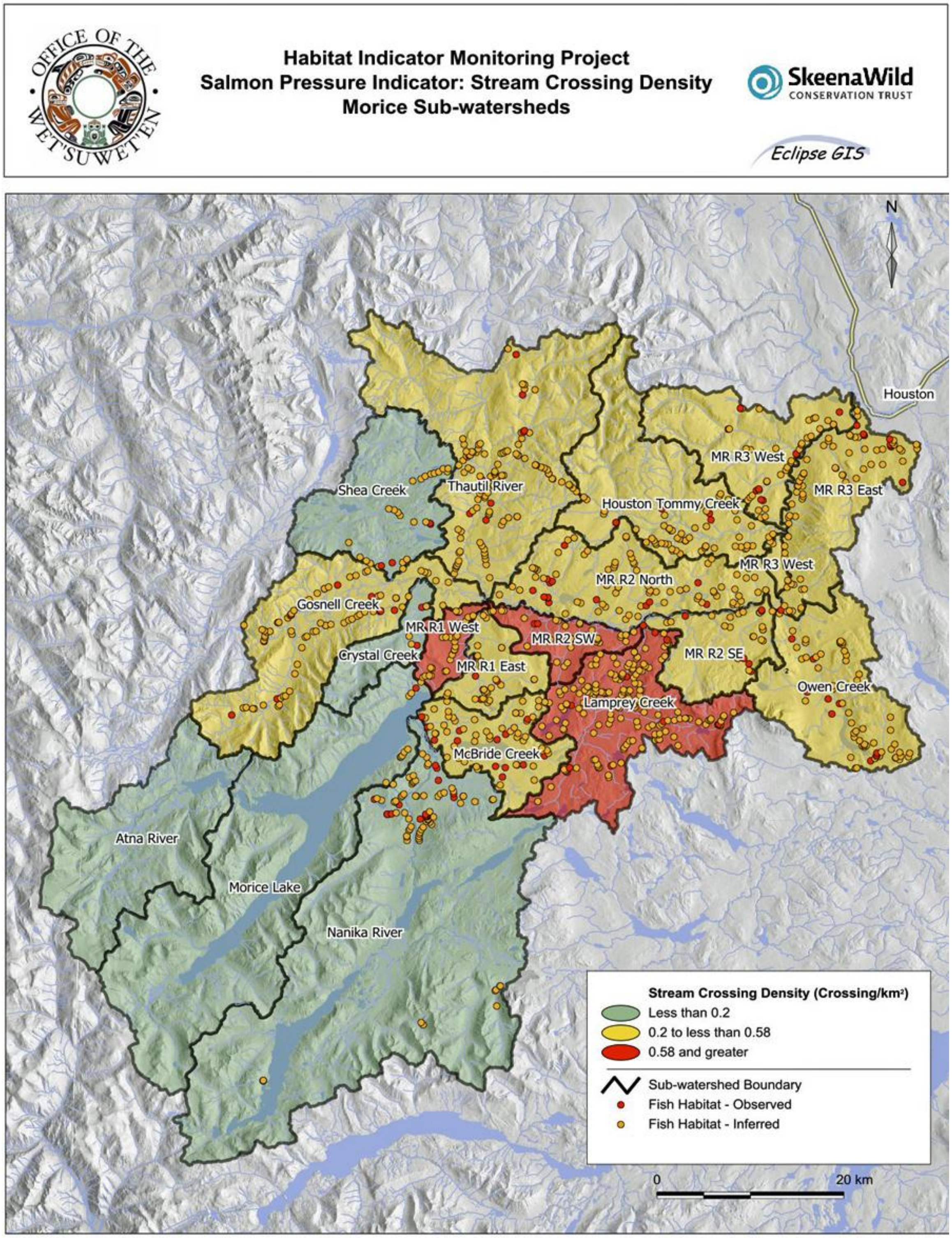


Figure 27. Culverted Stream Crossings and Density within Morice River Sub-watersheds.

5.2.3 Morice Watershed Culverted Stream Crossing Density Impacts

The watershed is overlaid with 2,110 km of roads that cross more than a thousand streams. The results of the culverted stream crossing density indicate moderate risk at the watershed-level. Similar to the road density impacts, this is phenomenal given that approximately 50% of the watershed has not been developed.

Results at the sub-basin level as shown in Figure 27 indicate:

- Atna River, Morice Lake, Crystal Creek, Shea Creek, and Nanika River are the only sub-basins in the low risk category; however, Crystal, Shea, and Gosnell sub-basins combined as the aggregate Gosnell drainage are characterized as moderate risk;
- Morice Water Management Area stream crossing density is considered low risk;
- Of the 18 Morice sub-watersheds, twelve sub-basins are considered moderate risk with McBride Creek sub-basin at the top end of the moderate risk category;
- Lamprey Creek, Morice Reach 1 West, and Morice Reach 2 Southwest sub-basins are rated high risk and highly impacted;

From the Wet'suwet'en House Territory perspective, the majority of the territories are overlaid with moderate risk stream crossing densities and are considered moderately impacted. Nelgi Cek territory located in the lower portion of Morice watershed includes a variety of road development other than forestry and is rated as high risk regarding stream crossing density, and thus highly impacted. The three territories – Talhdzi Wiyez Bin (Burnie), C'iniggit Nenikekh (Nanika & Atna), and Nelgi'I'at (upper Thautil) have very low level of stream crossing activity and are considered low risk.

Stream crossing density is ranked as a high value indicator in relation to salmon habitat degradation and declines in salmon populations and abundance. Stream crossed by road culverts, principally represent risk of local sediment and intercepted flow delivery, as well as potential physical impediments to fish movements. In general the greater the density of stream crossings on forest land, the greater the risk to fish and their habitats.

Analysis results indicate the developed portion of Morice watershed is considered at moderate or high risk in regard to stream crossing due to industrial disturbance. It is recognized that various types of crossings are deactivated and potentially do not contribute to adverse effects; however, these crossings require field verification.

A high-level understanding of the current stream crossing density in Morice watershed is important to informing aquatic conservation and restoration planning decisions. As well, planning and assessment activities will benefit from this stream crossing density analysis. An understanding of the stream crossing network assists in identifying the aquatic condition in Morice watershed and helps to identify areas of poor habitat quality where long-term investment needs to be applied.

5.3 Morice Fish Habitat & Presence

Two key indicators – key salmon habitat and resident and anadromous fish presence – provide a fundamental understanding of where and how much fish habitat is utilized in the Morice watershed. Salmon habitat is measured in stream length. Resident and anadromous fish presence is measured in fish accessible stream length. The key salmon habitat layer is a subset of the resident and anadromous fish presence layer that has been enhanced with local expert knowledge. The rationale behind two fish habitat quantity indicators is to modify and to align with the accessible stream length and key spawning area indicators utilized by the federal Wild Salmon Policy.

From a Wet'suwet'en perspective, the two indicators complement each other when considering the inter-annual variability of Morice fish abundance and when considering the complexity of habitats including the frequent occurrence of wetland complexes, floodplains, beaver ponds, and off-channel areas that provide diverse and critical habitat function in Morice watershed. The composition of fish and invertebrate communities in Morice watershed aquatic environments is related to a combination of factors, including the suitability and sustainability of the habitat at broad or fine spatial scales, and adequate access to this fish habitat.

5.3.1 Methodology

Salmon habitat consists of streams, or portions thereof, where salmon presence has been observed and recorded by provincial, federal, and local fisheries professionals. The data distinguishes between stream reaches identified as spawning activity and reaches that have salmon presence such as juveniles, but not necessarily any spawning activity.

Salmon lakeshore spawning is presented separately from the salmon stream habitat and reported out for Morice Lake and Atna River sub-watersheds, where lakeshore spawning data is available. Fish accessible stream length (FASL) consists of streams, or portions thereof, where resident and anadromous fish presence has been observed, or is inferred based on gradient and fish passage. The analysis results are presented by FASL – observed fish presence and FASL – inferred fish presence.

In the resultant tables presented, the salmon habitat analysis results are reported out separately to highlight the proportion of the collected data that is specific to salmon. For graphing purposes (see Figures 25, 27, 29, and 31) the total key salmon habitat values have been rolled up within the FASL – Observed and Inferred categories. Of importance to note, thresholds have yet to be determined for these indicators.

The following GIS spatial data was utilized in this analysis:

- Salmon presence and spawning data produced by SkeenaWild 2010-2012;
- Fish Habitat Data (BC Environment Culvert Assessment Project);
- Freshwater Atlas Lakes (1:20,000);
- DFO Sockeye Conservation Units;
- Modified Freshwater Atlas Assessment Watersheds;
- Wet'suwet'en House Territory boundaries;
- Morice Watershed Management Area boundary.

The salmon data was edited to ensure it is coincident with the 1:20,000 Freshwater Atlas streams to allow a comparable representation of salmon habitat to accessible stream length. The Fish Habitat layer was queried by the field FISH_HAB_1 = FISH HABITAT – OBSERVED, FISH HABITAT – INFERRED, and empty, indicating no inferred fish habitat. The GIS System Manifold was used to generate area and stream length. The spatial overlay tool was used to assign analysis units to stream segments. The resultant table was exported to excel where a pivot table was generated to summarize results.

5.3.2 Results

The habitat quantity indicators analysis results are reported out by the Morice watershed, the eighteen Morice sub-watersheds, the Morice Watershed Management Area, and the ten Wet'suwet'en House Territories within, or partly within Morice watershed.

5.3.2.1 Morice Watershed Fish Presence

The total stream length within the Morice watershed is 8,315.1 km as shown in Table 10. Of that, 5,771.6 km or 69.4% is characterized as fish accessible stream length meaning fish have been observed and or are inferred. The accessible stream length consists of 15.2% (878.6 km) of observed and 84.7% (4,892.9 km) of inferred habitat.

Of the 878.6 km of observed accessible stream length, 296.57 km is key salmon habitat as shown in Table 11. This habitat consists of 231.3 km of observed spawning activity, and 65.2 km of streams with identified salmon presence. Within the Morice Watershed, Atna and Morice lakes shorelines have documented salmon spawning habitat on 28% and 30% respectively as shown in Table 12.

Table 10. Resident and Anadromous Fish Accessible Stream Length (FASL) in km.

Total Stream Length (km)	Observed Presence (km)	Observed as % of ASL	Inferred Presence (km)	Inferred as % of FASL	Fish Accessible Stream Length (km)	FASL as % of Stream Length
8315.15	878.61	15.22	4892.99	84.78	5771.60	69.41

Table 11. Observed Salmon Presence (km)

Spawning (km)	Presence (km)	Salmon Observed (km)	Total Salmon as % of Total ASL
231.35	65.22	296.57	5.14

Table 12. Morice and Atna Lakes Lakeshore Spawning (km)

Lakeshore	Total Shoreline (km)	Spawning (km)	Salmon Spawning as % of Shoreline Length
Morice Lake	96.33	29.58	30.71
Atna Lake	51.91	14.67	28.26

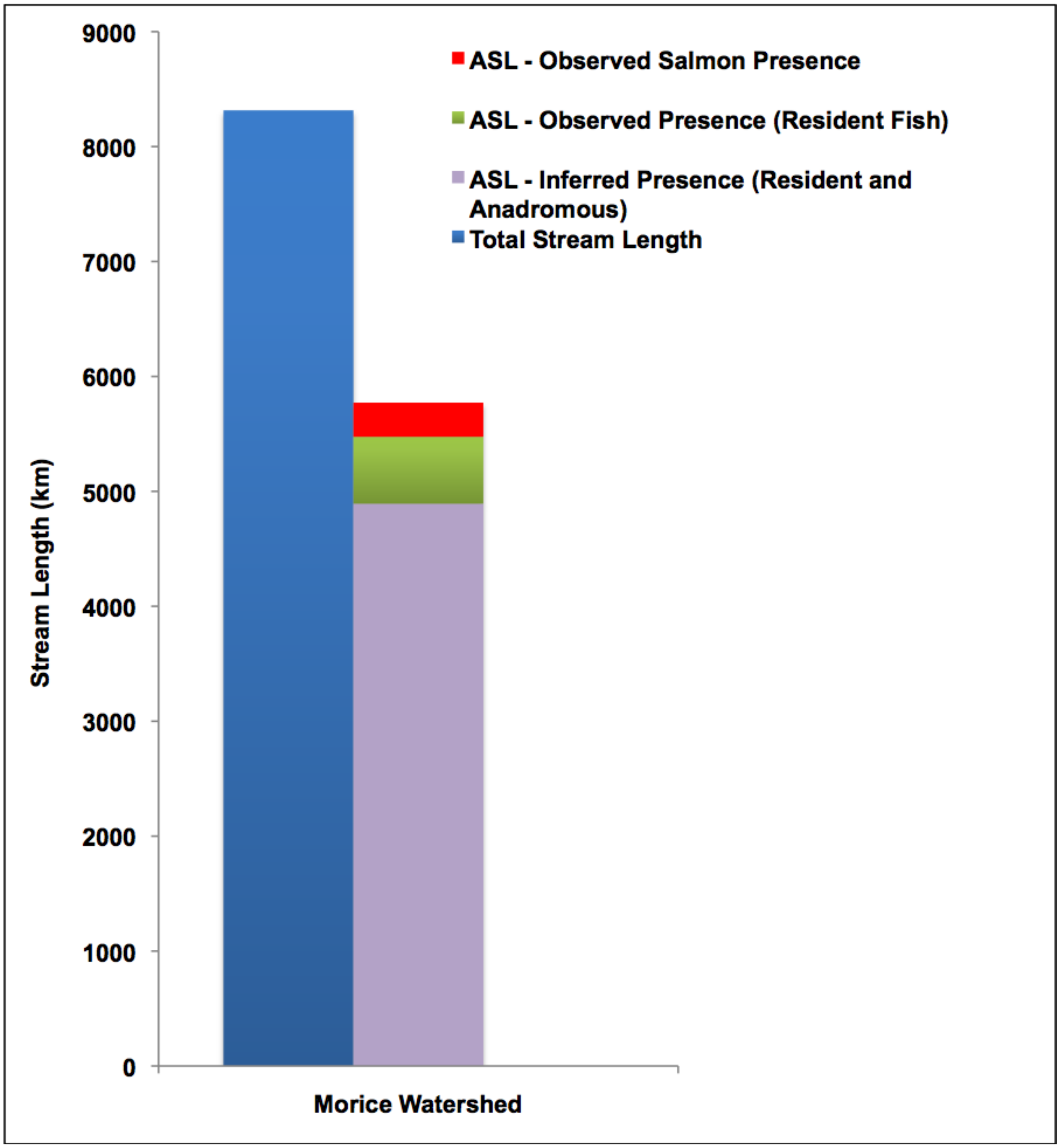


Figure 28. Morice Watershed Fish Accessible Stream Length. Note the key salmon habitat values have been rolled up within the ASL – Observed and Inferred categories.

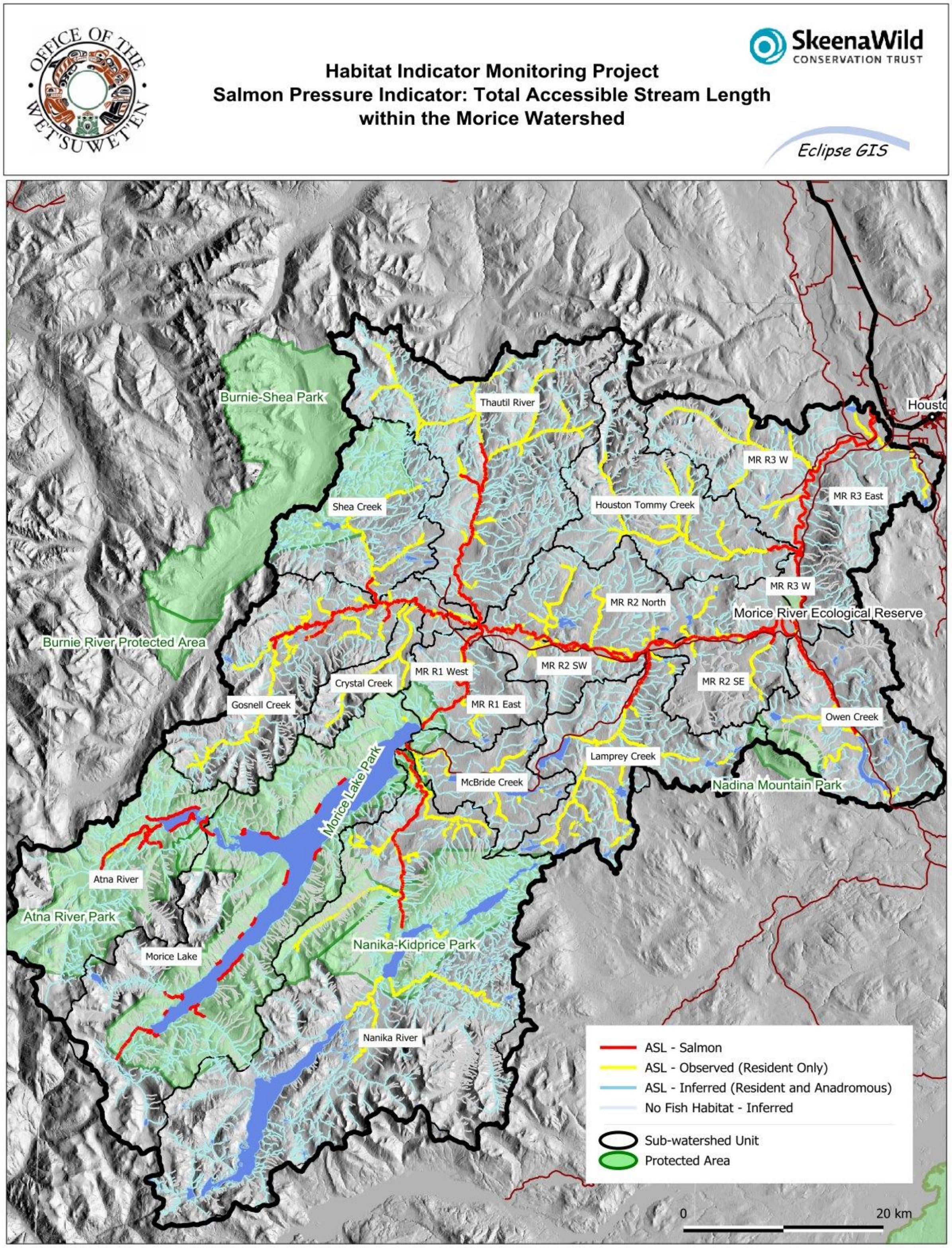


Figure 29. Morice Watershed Fish Accessible Stream Length.

5.3.2.2 Morice Watershed Management Area – Fish Presence

The Morice Watershed Management Area (MWMA) has a 7,049.7 km stream length of representing a drainage density of 2.07 km/km^2. Fish presence in 4,501 km is 63.8% of the total stream length within the Morice Watershed Management Area.

The total fish presence consists of 552.2 km (12.3%) of observed presence and 3,949.0 km (87.7%) of inferred presence as shown in Table 13. The MWMA contains 132.2 km of salmon spawning activity habitat, and 54.7 km of streams with identified salmon presence. The total salmon presence is 4.1% of the total fish presence as shown in Table 14.

Table 13. MWMA Fish Accessible Stream Length (ASL) for Resident and Anadromous Fish (km).

Total Stream Length (km)	Observed Presence (km)	Observed as % of FASL	Inferred Presence (km)	Inferred as % of FASL	Total FASL (km)	FASL as % of Total Stream Length
7,049.77	552.27	12.27	3,949.01	87.73	4,501.28	63.85

Table 14. MWMA Observed Salmon Presence (km).

