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Identifying Wetlands For Restoration And Enhancement

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Prepared For

Fish and Wildlife Compensation Program

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Executive Summary

Debris scour, wave action, and fluctuating water levels are negatively impacting nearshore vegetation and wetlands within the Finlay reach of the Williston Reservoir. During inundation of the river valleys, many wetlands were lost, along with the habitat they provided to wildlife and fish. Soil erosion continues to damage and puts nearshore wetlands at risk around the Williston Reservoir. Non-hydro-related impacts, such as roads, beetle kill, and climate change is adding to the scale and scope of degradation. The degradation of wetlands reduces and puts at risk Tsay Keh Dene Nation (TKDN) members' access to food and medicine from these aquatic ecosystems. As Elders in Nation are aging, there is significant added risk that traditional knowledge of such ecosystems and their uses could be lost.

This project facilitated engagement with TKDN membership and wetland experts to identify opportunities for wetland restoration within the Finlay Reach of the Williston Reservoir. A total of 4 wetland sites were shortlisted through review of our 2019 rapid wetland health assessments, along with community input and were included in our August 2020 site investigations.

The primary component of the FWCP Peace Action Plan, that aligns most closely with this project, is the Riparian And Wetlands Action Plan, priority action (2b-1): "to leverage a WLR trial wetland program to create wetland habitat."

The secondary Peace Action Plan that aligns most closely with this project is the Species of Interest Action Plan, priority action (4a-1) research and information acquisition: "to conduct a TEK study."

In order to achieve the Peace Action Plan goals, specific objectives of the project included to:

- Validate the results of the 2019 TEK study with the original participants
- Conduct detailed assessments of shortlisted wetland sites, and the development of restoration plans by a wetland restoration specialist
- Engage with TKDN membership about potential wetland restoration work, based on the development of detailed site plans. Engagements included inputs from community members about future restoration work.

The results of the 2020 assessments provided a more in-depth understanding into the history, issues, and ecology at each shortlisted site. This information was used to discuss and organize planning options for restoration and enhancement as presented in this report.

1 Introduction

An important part of the habitat for diverse groups of *red* and *blue* listed plant and animal species, wetlands "…provide ecosystem services disproportionate to their limited extend in the landscape" (Mackenzie and Moran, 2004, p. 210). Migratory birds rely on wetlands during their seasonal migrations, and non-migratory birds use wetland habitats for food and shelter. Large and small mammals depend on wetlands for food and shelter, and amphibians need water to complete the breeding and larval stages of their life cycle. Wetlands also regulate hydrological dynamics across watersheds (Cherry, 2011). The community of organisms that inhabit these ecosystems support a number of important ecosystem services and functions —including continued opportunities for food gathering and recreation by people (Cox, 2009).

It is evident that significant wetland areas were lost during the flooding of the Rocky Mountain Trench by the W.A.C. Bennet Dam in 1968. The filling of the reservoir displaced habitat for species that Tsay Keh Dene Nation (TKDN) members continue to rely upon for food, medicine, and other traditional uses —uses that link the community to the land. Wave action, fluctuating water levels, and log scour have continued to erode sediment from, and physically damage, the remaining nearshore wetlands, following inundation. In addition to reservoir-shoreline erosion, non-hydro related impacts from other industries (such as timber harvesting, road construction, and mining) continue to degrade inland wetlands within the Williston basin.

Land-use patterns within TKDN territory are consistent with those that are causing significant loss of wetlands across Canada and on a global scale (Davidson, 2014; Stadnyk & Déry, 2021). Wetlands of the Boreal forests are interconnected by a number of ecological processes, including the migration of aquatic to terrestrial phases of organisms that cycle and subsidize nutrients and energy throughout watersheds. This means that hydrological changes can have far reaching effects and unpredictable consequences. Changes to the hydrodynamics from climate change, including more extremes, earlier spring, and hotter and drier summers can be further exacerbated by road building, timber harvesting, wildfires, and beetle outbreaks (Stadnyk & Déry, 2021; Vore et al. 2020; Picketts et a;. 2017; Kreutzweiser et al. 2013).

As such, TKDN members have raised concerns about locally perceived and recognized threats to the wetlands that remain in their territory. TKDN members recognize and are concerned about the range of cumulative effects to the species that occupy these habitats and the degradation of ecosystem functions that may sever traditional-to-contemporary ties and uses of these culturally important sites. This concern is not specific to TKDN, and is shared by Elders from other First Nations as well (Blackstock, 2002)

In 2019, Chu Cho Environmental conducted rapid wetland health assessments of wetlands within the Finlay Reach of the Williston Reservoir. The results of the initial assessments are included in the final report for FWCP project: *PEA-F20-W-2966* (Khan et al. 2020). Of the wetlands assessed in 2019, three sites were shortlisted for more detailed assessments. An additional site was also identified in August 2020 and was included for assessment in 2020, as it was found to have good potential for restoration. These assessments were completed in August 2020 and are the primary subject matter of this report.

This project is designed with inputs from wetland restoration science (Moreno-Mateos et al., 2020; d'Entremont et al., 2020; Zedler, 2000), while also implementing measures to link local traditional values into the restoration planning steps. A local wetland habitat creation project in the Parsnip region, sponsored by BC Hydro's Water Use Plan (WUP) under their Water License Requirements (WLR), provided examples of wetland restoration. There are a series of monitoring reports from the WLR trial wetlands which will assess the significance of the restoration works for a 10-year period.

The goals of the *Identifying Wetlands for Restoration and Enhancement* report were to:

- Leverage the results of the WLR trial wetland program once the final monitoring assessments are released, as well as other wetland restoration projects in BC, to enhance wetland habitat within TKDN territory
- Conduct a Traditional Ecological Knowledge study in order to document the cultural importance values, and local perspectives of wetlands to TKDN membership and ensure these values are integrated into any restoration work.
- Develop restoration plans for inland wetland sites identified as *degraded*, in the vicinity of Tsay Keh Dene

Herein, we provide in-depth details into early-phase steps of wetland restoration and build on the success of the WLR wetland restoration, to advance restoration initiatives at priority locations within TKDN territory, specifically the Finlay Reach of the reservoir. The restoration assessments summarized in this report were completed in collaboration with wetland ecosystem experts. This report also presents on an analysis of the wetland sites through comparative interpretation of historical air photos dating back to 1939, loaned to CCE through the University of British Columbia (UBC), Geography Department. A Traditional Ecological Knowledge (TEK) study was also completed in partnership with TKDN Elders to identify and outline the opportunities presented in our discussion for wetland restoration that aligns with the values and land management goals of TKDN membership.

2 Traditional Ecological Knowledge Study

2.1 Methods

A TEK study was completed as part of this project, over 2 years, with Elders and knowledge holders from TKDN, to determine the traditional use of wetlands, and their significance to the community. Members of TKDN are one of the three communities which identify as Sekani and speak the Sekani (Tse'khene) language. Their territory includes the Parsnip and Finlay river basins in the Rocky Mountain Trench, in the area now occupied by the Williston Reservoir and its surrounding. A mixed-methods approach was used in the TEK study. The methods included background research, ethnography-based field research and observation, and one-on-one semi-structured interviews with interactive mapping support. Interview questions were developed after reviewing the goals and intention of the project, and collaborating with the Tsay Keh Dene Nation Lands, Resources, and Treaty Operations (LRTO) Department.

The TEK study commenced by inviting participation in a two-day course led by the British Columbia Wildlife Federation (BCWF), in June 2019. Community members and researchers were registered in the course which covered information and materials on the different types of wetlands, wetland health, and examples of design options for wetland rehabilitation or development. The course included field visits to local wetlands that were identified as degraded by the community participants.

Three Tsay Keh Dene Elders, including Rita Poole, Vera Poole, and Jean Isaac, helped to identify the sites that were selected for site visits during the field tour. The Elders joined the class at the wetland sites and all participants were given opportunity to share their thoughts on wetland health and reflect on cultural resources in the wetland environments. A social learning format was organized around direct outdoor experiences in TKD territory, along the shorelines of the wetlands selected. The Elders shared their stories and knowledge about the importance of wetland health. The outdoor learning environment created opportunities during natural storytelling to relive the descriptions of how the wetlands used to look, what kinds of resources had been available, and allowed participants to reflect on how things have changed.