Salmon Spawning (km)	Salmon Presence (km)	Salmon Stream Length (km)	Total Salmon as % of FASL
132.154	54.74	186.89	4.15

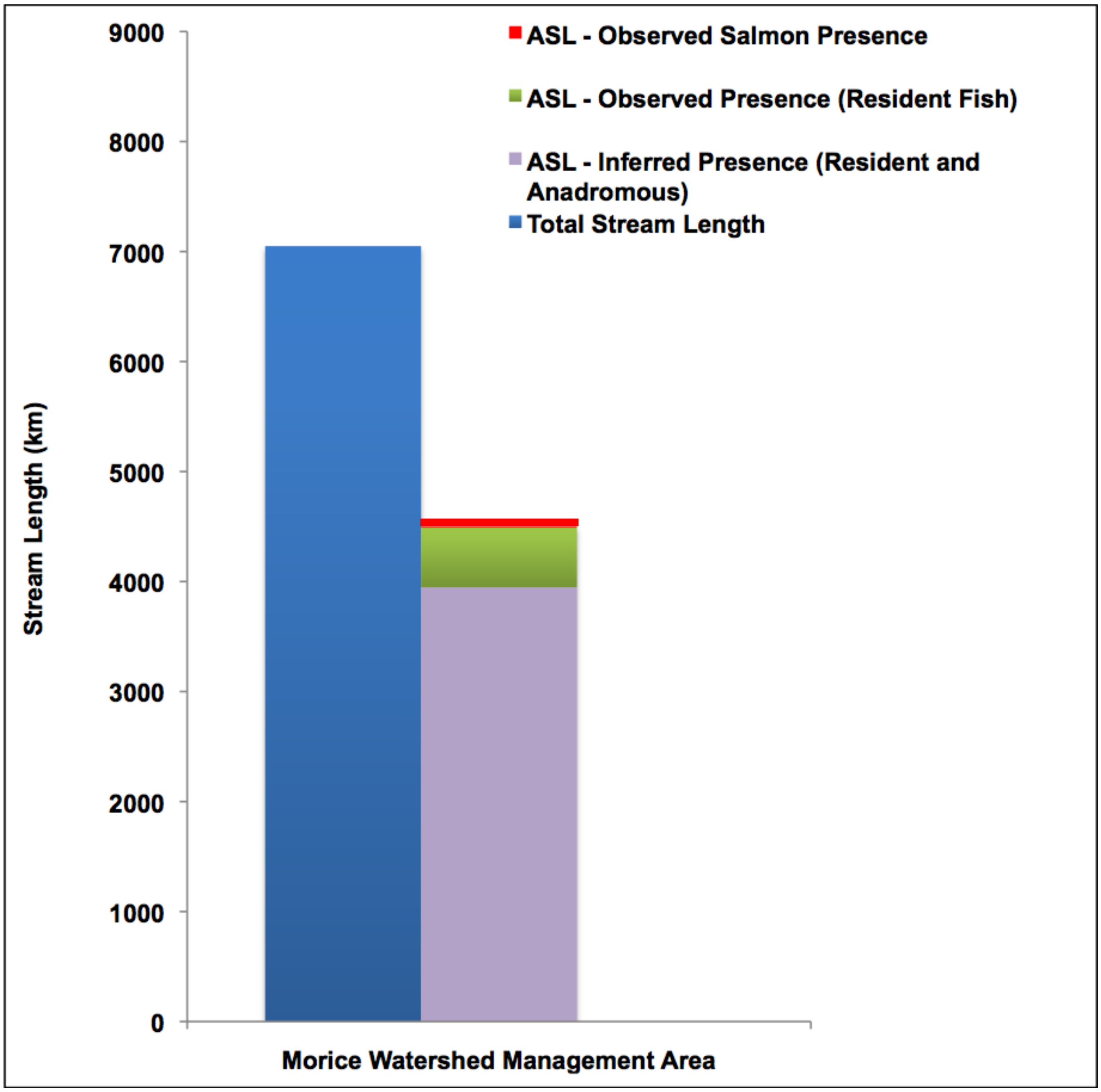


Figure 30. Morice Watershed Management Area Fish Accessible Stream Length.

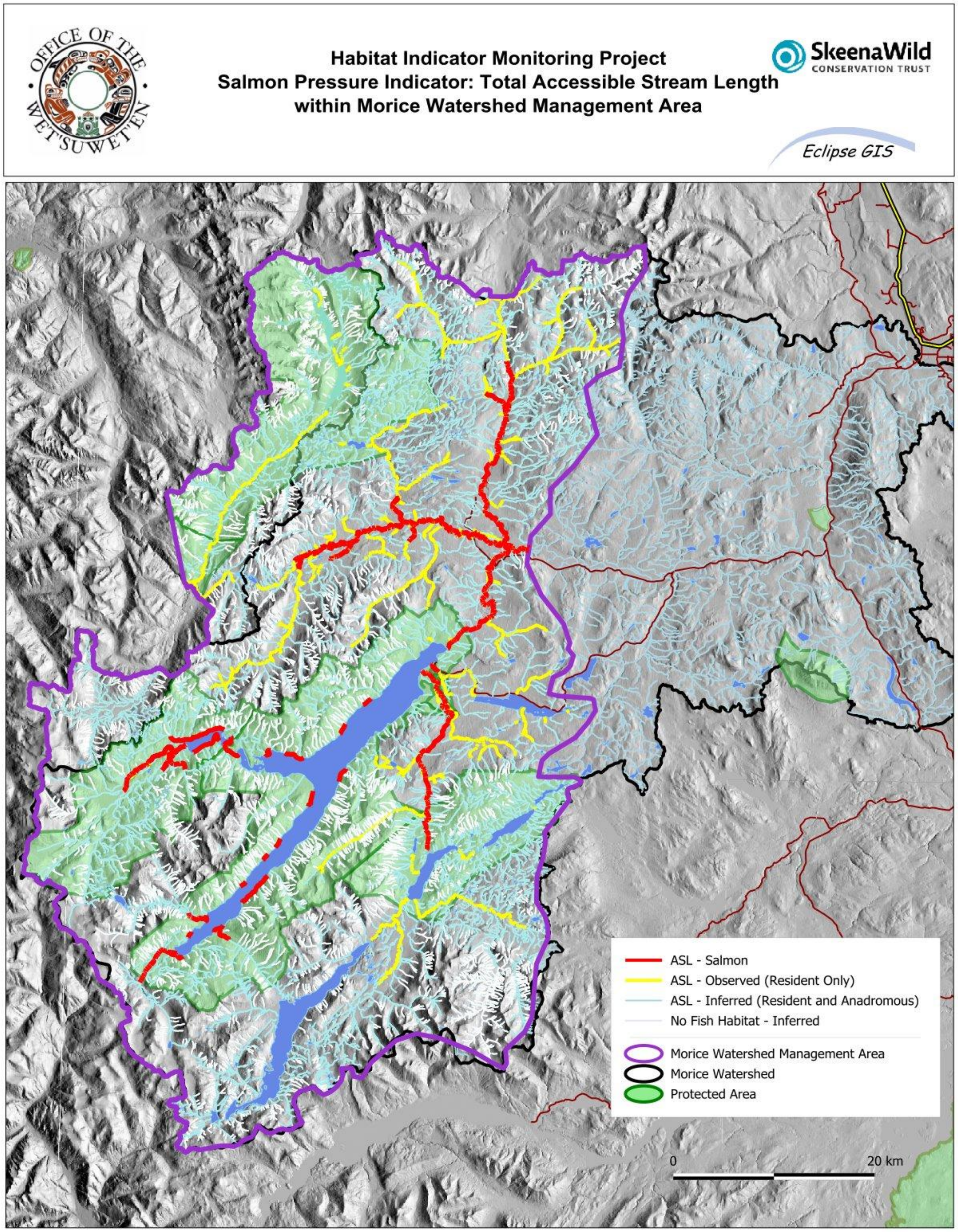


Figure 31. Morice Watershed Management Area Fish Accessible Stream Length.

5.3.2.3 Wet'suwet'en House Territories – Fish Presence

The ten Wet'suwet'en House Territories within or partly within Morice watershed have a total stream length of 11,196.5 km with an average drainage density of 1.9 km/km^2. The total fish presence ranges from 235.6 km in Bikh C'idilyiz Ts'anli to 1,403.5 km in the C'iniggit Nenikekh House Territory.

The total fish presence consists of 1,243.7 km of observed presence and 6,548.1 km of inferred presence. The House Territories contain 351.9 km of salmon spawning and presence.

Table 15. Fish Accessible Stream Length (FASL) for Resident and Anadromous Fish (km)

Wet'suwet'en House Territory	Total Stream Length (km)	Observed Presence (km)	Observed as % of FASL	Inferred Presence (km)	Inferred as % of total FASL	Total FASL (km)	FASL as % of Total Stream Length
Talhdzi Wiyez Bin	1,228.90	76.9	9.2	757.6	90.8	843.7	68.7
C'iniggit Nenikekh	2,563.80	79.8	5.7	1,318.10	94.3	1,403.60	54.7
Nelgi'l'at	978	105.8	16.3	541.8	83.7	664	67.9
Bikh C'idilyiz Ts'anli	304.7	41.5	19.2	174.8	80.8	235.6	77.3
Talbits Kwah	1,454.00	273.6	24.4	848.6	75.6	1,146.60	78.9
Lhudis Bin	1,609.90	200.5	16.7	1,002.20	83.3	1,219.30	75.7
C'idi To Stan	922.1	124.2	18.7	540.1	81.3	683	74.1
Bi Wini	1,382.90	209.2	20.2	827.9	79.8	1,057.30	76.5
Ts'in K'oz'ay	388.1	71	20.2	281.1	79.8	372.2	95.9
Nelgi Cek	364.1	61.2	19.3	256	80.7	336.5	92.4
Total	11,196.50	1,243.70	16	6,548.10	84	7,961.70	71.1

Table 16. Observed Salmon Presence (km)

House Territory	Salmon Spawning (km)	Salmon Presence (km)	Salmon Stream Length (km)	Salmon Stream as % of Fish Presence
Talhdzi Wiyez Bin	No known salmon presence			
C'iniggit Nenikekh	44.1	10.0	54.1	3.9
Nelgi'l'at	2.2		2.2	0.3
Bikh C'idilyiz Ts'anli	2.3		2.3	1.0
Talbits Kwah	71.7	34.3	106.1	9.2
Lhudis Bin	53.6	13.6	67.2	5.5
C'idi To Stan	2.8	18.3	21.1	3.1
Bi Wini	41.1	9.0	50.1	4.7
Ts'in K'oz'ay	18.1	8.4	26.5	7.1
Nelgi Cek	6.7	15.6	22.3	6.6
Total	242.7	109.2	351.9	4.4

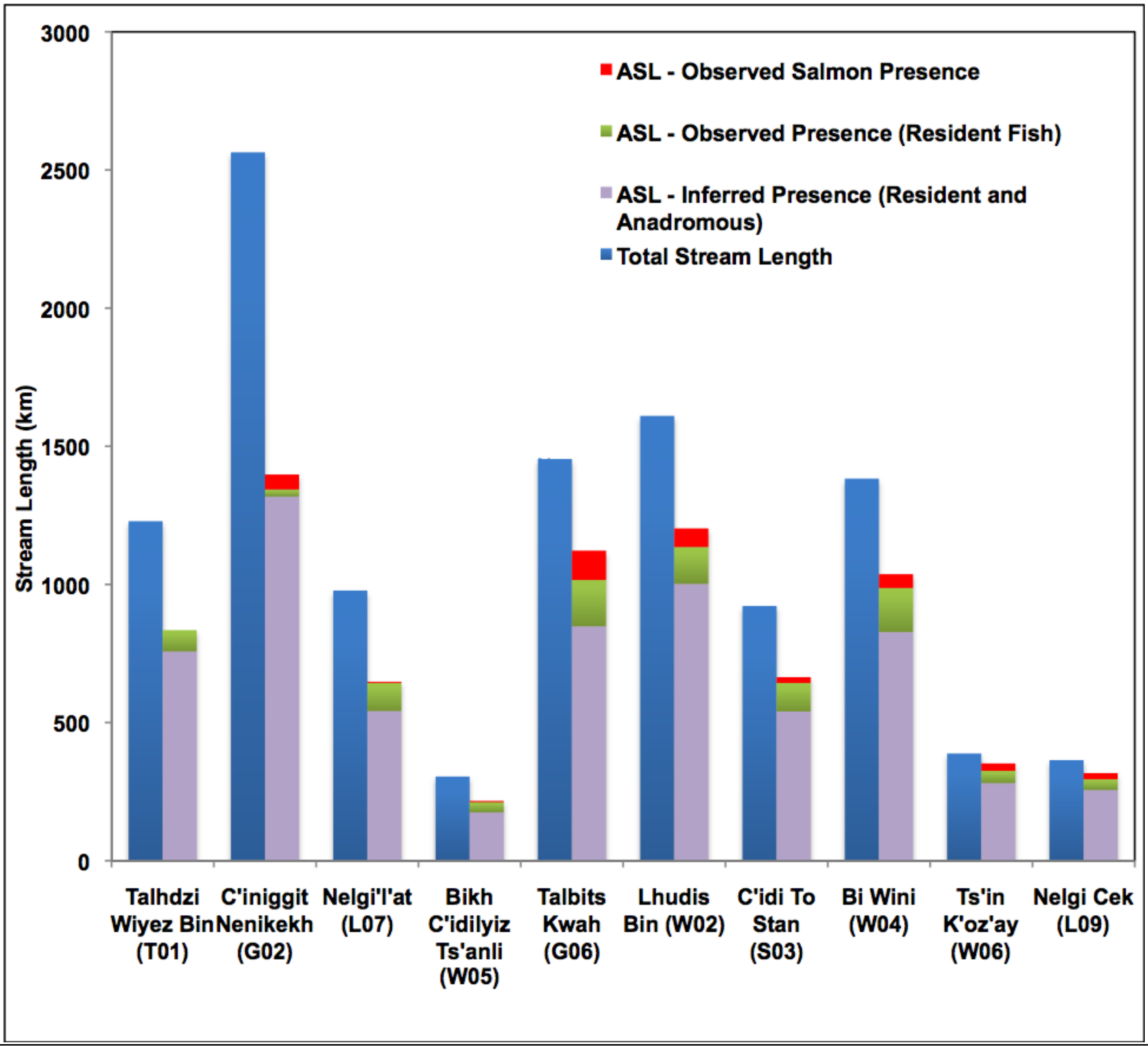
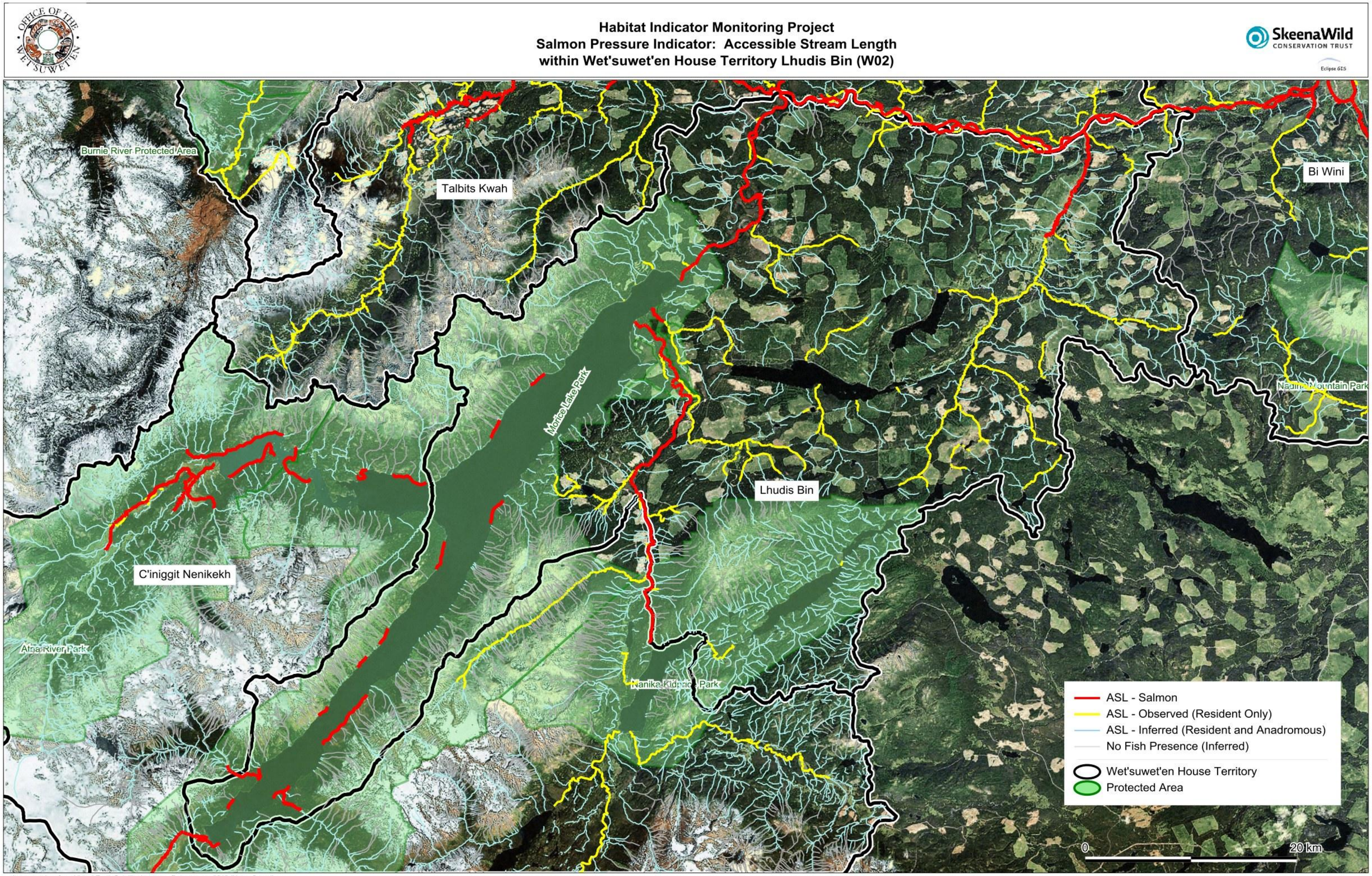


Figure 32. Wet'suwet'en House Territories – Fish Accessible Stream Length.



Imagery taken from Virtual Earth Satellite Imagery. Date approx. 2010 (Unconfirmed).

Figure 33. Lhudis Bin Territory – Fish Accessible Stream Length.

5.3.2.3 Morice Sub-watersheds Fish Presence

The Morice watershed is divided up into eighteen sub-watersheds and face units. The Gosnell watershed is broken out into three sub-watersheds: Crystal Creek, Shea Creek, and Gosnell Creek. The Morice River is separated into eight face units that characterize the three reaches and corresponding aspects.

Table 17. Morice Sub-watersheds Fish Accessible Stream Length (FASL).

Morice Sub-watersheds	Total Stream Length (km)	Presence Observed (km)	Observed as % of Total FASL	Presence Inferred (km)	Inferred as % of Total FASL	Total FASL (km)	FASL as % of Total Stream Length
Crystal Creek	119.8	28.6	40.4	42.2	59.6	70.9	59.2
Shea Creek	456.5	37.8	9	381.8	91	419.6	91.9
Gosnell Creek	635.8	116.8	30	272.2	70	389.1	61.2
Gosnell Subtotal	1,212.10	183.3	20.8	696.2	79.2	879.6	72.6
Atna River	520.6	13.1	4.1	305.9	95.9	319	61.3
Houston Tommy Creek	516.5	62	16.6	310.4	83.4	372.3	72.1
Lamprey Creek	348.4	75.2	21.7	271.7	78.3	346.8	99.6
McBride Creek	124.6	24.3	19.5	100.3	80.5	124.6	100
Nanika River	1,974.70	124.2	10.2	1,092.20	89.8	1,216.40	61.6
Owen Creek	262.8	36.5	19.2	153.6	80.8	190	72.3
Thautil River	1,057.70	123.2	14.6	720.1	85.4	843.4	79.7
Morice Lake	972.6	1.3	0.3	382.9	99.7	384.2	39.5
MR R1 East	97.1	25.5	26.6	70.3	73.4	95.8	98.7
MR R1 West	63.7	5.8	9	57.9	91	63.7	100
MR R2 North	316.7	84.3	26.7	230.9	73.3	315.2	99.5
MR R2 SE	134.3	19.5	32.4	40.7	67.6	60.2	44.9
MR R2 SW	81.1	11.7	16.1	60.9	83.9	72.6	89.5
MR R3 East	278.7	30.7	13.7	194	86.3	224.7	80.6
MR R3 NW	341.2	53.5	21.2	199.4	78.8	252.9	74.1
MR R3 SW	10.2	4.8	46.8	5.4	53.2	10.2	100
Subtotal	1,323.00	235.7	21.5	859.6	78.5	1,095.30	82.8
Total	8,315.10	878.6	15.2	4,893.00	84.8	5,771.60	69.4

Table 18. Morice Sub-watersheds Observed Salmon Presence (km).

Sub-watershed	Salmon Spawning (km)	Salmon Presence (km)	Salmon Streams (km)	Salmon Stream as % of FASL
Crystal Creek	0	0	0	0
Shea Creek	4.1	0	4.1	1
Gosnell Creek	25.5	16.6	42.1	10.8
Gosnell Subtotal	29.6	16.6	46.2	5.3
Atna River	29	2.7	31.7	9.9
Houston Tommy Creek	0	4.5	4.5	1.2
Lamprey Creek	6.6	2.5	9.1	2.6
McBride Creek	0	0	0	0
Nanika River	18	5.8	23.8	2
Owen Creek	16	0	16	8.4
Thautil River	10.3	17	27.3	3.2
Morice Lake	28.1	0	28.1	7.3
MR R1 East	8.5	4.2	12.7	13.3
MR R1 West	3.6	1.6	5.2	8.1
MR R2 North	34.8	4.8	39.6	12.6
MR R2 SE	10.6	0.4	10.9	18.2
MR R2 SW	5.3	0.5	5.8	8
MR R3 East	26	4.7	30.7	13.7
MR R3 NW	2.1	0	2.1	0.8
MR R3 SW	2.8	0	2.8	27.4
Subtotal	93.7	16.2	109.9	10
Total	231.4	65.2	296.6	5.1

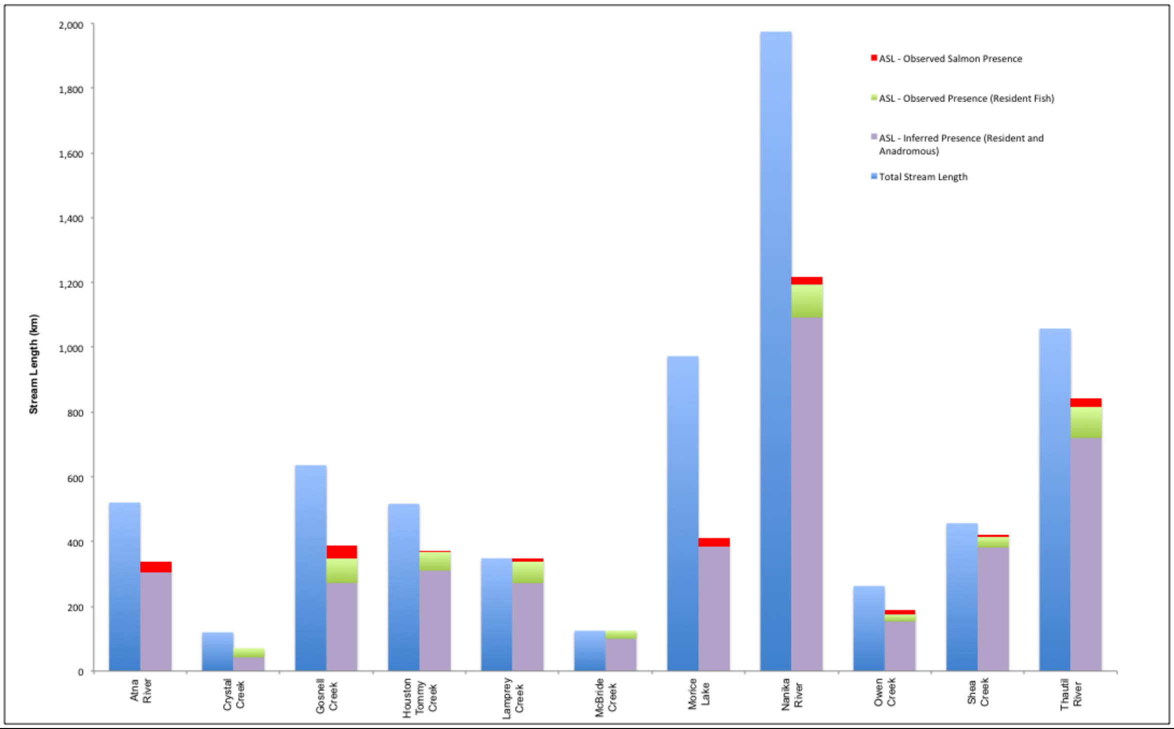


Figure 34. Morice Sub-watersheds Fish Accessible Stream Length.

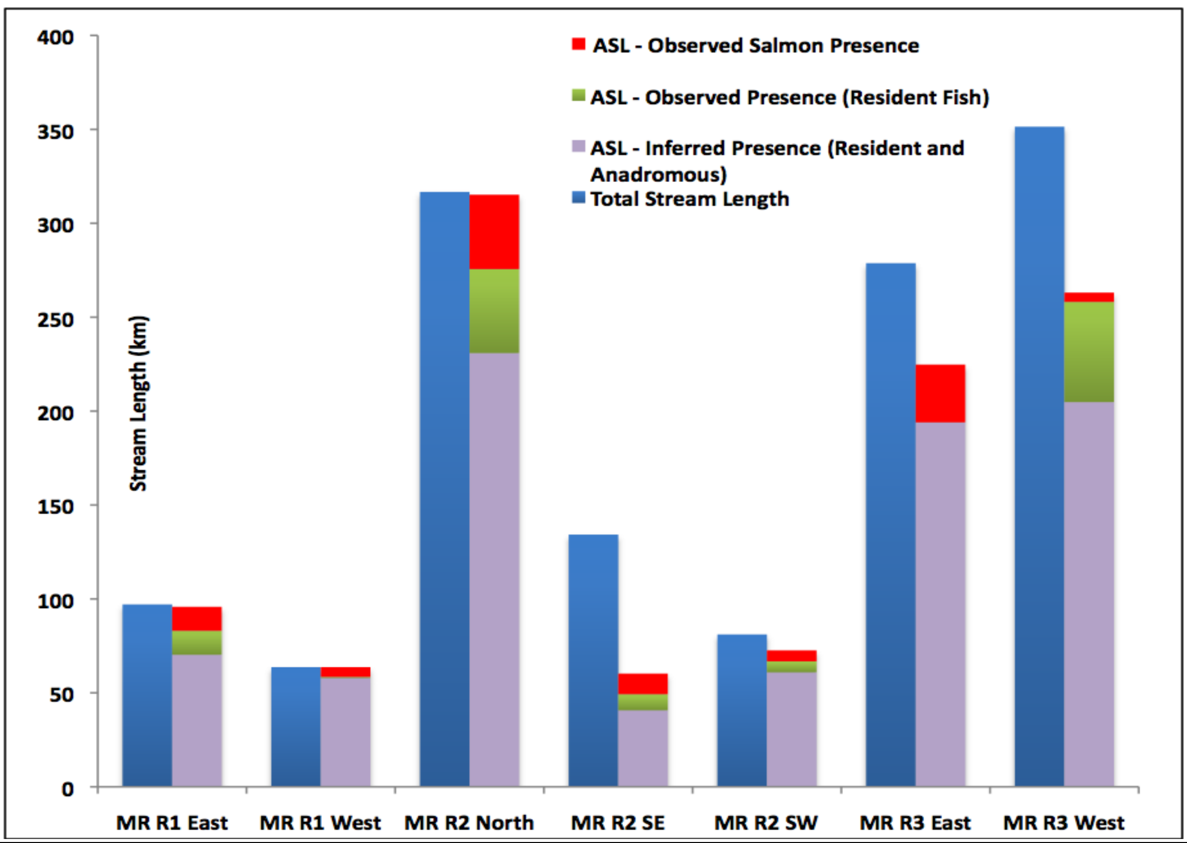
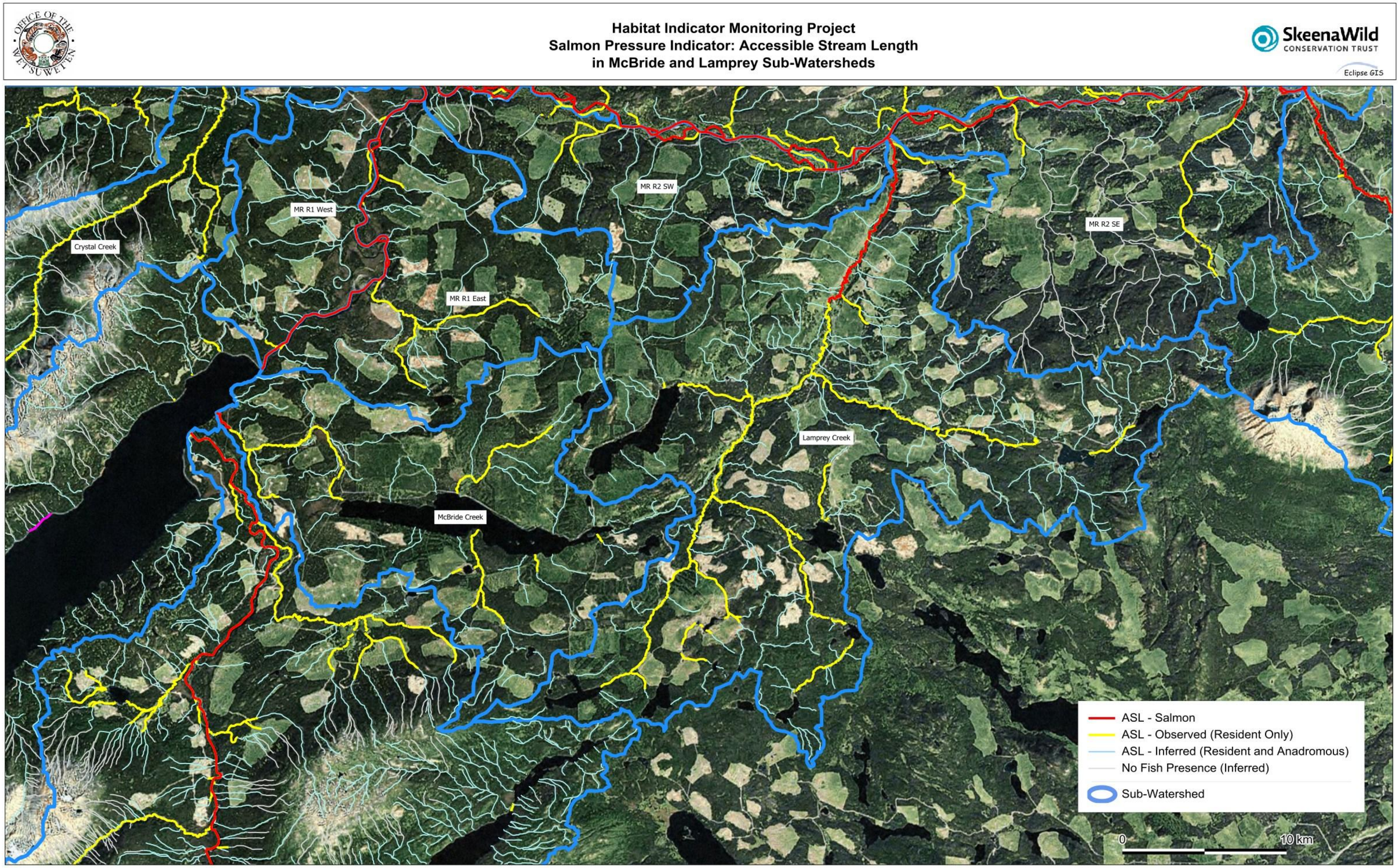


Figure 35. Morice Sub-watersheds / Face Units Fish Accessible Stream Length.



Imagery taken from Virtual Earth Satellite Imagery. Date approx. 2010 (Unconfirmed).

Figure 36. McBride and Lamprey Sub-watersheds Fish Accessible Stream Length.

5.3.3 Morice Fish Presence & Habitat

Morice watershed possesses abundant salmon and resident fish habitat. Currently known salmon habitat is almost 300 km of total Morice watershed stream lengths. Confirmed freshwater fish habitat is 878 km and inferred fish presence is approximately 4,900 km of stream. The total confirmed and inferred fish presence is about 70% of total stream length. This is a substantial and significant amount of fish habitat.

Data is limited regarding the general and specific condition and status of the streams and their fish habitat. These data limitations revolve:

- Stream temperature regime;
- Stream flow regime;
- Stream channel structure and conditions;
- Partial of full obstructions to juvenile and adult fish including temporary obstructions such as beaver dams and impassable falls;
- Sensitivity of watershed to fine sediment and siltation.

Morice salmon and resident fish have complex life-cycles, and consequently, relatively complex habitat requirements. Physical, chemical and biological threats to Morice fish habitat include barriers to migration, changes to riparian cover, changes to the stream channel, changes in water quantity and quality, and change resulting from a warming climate at the global scale.

5.4 Riparian Disturbance

Morice watershed contains approximately 500 km^2 of streamside riparian area. Riparian zones represent the critical interface between land and streams, lakes, and wetlands. In an ecologically healthy landscape, streams and their riparian areas form an inseparable unit—the stream corridor. The stream corridor encompasses the active river channel, the exposed bars and areas of ponded water near the channel, the floodplain surfaces above and outside the channel banks, and the adjacent riparian zone. A stream channel that has become disconnected from its riparian area no longer stores water and accumulates sediment, thus losing many of its ecological functions.

Ecologically healthy stream corridors and lakeshores are more than just water, channels, sediment, and floodplains. They include assemblages of riparian plant communities and wildlife that depend upon the natural hydrologic regimes representative of a particular landscape. In the absence of human alteration, riparian plant communities support numerous functions including: bank stabilization through root strength, sediment deposition on floodplains during periods of overbank flow, interstitial flow through the sediments, and large wood enabling diverse channel structure. Large wood has a substantial influence on channel morphology, complexity, and instream habitat features. Wetland riparian zones were not included in this analysis due to limited data.

5.4.1 Riparian Disturbance Methodology

The following GIS spatial data was utilized in this analysis:

- Fish Habitat Data (BC Environment Culvert Assessment Project);
- Salmon presence and spawning data produced by SkeenaWild 2010-2012;
- Digital Road Atlas (DRA);
- NTS railway and existing pipeline;
- Forest Tenure Roads (FTEN roads);
- FTEN Cut Blocks;
- RESULTS Silviculture Polygons;
- Freshwater Atlas Streams (1:20,000);
- Freshwater Atlas Lakes (1:20,000);
- Modified Freshwater Atlas Assessment Watersheds;
- Wet'suwet'en House Territory boundaries;
- Morice Watershed Management Area boundary.

The buffer tool in Manifold GIS was used to create a 30 m buffer[12] around all streams with observed and inferred fish presence, as well as streams with no inferred fish presence. Disturbance factors buffered include roads,[13] pipelines,[14] and the CN Rail as shown in Table 20 below.

The riparian disturbance indicator is used by and rated high value by the federal Wild Salmon Policy. It is also utilized in BC provincial policy and regulations, and used in a variety of other jurisdictions for salmon habitat health assessment applications. The threshold or metric used is "% of a stream's riparian area developed within 30 meters of the streambank." Currently, there is sufficient information in published literature to suggest the 30 m buffer utilized in this analysis is not the ideal buffer to sustain salmon habitat. For instance, Morice watershed tree lengths are on average 30 meters, so realistically riparian integrity needs to be 60 m width. Consequently, riparian buffer widths are proposed to be discussed in a near-future workshop to ensure the optimal buffer width for salmon habitat assessment is utilized in future analysis. Final thresholds are to be determined; however, for this analysis, interim thresholds used are shown in Table 19.

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[12] B.C. Ministry of Forests (MOF). 1995a. Interior watershed assessment procedure guidebook (IWAP0. http://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/iwap/iwap-toc.htm

[13] Coombs, T., A. Bernard, and G. Nigh. 2010. Forest access road widths in the Lakes Timber Supply Area. BC Journal of Ecosystems and Management 11 (1&2):84-90. http://jem.forrex.org/index.php/jem/article/view/15/29

[14] The 75 m pipeline buffer is intended to include not only a 25 m right of way but also allows for a 50 m construction zone to accommodate the construction of facilities.

The Morice Land and Resource Management Plan (Section 4.2.8, Page 161) provides management direction for the Morice River Resource Management Zone, including setting measures and targets for harvesting and road building within the 100 year floodplain, as well as a 1000 m buffer beyond the 100 year floodplain. Unfortunately, the 100 year floodplain is not spatially defined, and therefore cannot be included in any riparian analysis.

Table 19. Riparian Disturbance Risk Thresholds.

Low Risk	<5%
Moderate Risk	5 to <=15%
High Risk	>15%

Table 20. Riparian Disturbance Buffer Features.

Feature	Corridor width (m)
Stream	60
Road – mainline	30
Road – operational	18
Road – in-block	10
Railway ROW	30
Pipeline – existing	75
Pipeline – proposed	75

The riparian corridors were intersected with the various linear development features as well as area features such as cutblocks. The resultant tables were exported to excel where a pivot table was generated to summarize results.

5.4.2 Riparian Disturbance Results

The results of the riparian disturbance indicator are reported out by analysis units including the Morice watershed, the eighteen Morice sub-watersheds, the Morice Watershed Management Area, and the ten Wet'suwet'en House Territories within or partly within the Morice watershed.

5.4.2.1 Morice Watershed Riparian Disturbance

The streamside riparian area is 499.18 km^2 or approximately 11.4% of Morice watershed as shown in Table 21. Currently 3.2% of the riparian buffers are situated along salmon bearing streams, and 7.3% along resident fish bearing streams. The remaining 89.4% of the riparian buffers are situated along streams with inferred fish presence or streams with no inferred fish presence.

Table 21. Riparian Buffer (km^2) by Fish Presence.

Salmon Presence Observed	Fish Presence Observed	Fish Presence Inferred	No Fish Habitat Inferred	Total Riparian (km^2)
16.04	36.63	295.32	151.18	499.18

Across the Morice watershed, 7.98% of the riparian area has been altered by harvesting or road development as shown in Table 22. Of this riparian disturbance, road development contributes 2.9% while harvesting contributes 97.1%. Riparian impacts within teh salmon presence observed was not calculated.

Table 22. Existing Development within 30 m Riparian Buffer (km^2)

Total Riparian	Road Disturbance	Harvesting Disturbance	Pipelines	Total Riparian Disturbance	% Riparian Altered
499.18	1.17	38.65	N/A	39.82	7.98

5.4.2.2 Morice Watershed Management Area – Riparian Disturbance

Morice Watershed Management Area streamside riparian areas is 422.14 km^2 or 12.4% as shown in Table 23. Currently 2.1% of the riparian buffers are situated along salmon bearing streams, and 5.7% along resident fish bearing streams. The remaining 92.2% of the riparian buffers are situated along streams with inferred fish presence or streams with no (inferred) fish presence.

Table 23. Riparian Buffer (km^2) by Fish Presence

Salmon Habitat	Fish Presence Observed	Fish Presence Inferred	No Fish Habitat (Inferred)	Total Riparian
9	24.03	238.62	150.5	422.14

Across the Morice Watershed Management Area 4.31% of the riparian area has been altered by harvesting and road development. Harvesting contributes 97.3% of the disturbance to riparian areas with road development contributing 2.7%.

Table 24. Existing Development within 30 m Riparian Buffer (km^2).