After the course, researchers interviewed elders, some of whom had participated in the BCWF training. Questionnaires were created with open-ended questions intended to open discussion. The intent was to allow for natural conversation where people shared their experiences, thoughts, and opinions. Open-ended questions allowed for more nuanced answers than questions that just allowed for a yes/no answer. The participation in the social dynamics of the BCWF training format provided respondents with an increased knowledge and understanding of how wetland health is identified scientifically, culturally, and how this information relates to different methods that were reviewed on restoring and rehabilitating wetlands.

Eight interviews were conducted with TKDN Elders. The sample size of interviews was determined by the availability of knowledge holders and saturation; several knowledge holders were away in the field. In qualitative research, saturation is reached when you no longer receive new answers to questions. There was a significant gender bias with 7/8 participants were female, but information shared by the male participant was consistent with information provided by the women Elders. Table 1 summarizes the participants, in the 2019 TEK interviews and the 2020 TEK validation. Table 2 summarizes the questions that were asked of interview participants in 2019.

Table 1. Elder participants in the TEK interviews and TEK validation

Elder Participants	2019 TEK Interviews	2020 TEK Validation
Elsie Pierre	x	
Helen Poole	x	
Jean Chalifoux	x	
Jean Isaac	x	x
Mabel Troendel	x	x
Ray Izony	x	x
Rita McIsaac		x
Sarah Pierre	x	x
Seymour Isaac		x
Vera Poole	x	x

Table 2. The TEK Questionnaire

Interview Questions
▪ Can you tell me why you think wetlands are important? What makes wetlands special?
▪ Are there specific animals that you expect to see in wetlands?
▪ Are there any specific plants that you would go to a wetland to collect?
▪ Can you tell me how wetlands have been impacted within the territory?
o Causes (reservoir, logging, roads, mining, etc.)
o Locations (map)
o To what extent? How many?
▪ Can you think of any other places where there used to be wetlands, and now they are gone?
o Locations (map)
o Reasons?
▪ Have these changes to wetlands affected how Tsay Keh Dene hunt or harvest?
▪ Are there any places you would suggest restoring wetlands?
o Locations (map)
o Reasons? Why those places?

Interviews were recorded if permission was granted, and recordings were transcribed verbatim. If an interview was not recorded, then written notes were used to collect the data. The interview transcripts and notes were analysed by a TEK expert, Jennifer Herkes, using thematic analysis. This involved a thorough read-through of all of the interviews, while searching and flagging key words or concepts that were repeated. Key words and concepts were categorized into themes. Themes are usually subjective to the researcher and are guided by the intention of the research project. The transcripts were then coded for the themes. This allowed for a quantitative assessment of themes to some extent (i.e. 7/10 people mentioned the same theme or topic), but also provided a clear understanding of the connection of the themes. This type of analysis, while guided by the research question, is strongly informed by the information provided by the knowledge holders.

Interviews included a mapping portion where participants were asked to identify the location of wetlands that may have been lost or degraded. A large map of Tsay Keh Dene Nation territory was provided for participants to easily locate relevant areas. Background research by the interviewers included reviewing for archival and historic Tsay Keh Dene documents related to wetlands. Interview participants were asked to indicate locations on the map where they had knowledge of wetlands that are degraded or lost. The areas noted on the paper map were digitized for analysis and are in Figure 4, and Table 5.

We engaged with 7 Elders for verification of the TEK study and to follow-up on any outstanding questions related to tables, place names, and content. Between November – December 2020, the TEK chapter was validated by Tsay Keh Dene Elders who contributed to the study. The validation process provided the participant with a copy of the report and asked whether or not they wanted a high-level summary or preferred to go through the report in detail. Some Elders preferred to have a summary, or to be pointed to parts of the report in which they participated, while others preferred to go through the full report and provide comments. Due to the current Covid-19 travel restrictions our window for the TEK validation engagement in 2020 was delayed and in person engagement opportunities were limited. Validation was completed in November and December 2020, by a CCE staff member who was residing in TKD and was able to meet with participants after taking necessary precautions. The Elders who provided input for the validation are summarized in Table 1.