Total Riparian	Road Disturbance	Harvesting Disturbance	Pipelines	Total Riparian Altered	% Riparian Altered
422.14	0.5	17.7	N/A	18.2	4.31

5.4.2.3 Wet'suwet'en House Territories Riparian Disturbance

The streamside riparian area is 665.73 km^2 or 11.28% of the ten Wet'suwet'en House Territories within the Morice watershed as shown in Table 25. Currently 2.8% of the riparian buffers are situated along salmon bearing streams, and 8.2% along resident fish bearing streams. The remaining 88.9% of the riparian buffers are situated along streams with inferred fish presence or streams with no inferred fish presence.

Table 25. Riparian Buffer (km^2) by Fish Presence.

House Territory	Salmon Habitat	Fish Presence Observed	Fish Presence Inferred	No Fish Habitat Inferred	Total Riparian Area	Riparian as % of Total Watershed Area
Talhdzi Wiyez Bin	0	3.9	44.09	23.16	71.15	14.38
C'iniggit Nenikekh	1.96	2.66	79.55	69.15	153.32	11.85
Nelgi'l'at	0.13	6.16	32.2	19.32	57.81	14.93
Bikh C'idilyiz Ts'anli	0.31	2.29	10.43	5.2	18.23	12.79
Talbits Kwah	6.18	10.84	50.83	19.47	87.32	12.29
Lhudis Bin	3.21	8.32	60.63	24.1	96.26	9.73
C'idi To Stan	1.27	6.09	31.98	15.15	54.49	10.78
Bi Wini	3	9.51	49.6	20.55	82.66	9.36
Ts'in K'oz'ay	1.39	2.84	16.8	2.15	23.18	8.27
Nelgi Cek	1.34	2.11	15.08	2.78	21.31	9.91
Total	18.79	54.73	391.19	201.02	665.73	11.28

Across the ten Wet'suwet'en House Territories situated within or partly within Morice watershed, 7.67% of the riparian area has been altered by harvesting, roads, CN Rail, and the existing PNG pipeline. The majority of the disturbance to riparian areas – 95.9%, is due to harvesting. Forestry roads contribute 3.48%, while the existing railway and pipeline contribute less than 1% to riparian disturbance. The disturbance to riparian areas within the House Territories varies from 0.29 % in Talhdzi Wiyez Bin to 19.32% in Lhudis Bin House Territory as shown in Table 26.

Table 26. Existing Development within 30 m Riparian Buffer (km^2).

House Territory	Total Riparian Area	Road Disturbance	Railway Disturbance	Pipeline Disturbance	Harvesting Disturbance	Total Riparian Altered	% Riparian Altered
Talhdzi Wiyez Bin	71.15	0.01			0.19	0.2	0.29
C'iniggit Nenikekh	153.32	0.1			2.04	2.14	1.4
Nelgi'l'at	57.81	0.04			0.2	0.24	0.41
Bikh C'idilyiz Ts'anli	18.23	0.04			0.33	0.37	2.04
Talbits Kwah	87.32	0.23			8.65	8.89	10.18
Lhudis Bin	96.26	0.43			18.17	18.6	19.32
C'idi To Stan	54.49	0.23	0.09	0.06	3.67	4.05	7.43
Bi Wini	82.66	0.35			12.57	12.91	15.62
Ts'in K'oz'ay	23.18	0.14	0.01		2.08	2.22	9.59
Nelgi Cek	21.31	0.21	0.04	0.08	1.38	1.71	8.04
Total	665.73	1.79	0.14	0.14	49.28	51.34	7.71

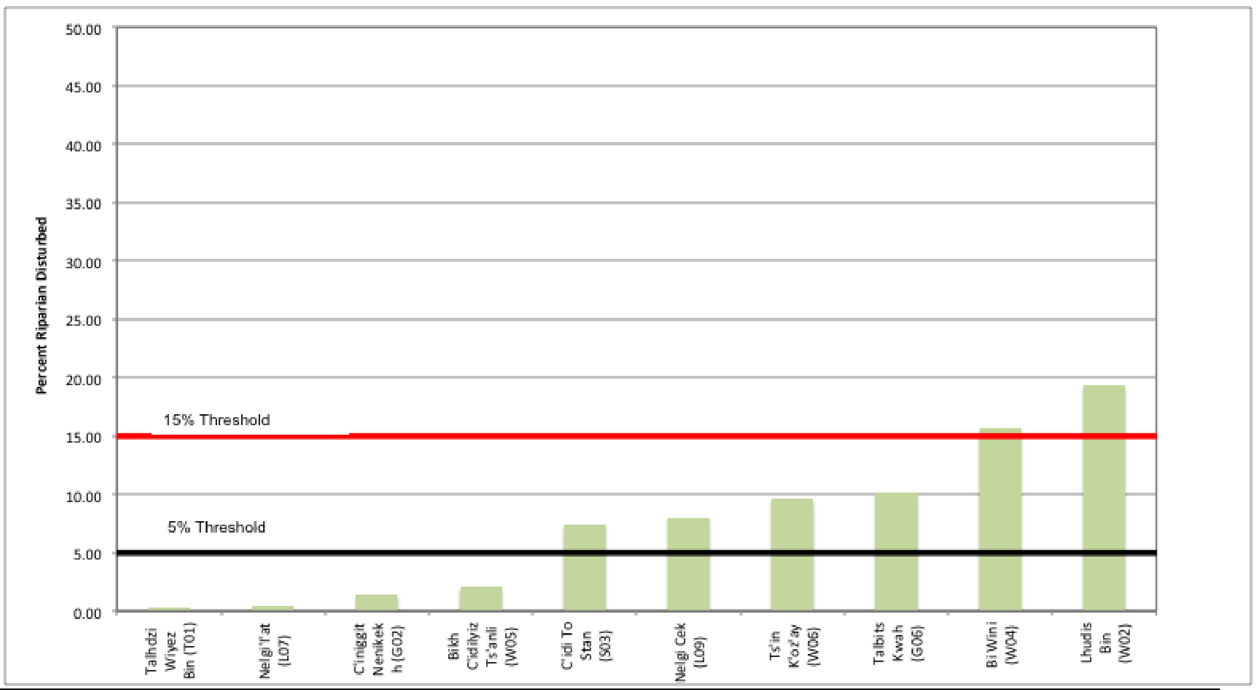

Figure 37. Wet'suwet'en House Territory and Percent of Riparian Disturbance.

5.4.2.4 Morice Sub-watersheds Riparian Disturbance

The eighteen Morice sub-watersheds contain 499.10 km^2 of streamside riparian area representing 11.4% of their total area as shown in Table 27.

Table 27. Riparian Buffer (km^2) by Fish Presence

Sub-watershed	Salmon Habitat	Fish Presence Observed	Fish Presence Inferred	No Fish Presence Inferred	Total Riparian Area	Riparian as % of Total Watershed Area
Crystal Creek	0	1.71	2.52	2.89	7.12	11.4
Shea Creek	0.25	2.03	23.23	2.19	27.7	14.21
Gosnell Creek	2.47	4.51	16.32	14.51	37.82	13.53
Gosnell Sub Total	2.72	8.25	42.07	19.6	72.64	13.53
Atna River	1.14	0	18.59	12.15	31.88	11.23
Houston Tommy Creek	0.27	3.44	18.64	8.5	30.85	12.43
Lamprey Creek	0.52	3.97	16.12	0.09	20.7	8.61
McBride Creek		1.46	6.04	0	7.5	6.52
Nanika River	1.43	5.97	65.74	44.73	117.87	13.25
Owen Creek		3.49	9.3	4.36	17.15	8.08
Thautil River	1.63	5.71	42.97	12.58	62.9	14.87
Morice Lake	0.79	0	23.44	34.86	59.1	9.86
MR R1 East	0.59	0.75	4.2	0.08	5.61	7.83
MR R1 West	0.45	0.21	3.49	0	4.15	10.11
MR R2 North	1.64	2.57	13.88	0.09	18.18	8.82
MR R2 SE	1.06	0.54	2.44	4.42	8.47	8.33
MR R2 SW	0.68	0.33	3.65	0.5	5.15	8.36
MR R3 West	1.02	2.57	12.18	5.2	20.97	12.65
MR R3 East	1.16	0	11.58	3.22	15.96	8.77
MR Face Units Sub Total	6.59	6.97	51.42	13.52	78.5	9.46
Total	15.1	39.26	294.34	150.4	499.1	11.4

Across the Morice Sub-watersheds, 7.98% of the riparian area has been altered by harvesting and roads. The majority of the disturbance to riparian areas, 97.1%, is due to harvesting. Roads contribute 2.9% of the disturbance of the riparian areas. The disturbance to riparian areas within the sub-watersheds ranges from no disturbance in Atna River to 42.72% and 42.33% in Lamprey Creek and McBride Creek respectively as shown in Table 28 below.

Table 28. Existing Development within 30 m Riparian Buffer (km^2).

Sub-watershed	Total Riparian Area	Road Disturbance	Pipelines Disturbance	Harvesting Disturbance	Total Riparian Altered	% Riparian Altered
Crystal Creek	7.12	0		0.24	0.24	3.38
Shea Creek	27.7	0.03		0.56	0.59	2.12
Gosnell Creek	37.82	0.08		3.66	3.74	9.9
Gosnell Sub Total	72.64	0.12		4.46	4.57	6.29
Atna River	31.88				0	0
Houston Tommy Creek	30.85	0.06		2.66	2.72	8.81
Lamprey Creek	20.7	0.19		8.65	8.84	42.72
McBride Creek	7.5	0.08		3.09	3.17	42.33
Nanika River	117.87	0.16		5.15	5.31	4.5
Owen Creek	17.15	0.09		2.21	2.3	13.42
Thautil River	62.9	0.08		1.58	1.65	2.63
Morice Lake	59.1	0.01		0.43	0.43	0.73
MR R1 East	5.61	0.03		1.62	1.65	29.36
MR R1 West	4.15	0.03		1.23	1.26	30.29
MR R2 North	18.18	0.09		4.21	4.3	23.65
MR R2 SE	8.47	0.05		0.96	1	11.87
MR R2 SW	5.15	0.05		0.69	0.74	14.39
MR R3 West	20.97	0.05		0.61	0.66	3.17
MR R3 East	15.96	0.09		1.1	1.19	7.48
Morice Face Units Total	78.5	0.38		10.43	10.81	13.77
Total	499.1	1.17		38.65	39.81	7.98

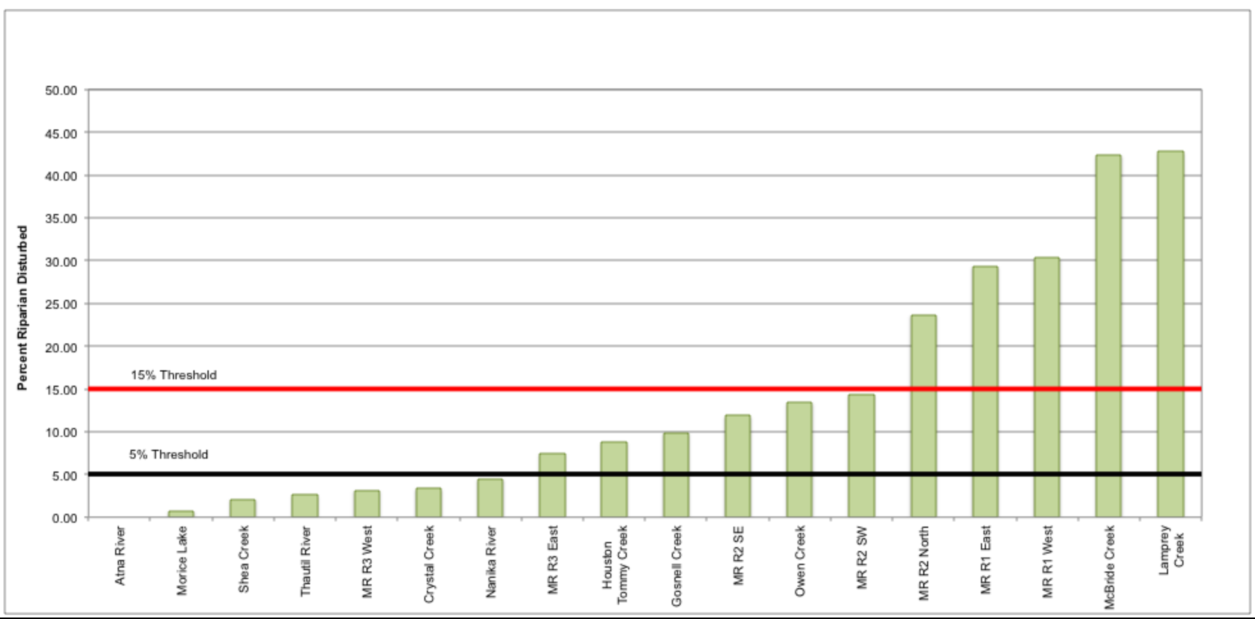

Figure 38. Percent Riparian Disturbed by Morice Sub-Watersheds.

5.4.3 Riparian Disturbance Discussion

Within Morice watershed, the riparian disturbance analysis highlighted a number of points, including:

- Streamside riparian areas total nearly 500 km^2;
- Nearly 40 km^2 or 8% of the riparian area had been disturbed to varying degrees and is rated moderate risk;
- Lhudis Bin and Bi Wini territories are both rated high risk and four other territories are rated moderate risk;
- Lamprey and McBride sub-basins have over 40% riparian disturbance and rated severe risk;
- Morice River Reach 1 and Reach 2 sub-basins are mostly high risk;
- Roads typically disturb 4% or less of the riparian area while logging typically accounts for 96% of the impacts. The forest industry accounts for nearly all anthropogenic riparian disturbance within Morice watershed;
- Current riparian zone management guidelines do not deliver their outcomes in protecting fish habitat.

Several questions arise:

- Why are forestry operations located so close to streams that even a 30 m cannot be kept intact?
- Why is adequate compliance and enforcement difficult?
- What education efforts are needed in order to achieve 0% riparian disturbance?

There is a need to consider setting an appropriate riparian zone width that is kept intact with 0% disturbance.

Properly functioning stream and riparian area conditions are defined as can:

- withstand normal peak flood events without experiencing accelerated soil loss, channel movement, or bank movement;
- filter runoff;
- store and safely release water;
- maintain the connectivity of fish habitats in streams and riparian areas so that these habitats are not lost or isolated as a result of management activity;
- maintain an adequate riparian root network or large woody debris (LWD) supply; and
- provide shade and reduce bank microclimate change.

5.5 Morice Watershed Land Cover Alteration

Total Land Cover Alteration (TLCA) reflects a suite of potential changes to hydrological processes and sediment generation, potential impacts to downstream salmon habitat, and as well, potential changes in biodiversity. In the Morice, developed land use is potentially characterized by altered stream hydrology, reduced channel complexity, larger and more frequent peak flows, and in some cases, reduced water storage. Peak flows can scour stream beds and displace juveniles in the absence of sufficient off channel habitat. The Wild Salmon Policy includes TLCA as a high value pressure indicator.

Total land cover alteration (TLCA) analysis for this project consists of two principal components: anthropogenic alterations to the land base and natural disturbances. Anthropogenic alterations to the land base include settlements, agricultural activities, transportation infrastructure, and resource-based activities such as forestry, mining, and energy development. This analysis refers to human alterations as the human development footprint (HDF) and applies interim thresholds to the analyses results.

Natural disturbances include abiotic elements, such as wildfires, windthrow, and geomorphic activity such as landslides, debris flows, or avalanches. Natural biotic disturbances include the effects from insect infestation and disease outbreaks[15]. When viewed over the long-term natural disturbances help preserve a diverse, resilient, and healthy ecosystem[16]. The natural disturbance analysis is based on fire and mountain pine beetle, placed within the context of natural disturbance zones. The final section presents a comparison of the various disturbance agents by natural disturbance type.

5.5.1 Methodology

The following GIS spatial information was utilized in this analysis:

- Forestry roads (FTEN database);
- Digital Road Atlas (DRA);
- Railway, natural gas pipeline, and transmission lines (NTS 1:50,000);
- Cut blocks (FTEN database);
- Silviculture openings (RESULTS);
- Crown Tenures (Agriculture, Industrial, Utility, Transportation, Commercial, Quarrying, Residential, Community);
- Mineral Tenures/Advanced Exploration Sites;
- Bing Maps Aerial photos.

The various land cover datasets listed above were integrated to form a comprehensive dataset representing the total human development footprint. A variable buffer was applied to the roads based on type of road (highway, mainline, secondary, in-block) based on criteria determined by Coombes (2010) for the Lakes Timber Supply Area[17]. The existing natural gas pipeline – Pacific Northern Gas and the proposed Pacific Trails Pipeline are represented by their tenure boundaries, resulting in a 2 km corridor. Proposed pipelines with no tenure issued were not considered for this analysis. A 50m buffer was applied to the Huckleberry transmission line based on measurements taken from Bing Maps,[18] as there is no tenure line work available.

Pending and cancelled cut block tenures were removed from the cut block data. Any overlap in silviculture polygons between the cut block data (FTEN) and Silviculture data (RESULTS) was removed from the cut block data to avoid duplication. Crown Tenures designated as commercial recreation, environmental conservation and recreation, and miscellaneous land uses were removed for the analyses, as these tenures did not show a significant visible footprint on the ground as per Bing Maps. Advanced

[15] Parminter, J., and Daigle P. (July 1997). FORREX Extension Note. Landscape Ecology and Natural Disturbances: Relationships to Biodiversity. Retrieved from www.for.gov.bc.ca/hrs/topics/fire.htm

[16] Wong, C., H. Sandmann, and B. Dorner. 2003. Historical variability of natural disturbances in British Columbia: A literature review. FORREX – Forest Research Extension Partnership, Kamloops, B.C. FORREX Series 12. URL: www.forrex.org/publications//forrexseries/fs12.pdf

[17] Coombes, T., A. Bernard, and G. Nigh. 2010. Forest access road widths in the Lakes Timber Supply Area. BC Journal of Ecosystems and Management 11 (1&2):84-90. http://jem.forerex.org/index.php/jem/article/view/15/29

[18] Viewed July 5th, 2013 at www.bing.com/map/

mineral exploration sites (point data) were extended to the relevant mineral claims (polygon data) that contained the exploration activity.

5.5.1.1 Human Development Footprint Thresholds

Interim thresholds used in these analyses follow the recommendations put forth by ESSA (2013)[19]. These values will be further revised if and when Wet'suwet'en thresholds are established.

Table 29. Human development footprint risk thresholds.

Low Risk	<6.4%
Moderate Risk	6.4% to < 22%
High Risk	>= 22%

5.5.2 Human Development Footprint Results

The results of the total human development footprint are reported out by analysis units including the Morice watershed, the eighteen Morice sub-watersheds, the Morice Watershed Management Area, and the ten Wet'suwet'en House Territories within, or partly within Morice watershed.

5.5.2.1 Morice Watershed Human Development Footprint

The Morice watershed has a total human development footprint of 771.8 km^2 as shown in Table 30 and Figure 37.

Table 30. Total Human Development Footprint within Morice Watershed.