All participants in the verification agreed to the final written content of the report and where questions or comments were raised, they were addressed. All agreed that the Sekani language should be absent from the tables for cultural reasons, but where the Sekani language is included, such as the title, were approved by the participants as being suitable for usage.

2.2 Results

The results of the TEK interviews are presented in themes. Each theme was explored in relation to the research question or project, as well as other previously recorded or known information. Poignant and pertinent quotes were used to highlight a theme or direction.

2.2.1 Wetland Health Is Related to Tsay Keh Dene Health

The theme around the importance of wetlands, was the important role that wetlands play as a place for plants and animals to get the food and water they need to be healthy. This in turn makes wetlands an important place for the Sekani people to gather resources to ensure their health and well-being. Therefore, wetland health is directly connected to the health of plants, animals and water, and in-turn, the health of the Tsay Keh Dene people.

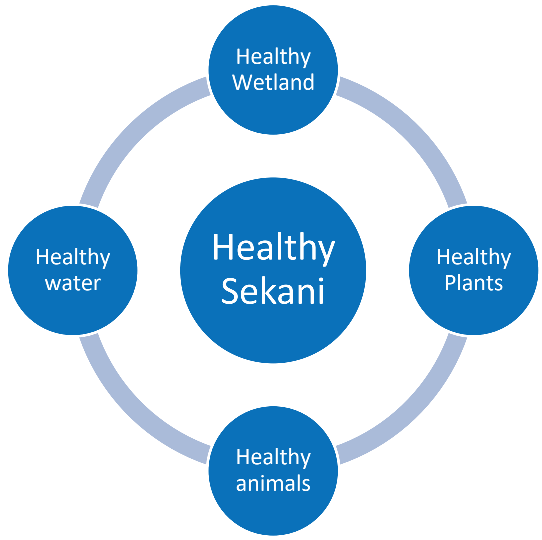

Figure 1. Relationships between wetland health and Sekani health, identified by TEK expert Jennifer Herkes.

2.2.2 Wetland Loss Is Related to A Loss Of Available Traditional Resources

The theme that emerged around wetland loss is closely connected to wetland health. As wetlands degrade, they no longer provide the healthy spaces needed by the plants and animals. This affects how and where Tsay Keh Dene can harvest as they have traditionally. The loss of wetlands to natural processes, climate change, and development has resulted in a loss of the healthy plants and animals that need those places to thrive.

2.2.3 Restoration of Wetlands

Restoration of wetlands was agreed to be a good option, as long as methods supported natural processes, rather than processes that are more invasive. There was a theme of concern about fighting against the forces of nature. It is important for the Tsay Keh Dene to respect and support natural changes.