Morice Watershed Area (km^2)	Total HDF Area (km^2)	Percentage of THDF within Morice Watershed
4,379.62	771.9	16.60%

19 ESSA Technologies. Porter et al. 2013. Skeena lake sockeye Conservation Units: Habitat report cards.

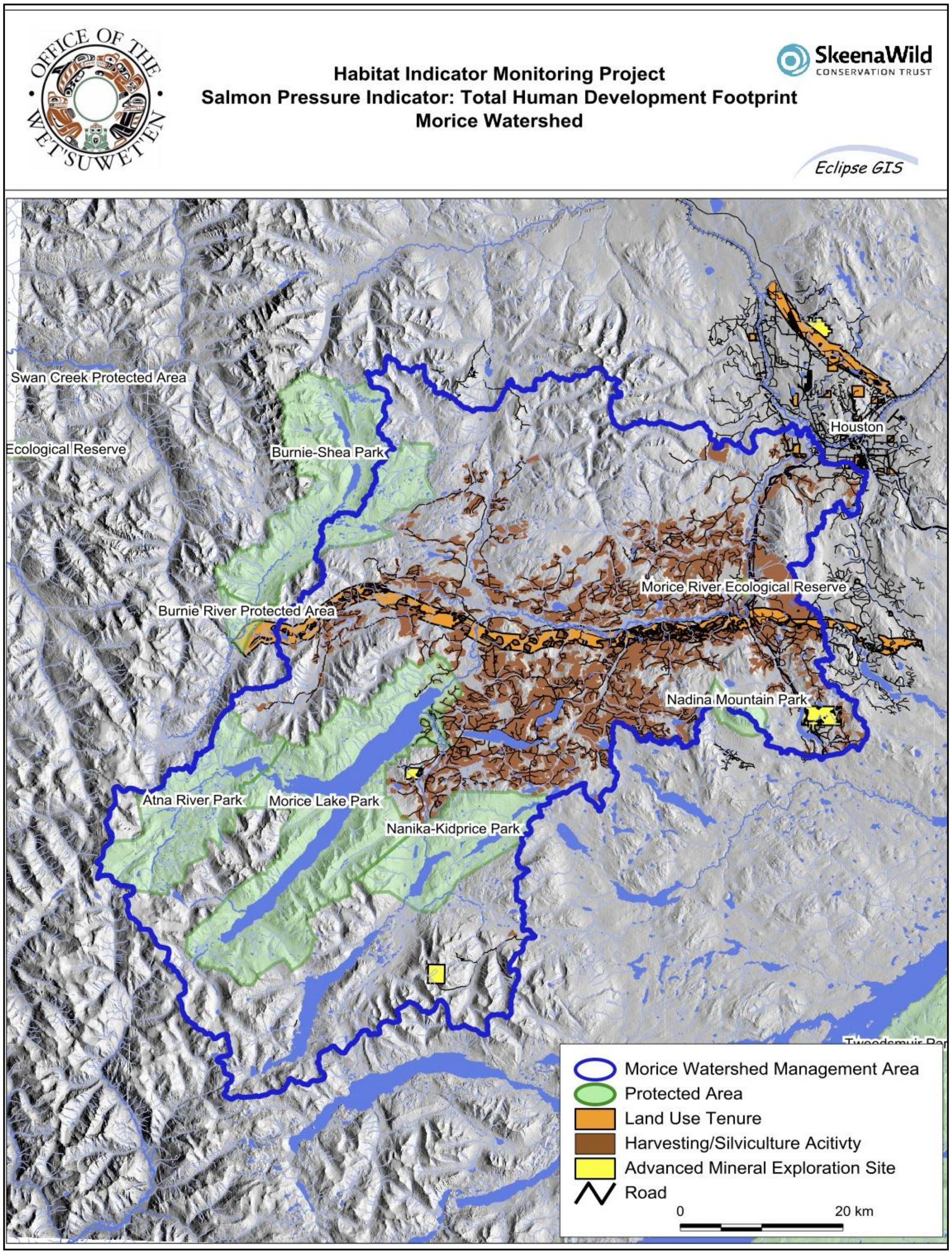

Figure 39. Morice Watershed Human Development Footprint.

5.5.2.2 Morice Watershed Management Area Human Development Footprint

Within the Morice Watershed Management Area 8.8% (300 km^2) of land has been altered by human activities as shown in Table 31 and Figure 38.

Table 31. Total HDF within the Morice Watershed Management Area

MWMA Area (km^2)	THDF Area (km^2)	Percentage of THDF within the MWMA
3,403.51	300	8.80%

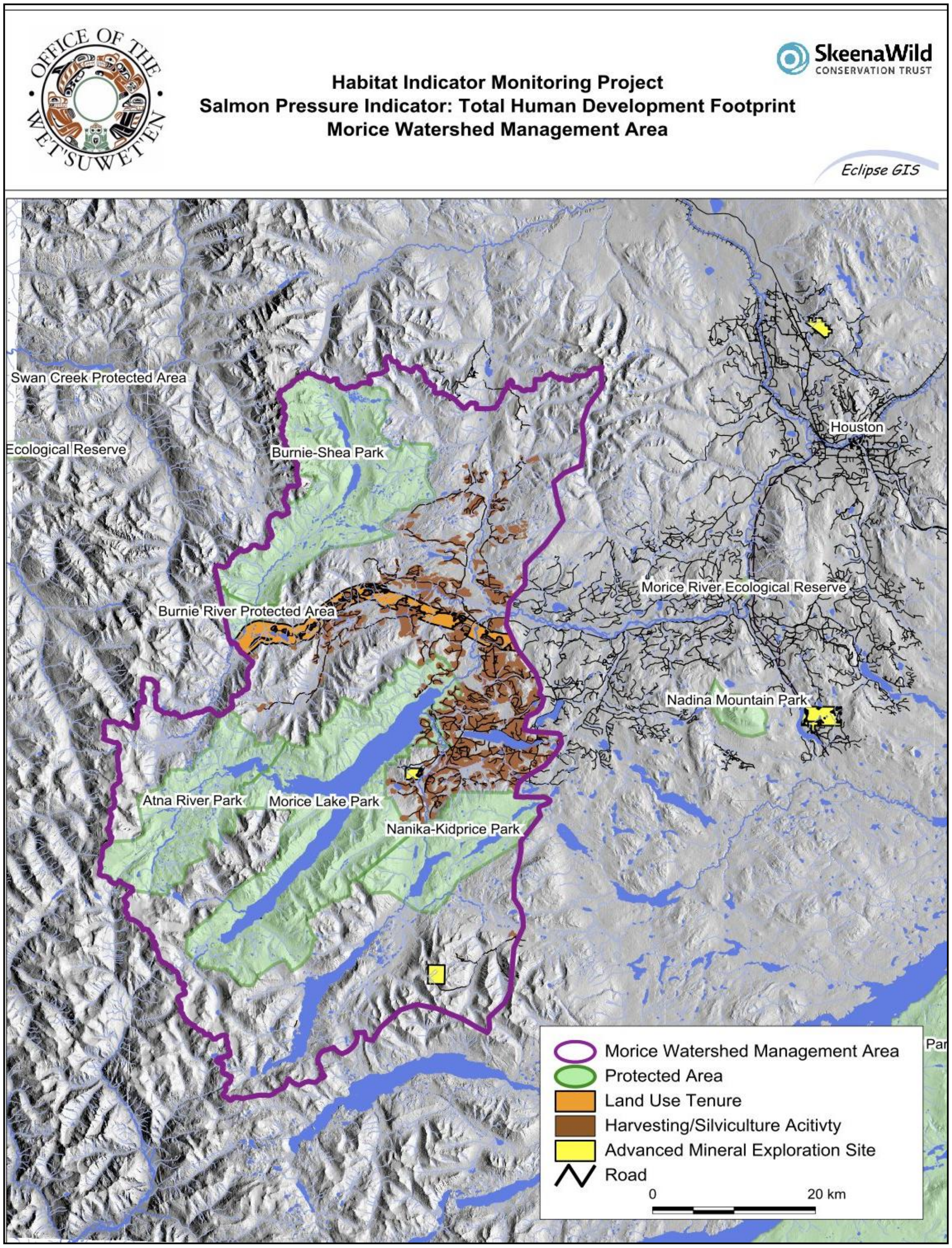

Figure 40. Morice Watershed Management Area Human Development Footprint.

5.5.2.3 Wet'suwet'en House Territories – Human Development Footprint

The total human development footprint within the ten Wet'suwet'en House Territories is 17.5% as shown in Table 32. The House Territories HDF values range from 0.6% in the Nelgi'l'at House Territory to 35.1% in the Bi Wini House Territory as shown in Figure 41. Seven of the ten House Territories have a THDF value greater than 6.4%, falling within the moderate or high threshold range.

Table 32. Total HDF within Wet'suwet'en House Territories.

House Territory	Area (km^2)	Total HDF	% Total HDF
C'iniggit Nenikekh	1,293.90	8.8	0.7
Talhdzi Wiyez Bin	494.8	17.4	3.5
Bikh C'idilyiz Ts'anli	142.5	12.4	8.7
Ts'in K'oz'ay	280.4	38.9	13.9
C'idi To Stan	505.4	88.2	17.5
Talbits Kwah	710.3	173.6	24.4
Nelgi Cek	215	55.9	26
Lhudis Bin	989.4	324.3	32.8
Bi Wini	883.3	310.2	35.1
Total	5,902.10	1,031.80	17.5

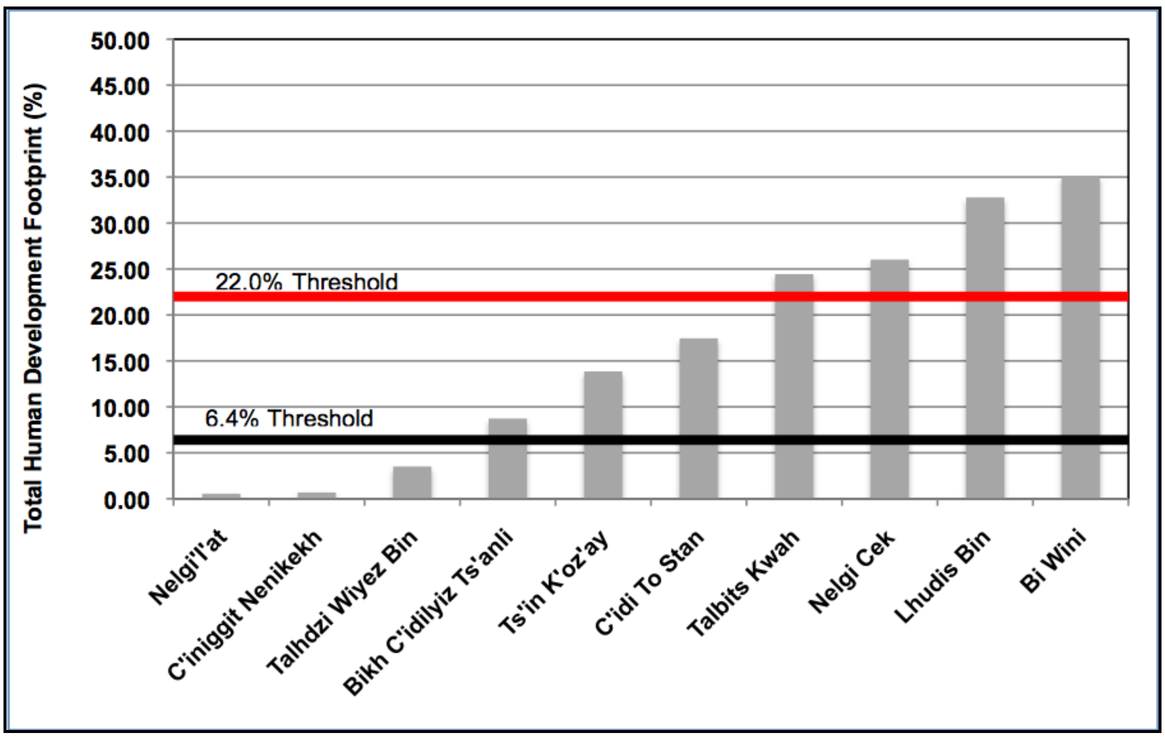

Figure 41. Total HDF within Wet'suwet'en House Territories.

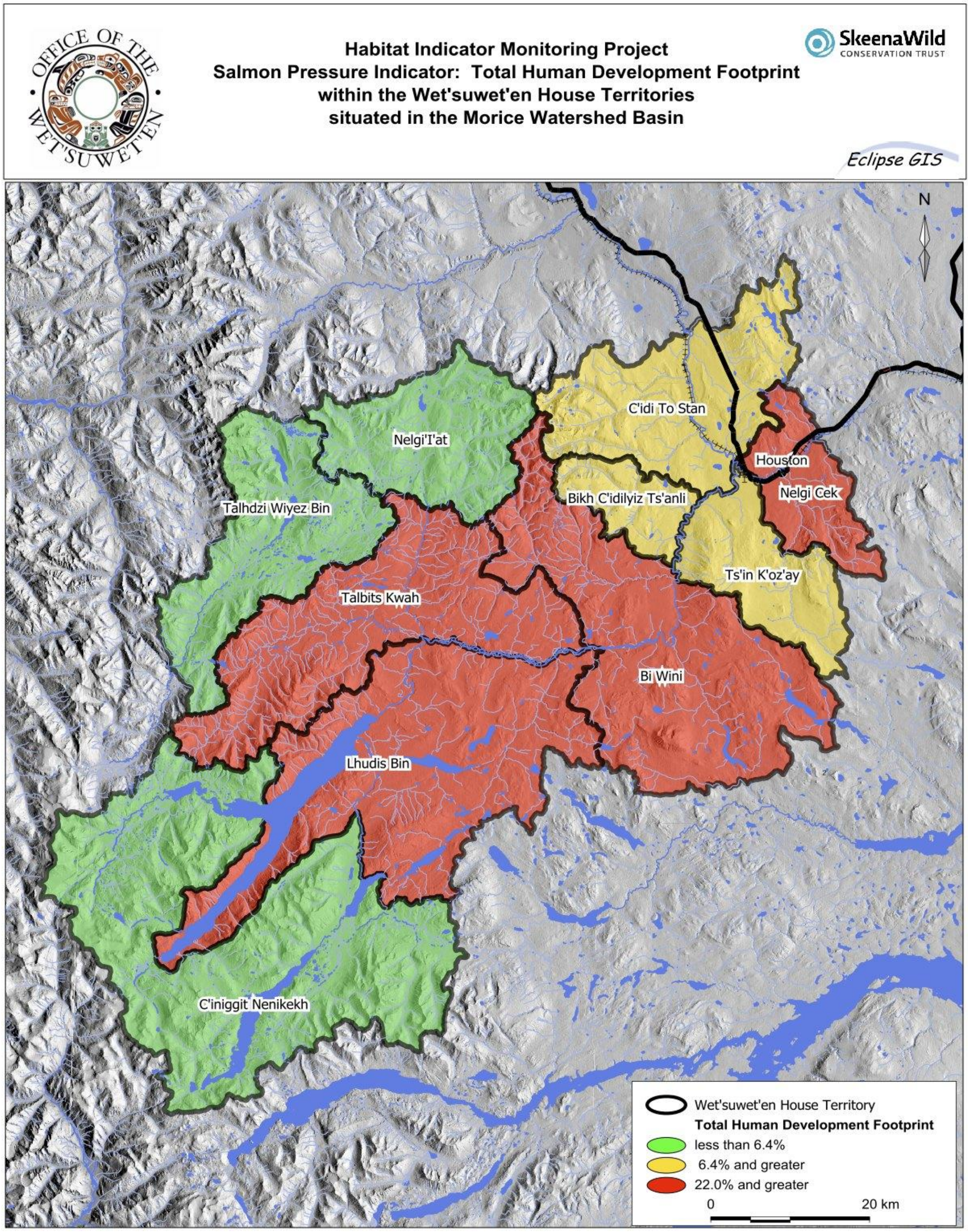

Figure 42. Wet'suwet'en Territories Human Development Footprint.

5.5.2.3 Morice Sub-watersheds Area Human Development Footprint

Within the eighteen Morice sub-watersheds the total human development footprint is 17.6% as shown in Table 33. The total HDF varies from no development in the Atna sub-basin to 61.5% in the Morice Reach 2 Southwest face unit. Four sub-watersheds have a THDF value within the low threshold category, four within the moderate category, and ten fall within the high threshold category as shown in Figures 43 and 44.

Table 33. Total HDF within Morice Sub-watersheds.

Sub-watershed	Area (km^2)	THDF Area (km^2)	THDF (%)
Crystal Creek	62.5	10	16
Shea Creek	195	9.7	5
Gosnell Creek	279.4	74.9	26.8
Subtotal	536.9	94.6	17.6
Atna River	283.9	0	0
Houston Tommy Creek	248.2	47.5	19.2
Lamprey Creek	240.3	129.6	53.9
McBride Creek	115	65	56.5
Nanika River	889.7	40.1	4.5
Owen Creek	212.4	67.2	31.7
Thautil River	423	25	5.9
Morice Lake	599.6	3	0.5
MR R1 East	71.7	43.3	60.4
MR R1 West	41	14.7	35.9
MR R2 North	206.2	87.8	42.6
MR R2 SE	101.6	47.8	47
MR R2 SW	61.6	37.9	61.5
MR R3 East	165.8	42.2	25.5
MR R3 West	181.9	25.9	14.2
Subtotal	829.9	299.7	36.1
Total	4378.9	771.8	17.6

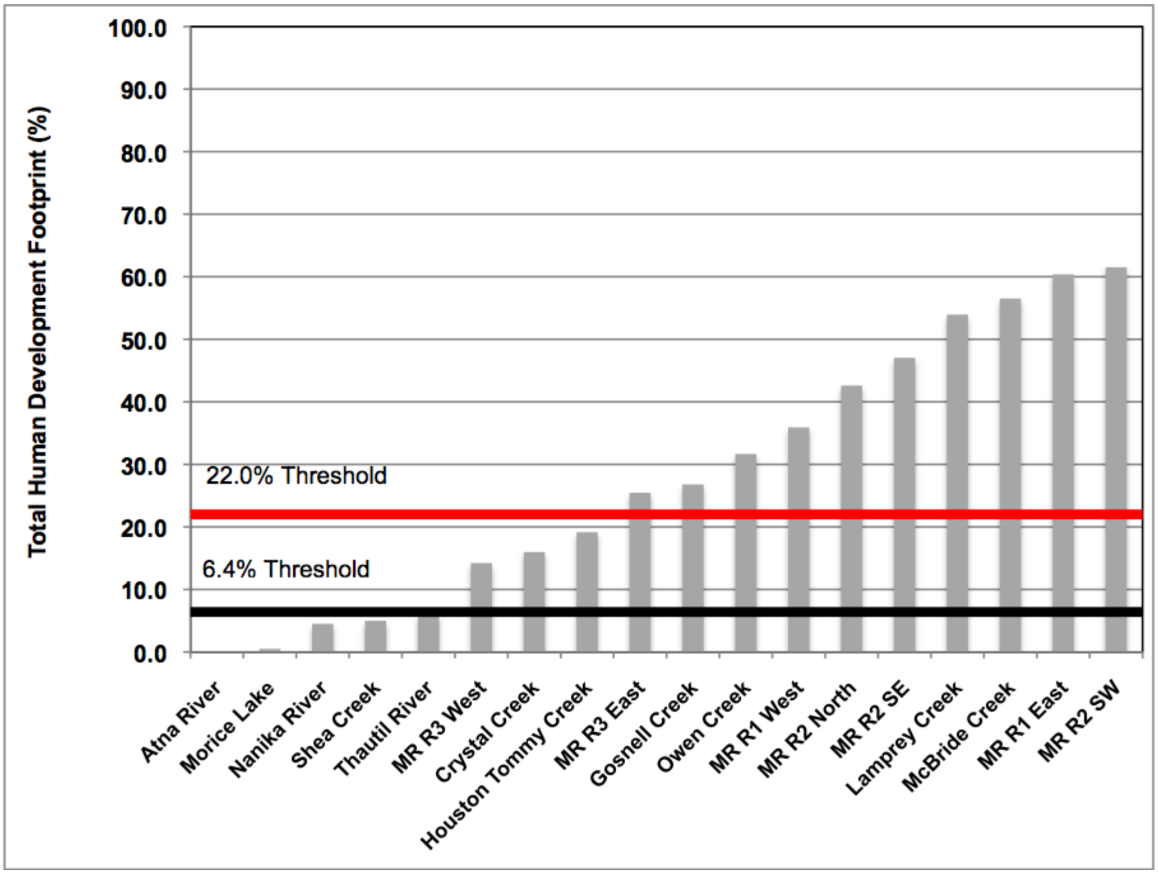

Figure 43. Total Human Development Footprint within the Morice Sub-watersheds

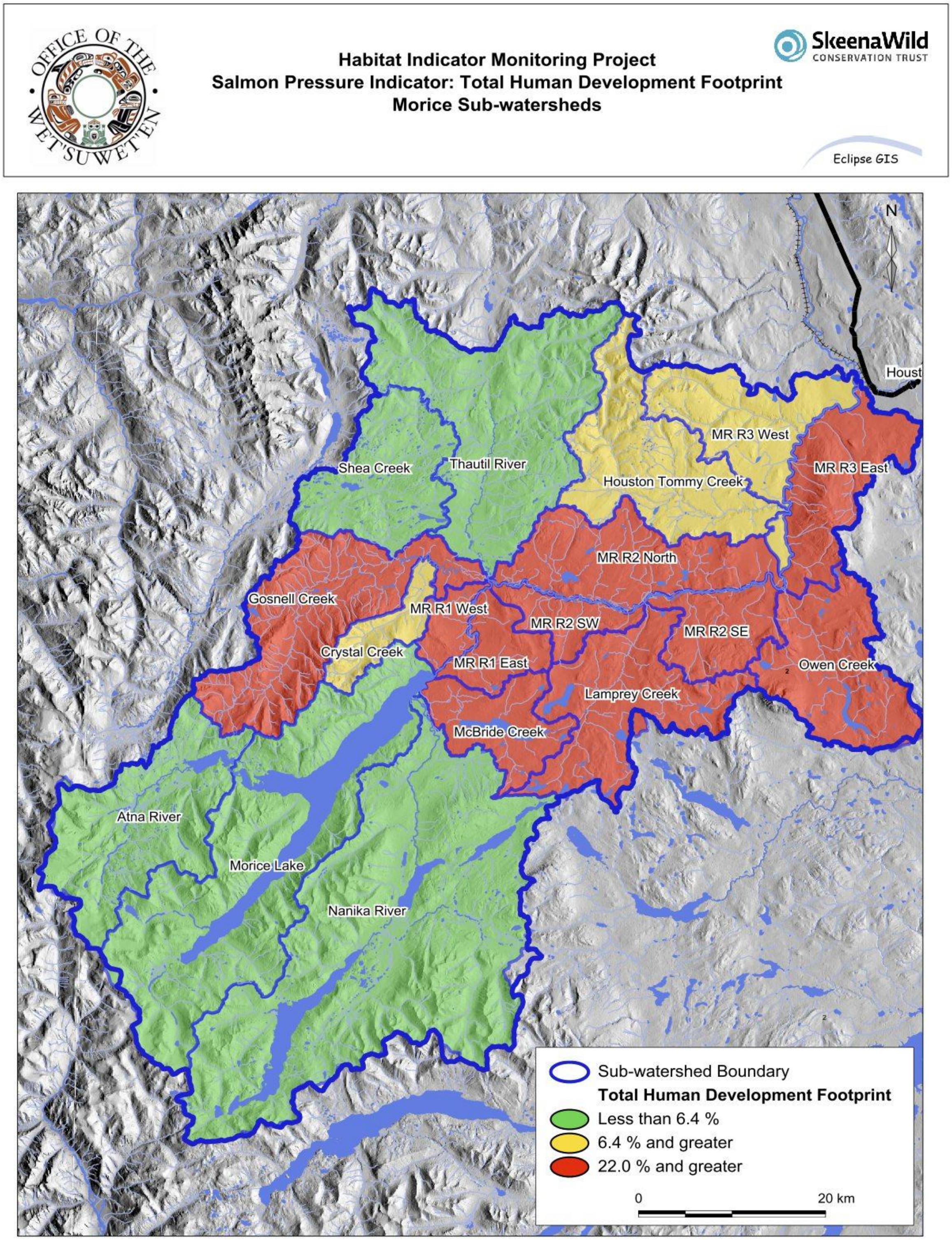

Figure 44. Morice Sub-watersheds Human Development Footprint.

5.5.3 Natural Disturbance Regimes: Mountain Pine Beetle and Wildfire

In order to understand the impact context on the land base by anthropogenic factors, it is useful to first have an awareness of the underlying natural disturbance regimes. Information on natural disturbance types, including their distribution and extent, frequency, and intensity is essential to better understanding the level of natural landscape biodiversity.

Natural disturbance is relevant such that when an ecosystem is managed within its historical range of variability, it will remain diverse, resilient, productive and healthy. Natural disturbances are now considered to be part of the process of forest and landscape development rather than an external goal of destruction.[20] Currently within British Columbia five natural disturbance types (NDTs) are recognized, based on Biogeoclimatic subzones and variants:

- NDT1 – Ecosystems with rare stand-initiating events;
- NDT2 – Ecosystems with infrequent stand-initiating events;
- NDT3 – Ecosystems with frequent stand-initiating events;
- NDT4 – Ecosystems with frequent stand-maintaining fires;
- NDT5 – Alpine Tundra and Subalpine Parkland ecosystems.

Natural disturbance types were established to set landscape level biodiversity objectives and provide a broad stratification of the landscape based on disturbance zones in BC. These natural disturbance types were based primarily on the frequency of stand-replacing disturbances. NDTs provide an ecological framework and bring context to the frequency and extent of natural disturbance analyses included below. The Morice Watershed consists of three natural disturbance types as shown in Figure 46 below. Recent research has furthered understanding of fire disturbance. Steventon (1997)[21] determined that the NDTs likely underestimate actual values by a wide margin. Retrospective fire research by Hawkes *et al.* (1997)[22] in analogous forests types in northeastern BC also determined that mean annual returns underestimate the true return values. In summary, natural disturbance regimes in Morice watershed are more complex than the broad natural disturbance types typically used by the province to set objectives for maintaining biodiversity.

5.5.4 Wet'suwet'en Fire Ecology

Forest utilization within the Wet'suwet'en territories was extensive and complex. Wet'suwet'en used fire as a tool to shape their environments and improve opportunities to harvest abundant, sustainable plant and animal resources. It has long been recognized that this tool was widely used by cultures worldwide (Boyd, 1999)[23]. By manipulating plant communities and landscape patterns, the Wet'suwet'en facilitated ecological disturbance and change within their traditional territories. Evidence presented in a number of ecological studies including Haeussler (1987)[24], note that semi-annual landscape burning activities established and contributed to the maintenance of extensive seral landscapes.

Within the Morice watershed, extensive seral landscapes are commonly characterized by younger pine stands (age class 4-7) as well as deciduous and mixed-wood stands. Many of these mid-elevation sites are associated with landscape burning, homeplaces, and major trail corridors that form part of the cultural infrastructure across the landscape.

Wet'suwet'en people relied largely on abundant harvests of berries, particularly black huckleberries, to meet their nutritional needs and provide for trading assets. The plant communities established and

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[20] Forest Practises Code (September 1995). Biodiversity Guidebook. Retrieved from www.for.gov.bc.ca/tasb/legsregs/fpc/FPCGUIDE/BIODIV/biotoc.htm

[21] Steventon, J.D. 1997. Historic Disturbance Rates for Interior Biogeoclimatic Subzones of the Prince Rupert Forest Region.

[22] Hawkes, B.C., W. Vasbinder, and C. DeLong. 1997. Retrospective fire study, final report: Fire regimes in the SBSvk and ESSFwk2/wc3 biogeoclimatic units of northeastern British Columbia. McGregor Model Forest Association, Prince George, B.C.

[23] Boyd, R. 1999. Indians, fire and the land in the Pacific Northwest. Oregon State University Press. Corvallis, Ore.

[24] Haeussler, S. 1987. Ecology and berry chemistry of some food plant species used by Northwest British Columbia Indians. Opinion Evidence for: Delgamuukw et al v. the Queen. Unpublished report on file at Office of the Wet'suwet'en. Smithers, BC.

renewed by non-stand-replacement burning (surface fires) provided an abundance of forage and structural attributes that contributed to animal feeding, protection, and breeding habitats (Williams *et al*, 2000)[25].

Traditionally, wild berries were the most important plant food on the territories in terms of amounts collected and consumed. Tremendous quantities of berries – blueberries, huckleberries, cranberries, saskatoons, and soapberries – were needed on a daily level to sustain the large Wet'suwet'en population living in the watershed. Trusler (2002)[26] conducted research into Wet'suwet'en landscape burning and his results document burning, berry gathering, processing, and storage.

With the surge of Euro-Canadians settlers following World War One, the forest service effectively halted traditional landscape burning practices because the colonial society possessed quite different environmental concepts. Successional processes acting on these ecosystems along with government fire suppression resulted in the substantial changes due to conifer ingress and canopy closure. Consequently, landscape conditions changed with implications for wildlife, forests, and landscape diversity.

Recent Wet'suwet'en research landscape burning in the Morice results indicate the incidence of fire scarring appears to have declined since the early 1900s. Interestingly, the landscape burning research results noted that due to spring burning, riparian zones were typically not affected by Wet'suwet'en burning activities.

Figure 45. View southward on Morice Lake, west side fire 2012.

Wet'suwet'en Knowledge of traditional land use management was honed over many thousands of years that established an understanding of the tools and techniques allowing for optimal utilization and conservation of plant foods, forests, animal populations and fish stocks. Detailed knowledge of the territories and the understanding of the commonality between nature and man enabled Wet'suwet'en people to live in the Morice watershed for a very long time and pass on management, conservation concepts, and laws to succeeding generations.

[25] Williams, H., D. McLennan, and K. Klinka. 2000. Classification and interpretation of hardwood dominated ecosystems in the dry cool Sub Boreal Spruce (SBSdk) subzone and moist cold Interior Cedar Hemlock (ICHmc2) variant of the Prince Rupert Forest Region. Unpublished report prepared for the Prince Rupert Forest Region. Smithers, BC.

[26] Trusler, S. 2002. Footsteps among the berries: the ecology and fire history of traditional Gitxsan and Wet'suwet'en huckleberry sites. MS Thesis, UNBC.

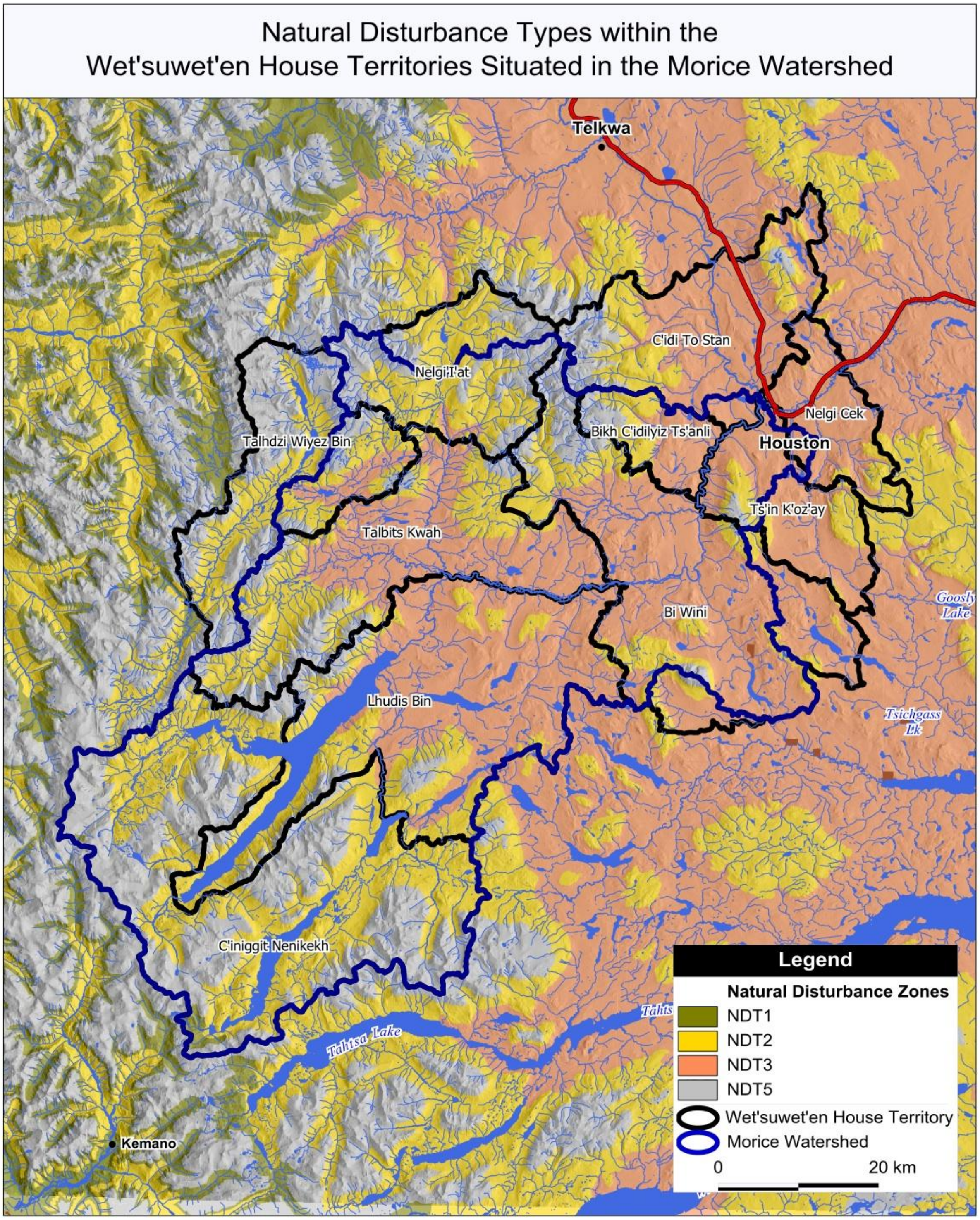

Figure 46. Natural disturbance types in Morice watershed.

5.5.3.1 Natural Disturbance Type Methodology

The following GIS spatial information was used in the natural disturbance analyses:

- Historical fire data from 1920 to 2011 (Fire Protection Branch, BC Gov't);
- Current fire data from 2012 (spot fires excluded – Fire Protection Branch, BC Gov't);

- Forest Health data specific to Mountain Pine Beetle, from 2001 to 2012, but excluding 2008[27]. (Forest Health Program, BC Gov't);
- Natural Disturbance Types (NDTs) (Research Branch, MoF).

Spatial data for other biotic natural disturbance agents such as disease and pests other than the MPB were available but not included as it was beyond the scope of the analysis. Reliable data for abiotic natural disturbance agents, such as windthrow, was not available. The wildfire data does not include traditional aboriginal burn sites. The wildfire database attempts to capture the historical frequency and extent of wildfires dating back to 1920, but there are limitations, especially in the 1940 – 1959 interval[28]. The historical fire data from 1920 to 2011 was used as is; the current 2012 fire polygons were added; however, spot fires were excluded.

The forest health data specific to the mountain pine beetle (MPB) was collated to include only those identified areas with more than 10% infestation[29.] Forest health data from 2001 to 2012 was combined, and where severity ratings across years overlapped, the higher severity rating prevailed. MPB data was analysed using the forest health data polygons and does not drill down to the stand level.

The severity rating here applies to the extent, not the intensity, of the MPB outbreak. Severity ratings are taken from the Aerial Overview survey methods and were revised in 2004 as follows:

Table 34. Forest Health Severity Ratings.

Severity	Code	Percent of Trees in Polygon With Red Attack
Trace	T	< 1% attack
Light	L	1 - 10% attack
Moderate	M	11 – 30% attack
Severe	S	31 – 50% attack
Very Severe	V	> 50% attack

The natural disturbance types provide a general framework for extent and frequency of disturbances such as mountain pine beetle infestations, fire, and possibly anthropogenic disturbances. Thresholds applied to the Total Human Development Footprint do not relate or directly transfer to natural disturbance agents such as mountain pine beetle and wildfires.

5.5.5 Natural Disturbance Type Results

The results of the fire and the Mountain Pine Beetle analysis are reported out separately by the Morice Watershed, the eighteen Morice sub-watersheds, the Morice Watershed Management Area, and the ten Wet'suwet'en House Territories within, or partly within Morice watershed.

5.5.6 Mountain Pine Beetle

5.5.6.1 Morice Watershed MPB

The forest health data from 2001 to 2012 indicate that 15.2% of the area has been rated moderate severity, with 24.3% of the stands having a moderate or higher severity rating, as shown in Table 41. The majority of the disturbance (69.2%) has occurred within the NDT3 zone, which is classified as an ecosystem with frequent stand-level initiating events. 30% of Mountain Pine Beetle activity is located in NTD2.

[27] The 2008 survey year experienced technical difficulties resulting in a poor quality data set.

[28] K. Rabnett, personal communication, September 9, 2013.

[29] The analysis method used here is dependent on the structure of the data. This analysis takes a conservative approach and removed Mountain Pine Beetle infestation areas with less than 10% infestation. The approach eliminated large polygons with low infestation rates which could skew the analyses results.

Table 35. Mountain Pine Beetle Severity by Natural Disturbance Type

Severity Rating	NDT2 (km^2)	NDT3 (km^2)	NDT5 (km^2)	Total Disturbance (km^2)	% of Watershed
Moderate (11 - 30%)	207.1	449.4	8.8	665.3	15.2
Severe (31 - 50%)	111.3	280.7	0.5	392.5	9
Very Severe (> 50%)	0.0	7.3	0.0	7.3	0.2
Total	318.5	737.4	9.3	1065.1	24.3

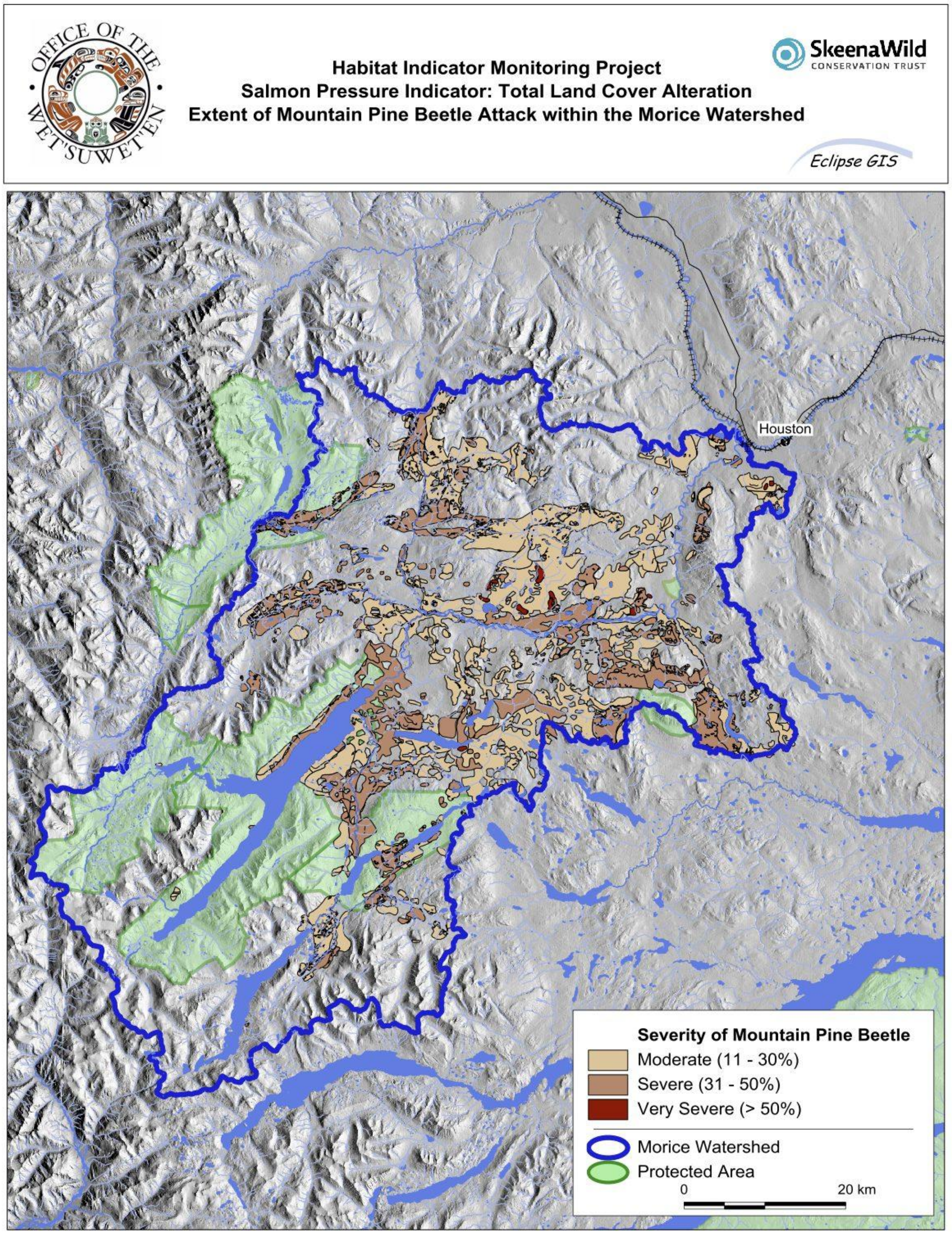

Figure 47. Morice Watershed Mountain Pine Beetle Attack.