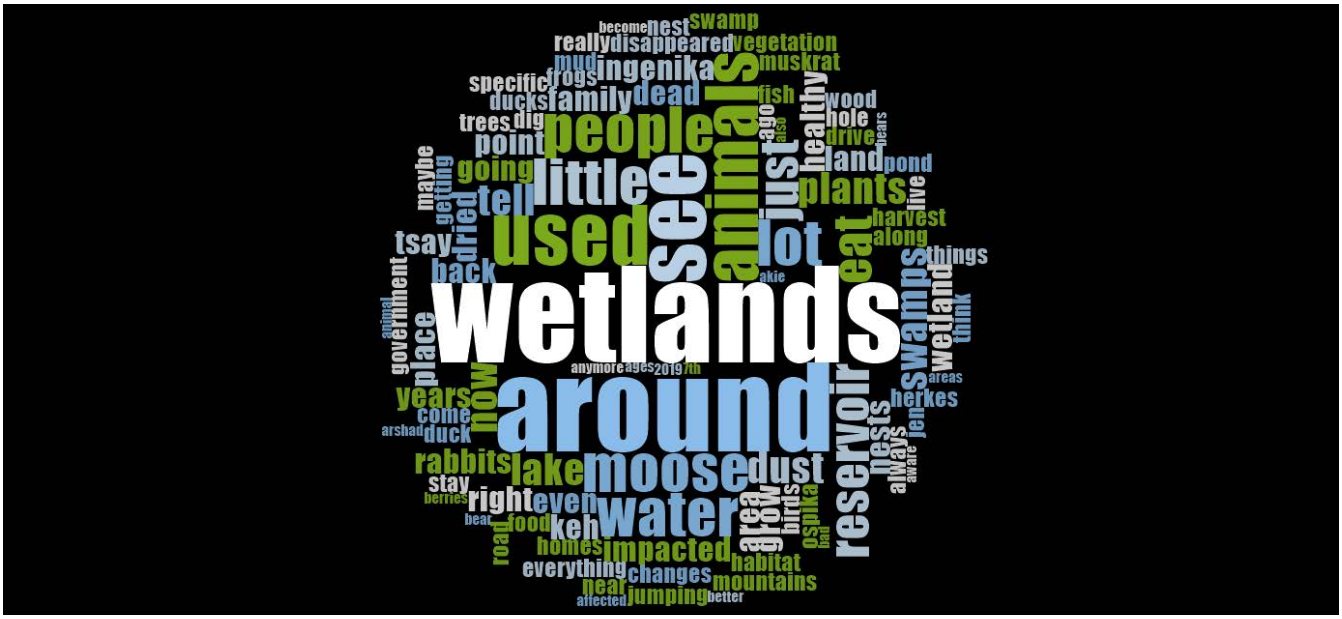

Figure 2. Word cloud derived from interview transcripts.

2.3 Discussion

2.3.1 Importance of Wetlands

The ethnographic study and interviews with Tsay Keh Dene Elders reinforced the importance of wetland ecosystems in the life and culture of the Tsay Keh Dene community. The respondents discussed the various roles of the plants and animals inhabiting wetland communities and how they rely on these ecosystems for their survival. It was evident that they were intimately familiar with and had historical knowledge about the changes that have taken place in local wetlands that were identified and visit. A strong theme emerged, a cultural ethic, on the importance and value of the water in the wetlands as they described ecosystem functions that regulate the health of the plants, animals, and wider ecosystems across their territory.

The Elders emphasized how they have and continue to rely on the health of these environments for collection of medicinal plants, as places that have spiritual and cultural ties, and as habitat for animals (e.g., moose and beaver) that need these places to survive. A theme was also identified that relates, importantly, to the issue of restoration. They noted the importance of not interfering in the natural course of nature, giving nature room to operate without interference. This theme may be considered in line with the theme of advancing natural regeneration. An overarching theme was identified of the relationship that Tsay Keh Dene people have with the land, water, and the health of all of these things that they see as interconnected.

2.3.2 The Role of Wetlands in the Ecosystem

The interviews illustrated the Tsay Keh Dene understanding of the importance of wetlands. The respondents explained that wetlands provided habitat for a number of plants, animals, birds, insects, and other creatures. Wetlands are a place where water retention encourages vegetation growth that attracts wildlife which in turn attracts Tsay Keh Dene to pursue traditional activities such as hunting and plant gathering.

In a report written in 2011 (Izony 2011: 65), elder Ray Izony describes wetlands, "All these places [rivers] hold their swamps, that attracts wildlife with their character, and accommodate their service to the air and weather. In return our people were attracted to the game they enticed. This made since time immemorial, our trails, camp sites, names to some of our best hunting areas for moose, deer, caribou, and other animals and bird." This statement explains how healthy wetlands are connected to environmental health and the ability for Tsay Keh Dene to practice traditional activities such as hunting.

The respondents described a large number of animals, plants, and other elements that thrive in healthy wetlands. According to the respondents, the existence, of these plants and animals, acts as indicators to wetland health. When asked to describe what makes a wetland healthy, Jean Chalifoux explained, "it is healthy if the vegetation is healthy, if it is not dry. If the animal tracks show, then it is healthy. If there is dead vegetation and scummy water and no animals around, that would cause worry." The responses illustrate a clear understanding of the reciprocal connection between the wetlands and its inhabitants. The respondents described a large number of animals, plants, and other things that thrive in healthy wetlands. According to the respondents, the existence of these plants and animals acts as indicators to wetland health. It is clear that the health of the wetland is dependent on the health of the plants and animals, and that the health of the plants and animals is dependent on the health of the wetland.