5.5.6.2 Morice Watershed Management Area – MPB

Across the MWMA, Mountain Pine Beetle affects 15.1% of pine leading stands. The majority of the MPB disturbance has occurred in the NTD2 (47.2%) and NTD3 (51.8%) zones. The NDT2 zone is more prevalent to the west, and therefore the MWMA has a greater representation of the NDT2 zone than the Morice watershed.

Table 36. Mountain Pine Beetle Severity by Natural Disturbance Type in the MWMA.

Severity Rating	NDT2	NDT3	NDT5	Total (km^2)	% of MWMA
Moderate (11 - 30%	144.3	129.2	5	278.5	8.2
Severe (31-50%)	98.5	136.9	0.2	235.7	6.9
Very Severe (> 50%)		0.5		0.5	0
Total	242.9	266.7	5.2	514.7	15.1

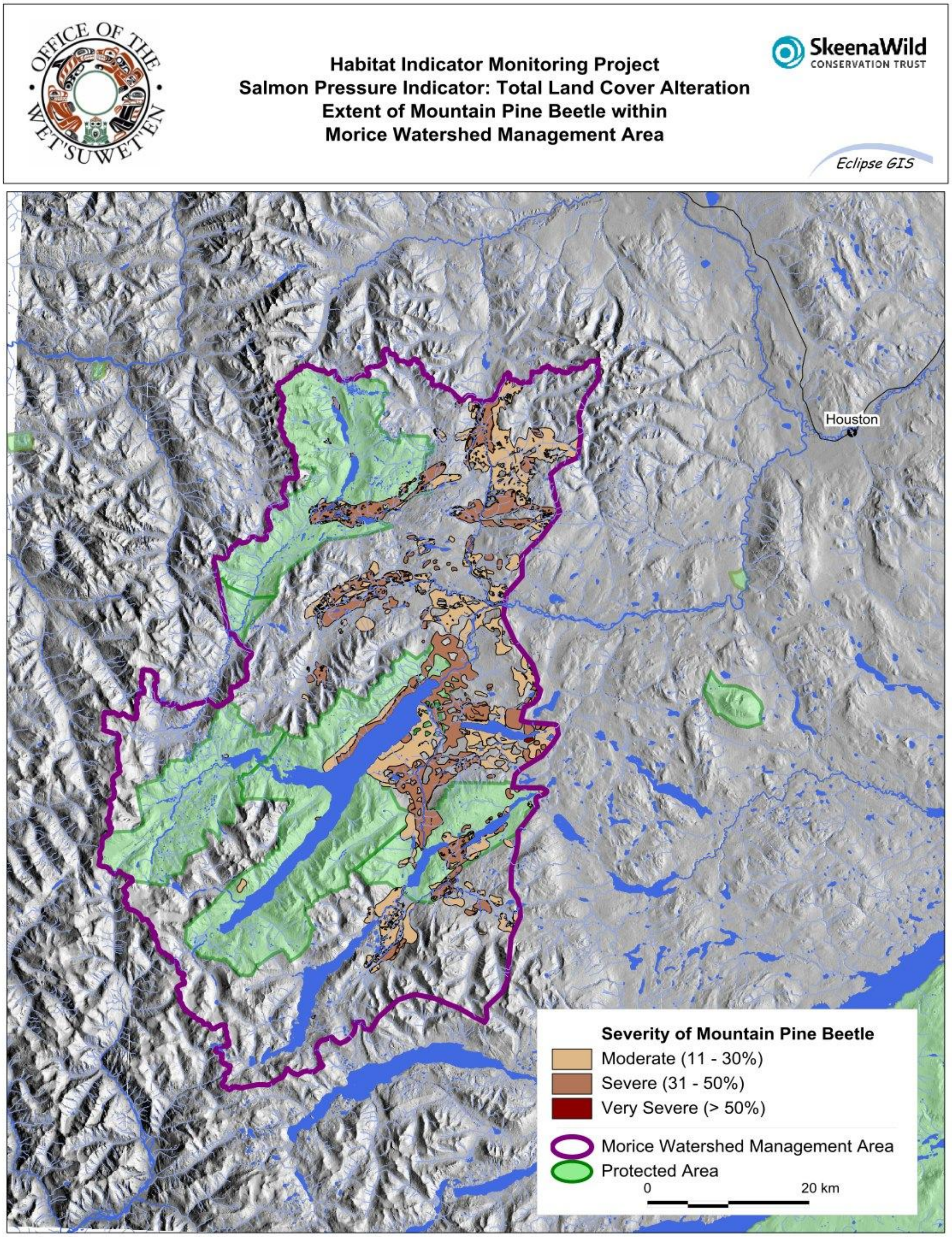

Figure 48. Morice Watershed Management Area MPB Attack.

5.5.6.3 Wet'suwet'en House Territories within Morice Watershed

Mountain Pine Beetle has affected 24.5% of the pine across the ten Wet'suwet'en House Territories situated within, or partly within Morice watershed. The extent of the Mountain Pine Beetle varies across the House Territories, ranging from 5.2% in the C'iniggit Nenikekh territory to 42.4% in the Bi Wini territory. The MPB affected NDT2 and NDT3 zones were respectively 33% and 67% and collectively contained 99% of the disturbance.

Table 37. Percent of House Territory Affected by Mountain Pine Beetle Severity

	NDT2				NDT3				NDT5				
House Territories	**Moderate (km^2)**	**Severe (km^2)**	**Very Severe (km^2)**	**Total (km^2)**	**Moderate (km^2)**	**Severe (km^2)**	**Very Severe (km^2)**	**Total (km^2)**	**Moderate (km^2)**	**Severe (km^2)**	**Total (km^2)**	**Total (km^2)**	**% of House Territory**
Bi Wini	57.5	22.1	1	80.7	160.8	120.4	9	290.2	3.5	0.2	3.7	374.6	42.4
Bikh C'idilyiz Ts'anli					13	0.6		13.5				13.5	9.5
C'idi To Stan	18	2.9	0.2	21.1	72.1	17.9	1.6	91.6	2.7		2.7	115.4	22.8
C'iniggit Nenikekh	45.6	17.7		63.3	0.1	3		3.1	0.3		0.3	66.7	5.2
Lhudis Bin	43.7	25.7		69.4	174.4	119.8	0.5	294.7	0.3		0.3	364.4	36.8
Nelgi Cek	14.1	0.1		14.2	44.6	8.9	0.7	54.2				68.4	31.8
Nelgi'I'at	80.7	21		101.7	8	2		10	4.6	0.1	4.7	116.4	30.1
Talbits Kwah	31	25.1		56.1	96.4	51.9	5	153.4	0.3	0.1	0.4	209.9	29.6
Talhdzi Wiyez Bin	2.8	15.9		18.7	4.2	11.3		15.4	0.2		0.2	34.3	6.9
Ts'in K'oz'ay	14	7.6		21.6	30.6	31.7	0.1	62.3		0.1	0.1	84	30
Total	307.5	138.1	1.2	446.8	604.2	367.3	16.9	988.4	11.8	0.5	12.3	1447.5	24.5

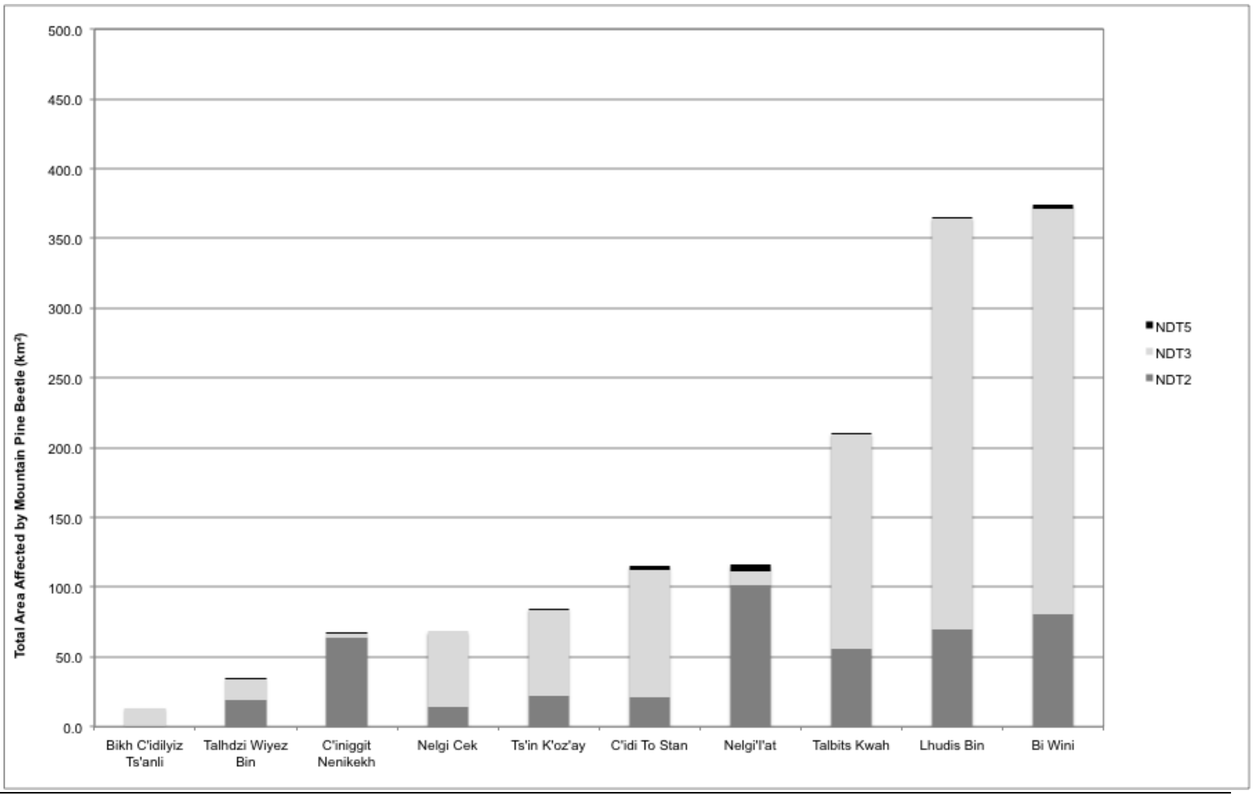

Figure 49. House Territory Areas in km^2 affected by MPB and by Natural Disturbance Type.

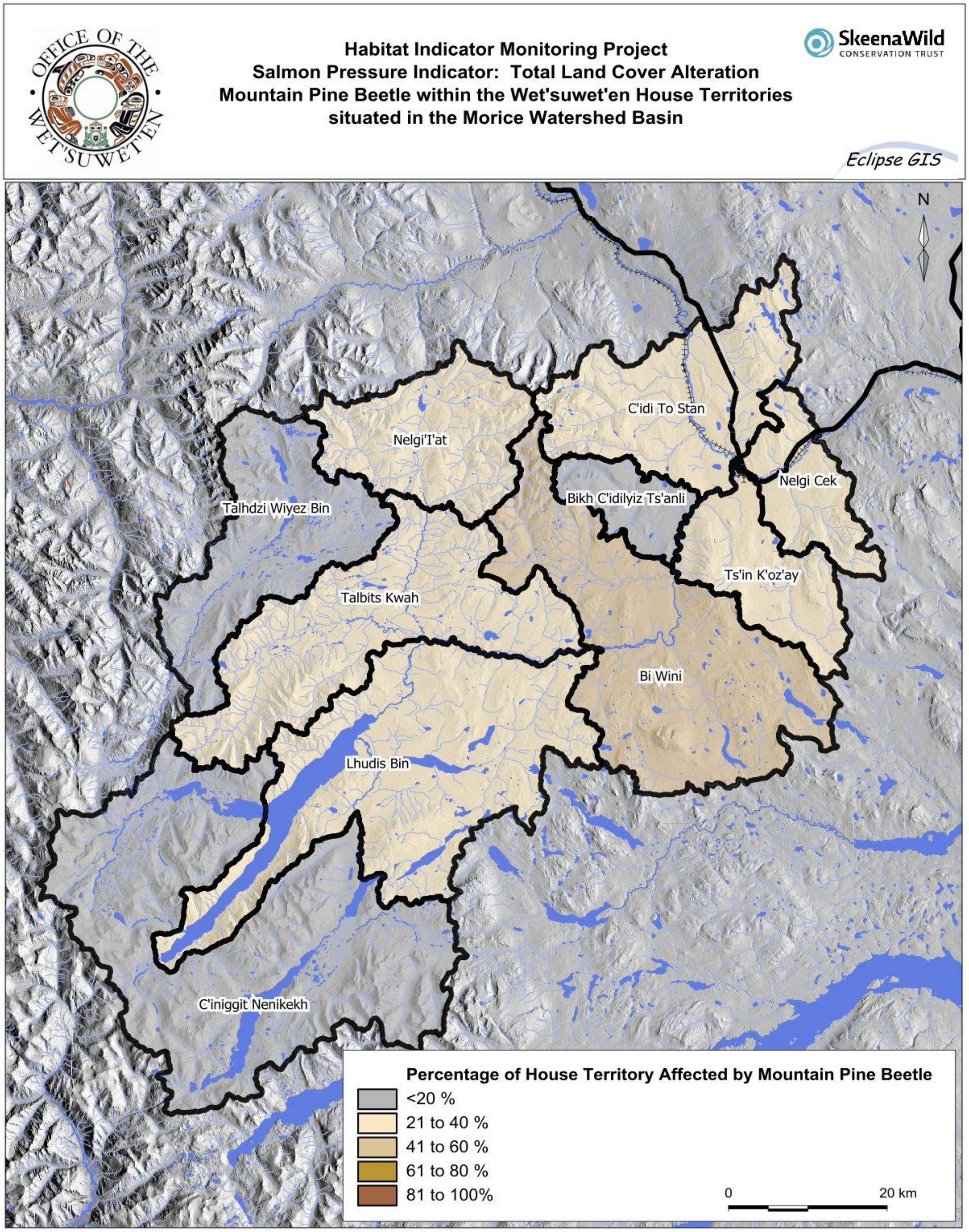

Figure 50. Percentage of House Territory Affected by Mountain Pine Beetle.

5.5.6.4 Morice Sub-watersheds

Mountain Pine Beetle activity within the eighteen Morice sub-watersheds ranges from 0.1% in Atna River to 61.2% in Morice River Reach 1 West. Sub-watersheds with more than 50% MPB activity include Morice River Reach 2 Southeast (56.0%), McBride Creek (56.6%), Lamprey Creek (57.3%), Morice River Reach 1 North (61.2%), and Morice River Reach 2 North (58.6%). The majority of the MPB disturbance occurred in NDT3 (69.2%), with 30.0% occurring in the NDT2 zone.

Table 38. Sub-watershed Mountain Pine Beetle Severity and Natural Disturbance Type.

	NDT2			NDT3				NDT5			Summary	
Sub-watershed	Moderate (km^2)	Severe (km^2)	Total (km^2)	Moderate (km^2)	Severe (km^2)	Very Severe (km^2)	Total (km^2)	Moderate (km^2)	Severe (km^2)	Total (km^2)	Total (km^2)	% of Sub-watershed
Atna River	0.3		0.3								0.3	0.1
Crystal Creek		0.2	0.2	4.4	1.2		5.6				5.8	9.3
Gosnell Creek	10.8	13.5	24.3	14.8	13.8		28.6	0		0	52.9	18.9
Houston Tommy Creek	39.6	0.6	40.2	48.3	2.4		50.7	3.4	0.2	3.6	94.5	38.1
Lamprey Creek	13.3	2.8	16.1	85.2	36.5		121.7				137.8	57.3
McBride Creek	1.3		1.3	27.7	35.6	0.5	63.9				65.1	56.6
Morice Lake	13.5	4.3	17.8	9.6	9.7		19.3	0.5		0.5	37.6	6.3
MR R1 East	3.9	0.1	3.9	11.2	7.1		18.3				22.3	31.1
MR R1 West		2.6	2.6	11	11.5		22.5				25.1	61.2
MR R2 North	4.2	0.2	4.4	82.7	27.7	6	116.5				120.9	58.6
MR R2 SE	0.2	9.3	9.5	23.3	24.1		47.3				56.9	56
MR R2 SW	3.4		3.4	11.7	0.2		11.8				15.3	24.8
MR R3 East	0.2	2	2.2	17.2	6.2	0.6	24		0.1	0.1	26.3	15.9
MR R3 West				24.2	2.9		27.1				27.1	14.9
Nanika River	58.4	35.8	94.3	19.6	28.7		48.3	0		0	142.6	16
Owen Creek	1.6	3.1	4.6	29.7	42.6	0.2	72.5				77.1	36.3
Shea Creek	1.9	10.8	12.7	7.3	13.7		21.1				33.8	17.3
Thautil River	54.7	25.9	80.6	21.5	16.9		38.3	4.8	0.2	5	123.9	29.3
Total	207.1	111.3	318.5	449.4	280.7	7.3	737.4	8.8	0.5	9.3	1065.1	24.3

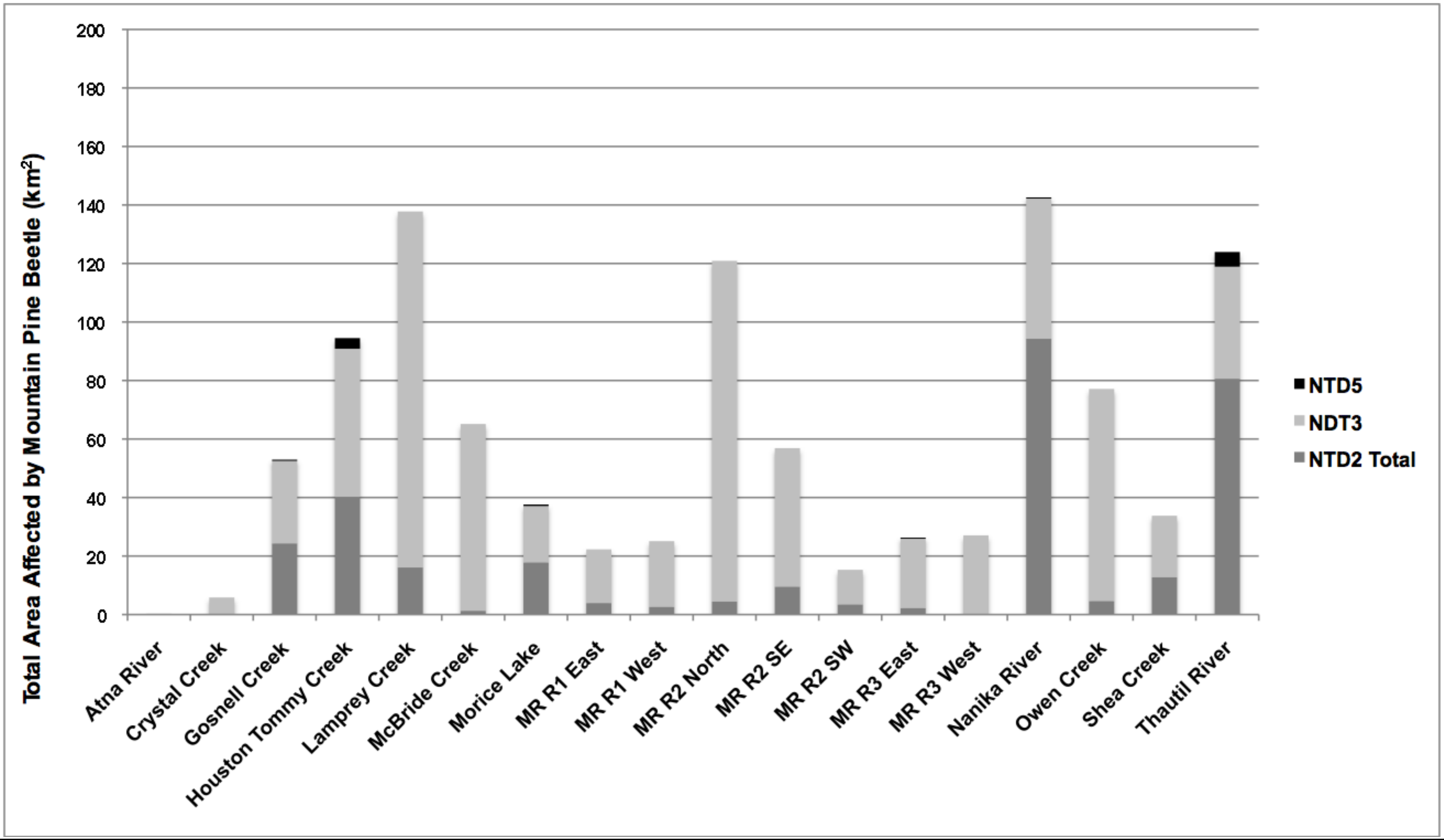

Figure 51. Morice Sub-watersheds affected by Mountain Pine Beetle and Natural Disturbance Type.