2.3.2.1 Plants

The importance of plant species in the wetlands was related to their providing sustenance to other animals. This includes forage for moose and caribou as well as migratory birds, and people. Elsie Pierre explained, "plants are important. Whatever the geese eat, or swan. I don't know what they eat, but they must get something from there [wetlands]." Another explained how the rabbits drink the water and eat the weeds along the shore.

A variety of plants that have been used traditionally were named throughout the interviews and identified during the field visits (Table 3). All of these plants have nutritional and/or medicinal properties and have been used traditionally by the Tsay Keh Dene for generations. The health of the plants signifies the health of the wetland, and its ability to provide for animals and people.

The field visits provided the opportunity to identify and collect some mint (*Mentha arvensis*) from along the edges of the wetlands that were visited. The informants explained that the leaves would be dried, and it would be used for tea. In the *Sekani Ethnobotany: Traditional Role of Plants Amongst the Sekani People* (Davis 2008), mint is described as a beverage plant.

Table 3. Plants mentioned in interviews related to wetlands.

Common Name	Latin Name
Bear root	*Hedysarum alpinum*
Devil's Club	*Oplopanax horridus*
Black Spruce	*Picea mariana*
Caribou berries/lingonberry	*Vaccinium vitis-idaea*
Bull rushes/cattail	*Typha latifolia*
Grass	Grass spp.
High bush cranberries	*Viburnum edule*
Labrador Tea	*Rhododendron groenlandicum*
Lichen	*Peltigera aphthosa*
Wild Mint	*Mentha arvensis*
Sphagnum Moss	*Spagnum capillaceum*
Moss	Moss spp.
Wild Onion	*Allium cernuum*
Yellow Waterlily	*Nuphar luted polysepala*
Red (osier dogwood) Willow	*Salix* sp.

The Sekani word for black spruce translates as 'swamp tree'. The name reflects the relationship the tree has within the wetland ecosystem. Black spruce is traditionally collected for a variety of uses including building materials, snowshoes, and the roots were used for rope and basket weaving (Davis 2008). The interview respondents and field participants referred to gathering swamp acorns – the cones of the spruce tree. The cones are boiled or chewed for a medicinal remedy to sores in the mouth (Davis 2008).

2.3.2.2 Animals

Wetlands were described as places of refuge and resources for animals. They are places where animals come to get water, find healthy vegetation, and seek refuge from the heat. These include animals of all sizes from moose to birds, to small rodents and frogs. The animals mentioned during the interviews and discussions are summarized in Table 4.

Moose was the most commonly referenced animal that is expected to use and benefit from wetlands. Every respondent referred to moose, and it also had the most references (28 references) throughout the interviews; this was followed closely by birds (25 references).

Wetlands are described as being rich in resources for the animals. Jean Chalifoux explained, "[the animals] go to the wetlands because of the food. Moose eat willow, bears eat the tender green shoots, they go in the spring and dig up the roots to eat them. Rabbits eat horsetail and birds live around and dig around for worms and snails."

Table 4. Animals mentioned in interviews related to wetlands.

Common Name	Latin Name
Wolverine	*Gulo gulo*
Rabbit	*Lepus americanus pal.*
Rodents	-
Muskrat	*Ondatra zibethicus*
Deer	*Odocoileus hemionus*
Frog	-
Caribou	*Rangifer tarandus*
Beaver	*Castor canadensis*
Elk	*Cervus canadensis*
Fish	-
Bear	*Ursus americanus*
Moose	*Alces alces andersoni*
Birds	
Barred Owl	*Strix varia*
Hawk	-
Canada Goose	*Branta canadensis*
Swan	*Cygnus buccinator*
Ducks	-
Whiskey Jack/Gray Jay/Camp Robber	*Perisoreus canadensis*
Sandhill Crane	*Antigone canadensi*
Bald Headed Eagle	*Haliaeetus leucocephalu*