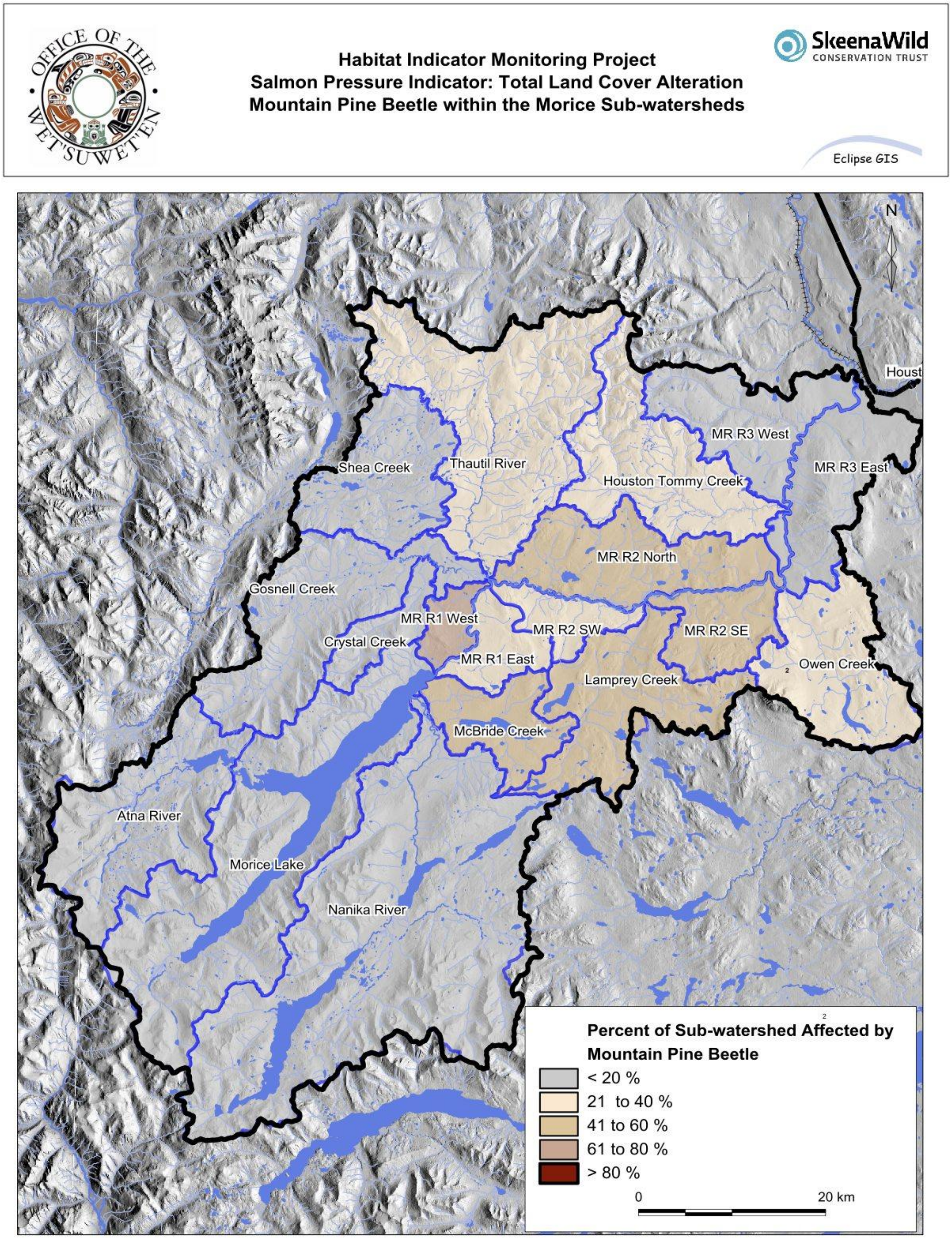

Figure 52. Percentage of Morice Sub-watersheds affected by Mountain Pine Beetle.

5.5.7 Fire Disturbance

Fire History data from 1920 to 2012 was analyzed by frequency as well as extent. In order to maintain perspective, the results are presented only by the extent of the largest analysis unit, the Wet'suwet'en House Territories within, or partly within Morice watershed. The fire disturbance data is summarized by 20-year intervals, and further broken down by Natural Disturbance Type. The compiled fire history data is respectable; however, the reader is cautioned that many fire events have not been recorded.

5.5.7.1 Fire Frequency

From 1920 to 2012, average fire frequency within the study area is 1.6 fires per year. The breakdown of fire frequency by Natural Disturbance Type is 18.9% in NDT2, 60.1% in NDT3, and 20.0% in NDT5. The cause of wildfires within the Morice watershed has shifted over the past 12 years. Prior to 2000, man caused 64% of the fires within the Morice watershed. Since 2000, only 3% of the wildfires were caused by man with the remaining 97% of the wildfires caused by lightning strikes.

Table 39. Fire Frequency by Year (1920 – 2012) and Natural Disturbance Type.

Fire Year	NDT2	NDT3	NDT5	Total Number of Fires
1920-1939		47		47
1940 - 1959	2	11	15	28
1960 - 1979	2	7	2	11
1980 - 1999	4	9	7	20
2000 - 2012	19	12	6	37
Total	27	86	30	143

5.5.7.2 Fire Extent

The average fire size from 1920 to 2012 is 2.26km^2; however, if the 1983 Swiss Fire is excluded, the average fire extent drops to 0.84 km^2. The 1983 Swiss Fire was 21,576.8 ha (216 km^2) and spanned NDT3, NDT2 and NDT5 mostly due to wind direction and intensity. Since 1920 85.2% of the recorded fires occurred in the NDT3 zone, 13.9% in the NDT2 zone, and the remaining 0.9% within the NTD5 zone. Although 19.7% of the fires occurred in the NTD5 zone from 1940 – 2012, they were all small fires covering a total extent of 2.8 km^2.

Fire behaviour is complex and generally governed by pre-fire moisture levels, types and amounts of fuel load, wind, and topography. In general, stand-replacing fire disturbances appear to vary across the landscape closely following a gradient in precipitation or micro-climate sites. It is important to understand that the moderate and severe fire severity regimes are inclusive of a complex mix of uneven severity with ranges from lightly burnt to severely burnt.

Table 40. Fire Extent by Year and Natural Disturbance Type.

Fire Year	NDT2	NDT3	NDT5	Total (km^2)
1920 -1939	0.0	51.6	0.0	51.6
1940 - 1959	1.3	9.1	0.6	11.1
1960 - 1979	0.5	4.2	0.2	5.0
1980 - 1999	25.3	191.2*	1.9	218.4
2000 - 2012	20.8	36.3	0.1	57.3
Total	47.9	292.5	2.8	343.4

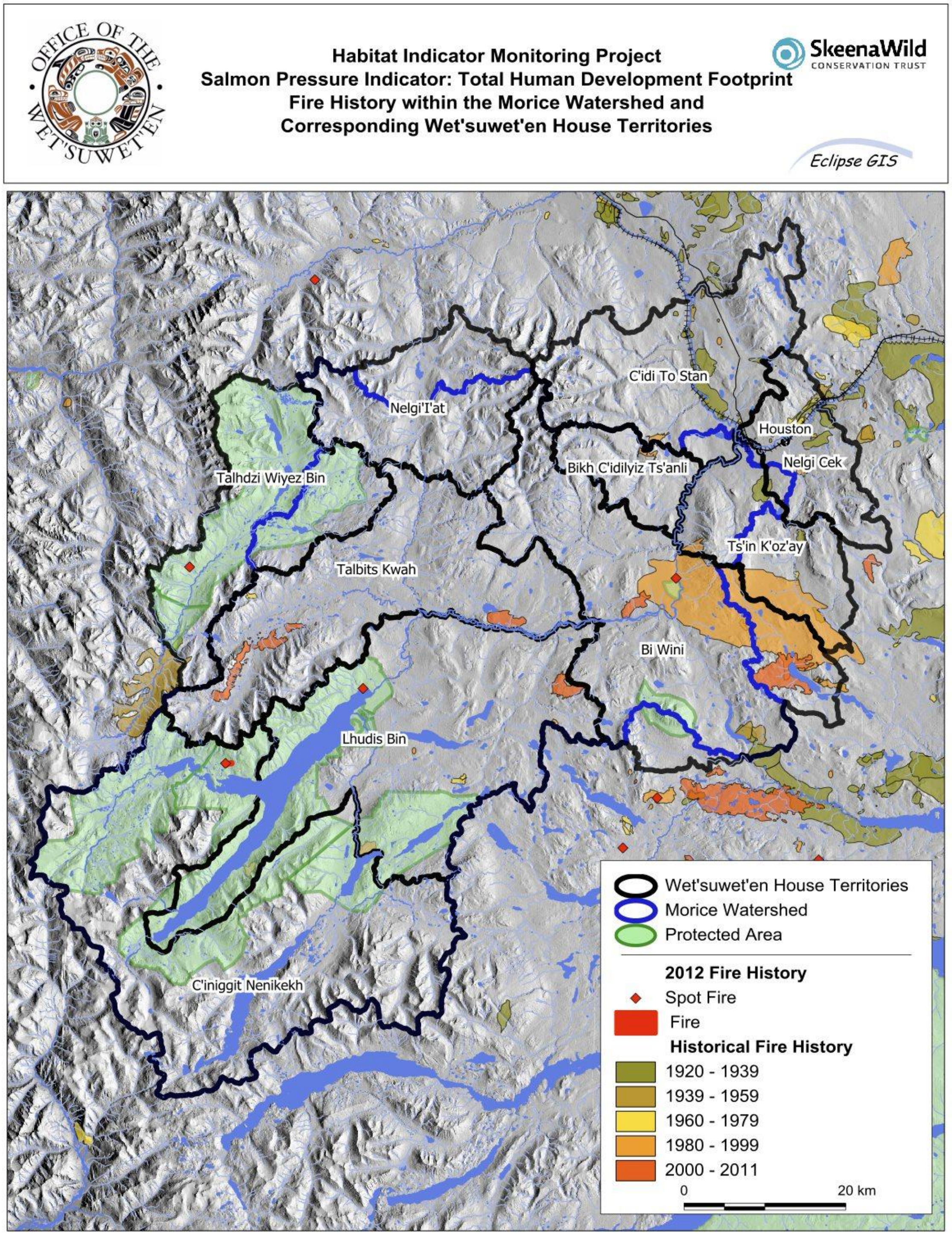

Figure 53. Morice Watershed Fire History.

5.5.8 Summary of Development and Natural Disturbance Type

These analyses present a synopsis of the three disturbance regimes including current development, wildfire, and mountain pine beetle. The analyses provide a high level comparison of the natural disturbance regimes – mountain pine beetle and wildfire footprints, and human development footprint placed within a threshold context.

Table 41. Extent of Disturbance by Natural Disturbance Type.

	NDT2	NDT3	NDT5	Total Disturbance (km^2)
Extent of Wildfire (km^2)	47.9	292.5	2.8	343.4
Total HDF (km^2)	82.1	684	5.8	771.8
Extent of MPB (km^2)	318.5	737.4	9.3	1065.1

The relative extent of the three disturbances ranked from lowest to highest is: wildfire, human development, and mountain pine beetle as shown in Table 41. Wildfire has the lowest footprint at 343.4 km^2. The human development footprint of 771.8 km^2 is over double that of the wildfire footprint. Mountain pine beetle activity is the largest footprint at 1,065.1 km^2. All three disturbances are more prevalent within the NDT3 zone, with a relatively low disturbance footprint within the NDT5 zone.

The wildfire and mountain pine beetle analyses presented only looks at the extent of the disturbance and as such, does not indicate the severity or intensity of the disturbance. The severity of the disturbance is unknown at this level of analysis and is beyond the scope of this project. Given the uncertainty around the severity of MPB, the intensity could be much lower than wildfire or human disturbance because areas with less than 10% of MPB activity were excluded from the database..

The results presented in these analyses represent a snapshot in time, as natural disturbance regimes are dynamic processes. The interaction between natural disturbance agents and development activities is not well understood; however, in the Morice, forest development has generally focused logging on forest fire and MPB activity areas, except where forest health priorities target pine leading stands or stumpage incentives benefit spruce and sub-alpine fir harvesting.

Natural disturbance regimes are complex processes, and our "understanding and prediction of even current forest disturbance regimes is elementary and disparate among disturbance types, making projections into the future under a warmer climate extremely difficult."[30]

An understanding of the impact of mountain pine beetle outbreaks on the surviving trees in residual stands, regeneration, woody debris dynamics, and fire potential is needed for managers to make better decisions regarding conservation management of residual mountain pine beetle affected stands.

5.5.9 Morice Land Cover Alteration Discussion

The majority of the human development footprint and the natural disturbances are located in the easily accessible, lower portion of the watershed generally lying upon the Nechako Plateau, including where it fingers into the Kitimat and Tahtsa Ranges. Over the last 60 years, since clearcut became the preferred method of logging, land cover alteration in Morice watershed has been considerable and in summary includes:

- Human development footprint is currently 772 km^2;
- Mountain pine beetle activity – mostly rated as moderate and severe – has disturbed 1065 km^2;

[30] Haughian, S.R., P.J. Burton, S.W. Taylor, & C. L. Curry. 2012. Expected effects of climate change on forest disturbance regimes in British Columbia. BC Journal of Ecosystems and Management 13(1):1-24 Published by FORREX Forum for Research and Extension in Natural Resources. http://jem.forrex.org/index.php/jem/article/viewFile/152/107

- Fires over the last three decades have burnt 276 km^2;
- Total land cover alteration is 2112 km^2 or 48% of the 4,380 km^2 Morice watershed area.

The analysis shows that many territories, in particular Talbits Kwah, Lhudis Bin, and Bi Wini – have had far-reaching and significant environmental changes, particularly in regard to access roads, land use, forest cover, and aquatic habitat. Land use change in the Morice has been unsustainable and has impacted fish, wildlife, water, biodiversity, and Wet'suwet'en health and well-being. Given the current status of the human development footprint and natural disturbance regimes, the Wet'suwet'en can no longer rely on stability and predictability in BC government land use strategies and models including forest management. It is time to establish new policies and procedures based on conservation and sustainable, low-impact economic development that supports landscape level recovery planning.

5.6 Climate Change

Climate change is happening here and now—not in abstract global climate models or projected future scenarios. The mountain pine beetle outbreak that swept through BC's interior illustrates the catastrophic results of seemingly minor temperature shifts. Climate change is making life difficult for the magnificent runs of wild Pacific salmon that swim upstream approximately 515 km from the ocean, to spawn and die in the Morice streams and lakes where they were born. It is also making life harder for the incredible resident fish due to alteration of the local environment particularly in regard to four general important risks:

- Change in stream temperature;
- Change in stream flow regime;
- Alteration of stream channel structure;
- Stream siltation.

Climate change has complicated management of Morice watershed natural resources – especially forests, fish, and wildlife. The globe is seeing species extinction rates at levels not seen since the age of the dinosaurs. We are in an age of predicted massive human induced loss of biological diversity over the next century (Wilson 1993)[31]. It is recognized and acknowledged there is uncertainty about the rate, dimensions and projected impacts of climate change. But, the magnitude of what is certain – will change everything.

Shifting disturbance regimes and patterns could become as important as increasing temperature and changing levels of precipitation. Landscape-scale disturbances and extreme weather events could determine the character of transient and ultimately new ecosystems.

Climate is a huge challenge and includes maintaining the productive capacity of fish habitat in the face of a changing climate. Changing climate is having and will have further effects on the environmental conditions experienced by salmon and resident fish in both the freshwater and marine locales, and also on the impacts to aquatic ecosystems from human activities.

On a practical level, that means there is a need to coordinate development and conservation around a strategy focused on getting as many species as possible through the extinction bottleneck in order to retain maximal levels of biological diversity. Ecosystem responses are complex and difficult to predict; they reflect combined and synergistic effects of climate, natural disturbances, land & resource uses, and invasive species.

Overall, one can only expect surprises with climate change.

[31] Wilson, E.O. 1993. The Diversity of Life.

6.0 CUMULATIVE RISK

Within the last 60 years, the Wet'suwet'en have witnessed one crisis after another that has brought Morice watershed, land use, and its resources into its present conditions; these include:

- Missing salmon and diminished abundance since the mid-1950s;
- Construction of 2,020 km of access roads;
- Logging of more than 750 km^2;
- Mountain pine beetle outbreak affecting at least 1,065 km^2;
- Loss of massive amounts of Wet'suwet'en cultural heritage;
- Erosion of Wet'suwet'en rights and title and the ability to exercise the rights;
- Climate change.

Table 42. Morice Sub-watersheds Cumulative Risk.

Sub-watershed	Road Density	Stream Crossings	Riparian Disturbance	HDF	Natural Disturbance[32]
Crystal Creek	[green]	[green]	[green]	[yellow]	Light
Shea Creek	[green]	[green]	[green]	[green]	Light
Gosnell Creek	[green]	[yellow]	[yellow]	[red]	Moderate
Atna River	[green]	[green]	[green]	[green]	Light
Houston Tommy	[yellow]	[yellow]	[yellow]	[yellow]	Severe
Lamprey Creek	[red]	[red]	[red]	[red]	Very Severe
McBride Creek	[red]	[yellow]	[red]	[red]	Very Severe
Nanika River	[green]	[green]	[green]	[green]	Light
Owen Creek	[yellow]	[yellow]	[yellow]	[red]	Severe
Thautil River	[green]	[yellow]	[green]	[green]	Severe
Morice Lake	[green]	[green]	[green]	[green]	Light
MR R1 East	[yellow]	[yellow]	[red]	[red]	Severe
MR R1 West	[yellow]	[yellow]	[red]	[red]	Very Severe
MR R2 North	[red]	[red]	[red]	[red]	Very Severe
MR R2 SE	[yellow]	[yellow]	[yellow]	[red]	Very Severe
MR R2 SW	[yellow]	[red]	[yellow]	[red]	Moderate
MR R3 East	[yellow]	[yellow]	[yellow]	[red]	Moderate
MR R3 West	[yellow]	[yellow]	[yellow]	[yellow]	Moderate

Low Risk Sub-watersheds [green]	Moderate Risk Sub-watersheds [yellow]	High Risk Sub-watersheds [red]

32 Natural Disturbance column refers to Mountain Pine Beetle Severity