In general, there was a sense that a healthy wetland provides a healthy environment for plants and animals to thrive. It is an integral part of the ecosystem where all things great and small contribute to the health. The story of the Mosquito people (see Appendix 1), recorded by Diamond Jenness (1924) and attributed to the Tlotona Indians (Sekani people from the north west) tells of a man who goes out to hunt for his wife's village. The story focuses on a swamp where he caught a beaver, but also found a number of frogs. The people in the story were very interested in the frogs, this was because they were mosquitos. Traditional stories such as this illustrates how all the creatures are interconnected, including people, and they are all integral to each other's lives. While this story was not specifically shared by the interview participants, it reflects a long-term understanding of the connection between the animals, insects, and people that use wetlands.

2.3.2.3 Water

When speaking about wetlands and wetland health, the discussion always returned to water. A wetland was healthy only when it was wet and there was a recognition that many wetlands have been lost or are deteriorating because they are drying up. Elder Ray Izony explains, "In the spring, the water melts and replenishes and cleans the rivers, creeks, lakes, and swamps. Life in the ecosystem is always rejuvenated by water, so it could be there for Tsek'ene Dene. Water is a giver of life to our people and the eco-system in our territory. Therefore, we the "Dene" have always waited for water to run its course, and respected its awesome powers, and abided by its laws" (Izony 2011:30).

There was a sense that wetlands helped to provide water to the broader ecosystem. Elder Jean Isaac explains, "wetlands are important because they hold water. For example, it's like a sponge, and it holds water, and when there's dry seasons, that were the plants and the animals still grow." The water that is provided and contained by the wetlands is what contributes to the healthy dense foliage and resources for other creatures as mentioned previously.

When it is understood that water is life, then the connection that wetlands have with water becomes far more profound. Wetlands provide water, and therefore, life to the ecosystem they are a part of.

2.3.3 Wetland Loss and Loss of Cultural Resources

There is an acknowledgement by the Tsay Keh Dene that the landscape changes over time for a variety of reasons, both natural and human caused. Whether a wetland's health is degraded or lost because of natural process such as river mobility, or more recent causes such as climate change, or disturbances are caused by human development activities, the result is impacts of ecosystem loss and the related loss of cultural resources connected to that resource.

2.3.3.1 Natural and Climate Changes

In terms of the natural landscape changing, the process is described in the Elder Engagement Report (2011), "Our rivers hold their own sloughs and made them when they renew their course. Some sloughs were there since time immemorial, their age usually turns them into lakes, and some sloughs still connect them to their river, many are new in our rivers, depend on snowfall in the winter. To us these sloughs are important, some attract fish, moose, ducks, beaver, otter, mink, and bear. Our favorite sloughs we gave name to and had trails to them, and our campsites are there." The implication is that wetlands alter from wetlands to lakes, and potentially dry out as the river course changes. No matter the cause, the wetlands remain a vital connection to the cultural resources including campsites.

All of the respondents noted a general trend of wetlands drying out, and few respondents could identify any newly formed wetlands. Many informants referenced changes to the climate that have been affecting wetland health. Elder Elsie Pierre shared, "I was going to tell you something. I think we need rain. We need more rain to fix that. Sometimes it was when start raining really hard how much years ago." Ray Izony explained, "wetlands are going to feel it and they are going to start shrinking way, you know that. Especially the water courses. You are going to have more heat, you know you're going to have more a lot of dried-up places, you know pretty soon."

The perceived decreases in precipitation and overall drying out on the land is connected to the previous sections related to the indicators of wetland health. Without water, the wetlands are drying out and are no longer providing the resources and refuge to the animals.

2.3.3.2 Changes Caused by Development

The primary impacts that respondents felt affected wetland health were human caused. Concerns related to the reservoir, forestry, and industrial development (including roads) were noted. These impacts have been noted by Tsay Keh Dene for some time. A reference from the 2011 (Elder Engagement: 36) describes the situation, "Today, there are developments, and roads that cross creeks and impact swamps; there is logging that encroaches on the eco-system of the bear and the mountain goat. When things are taken, nothing is given back. Our people knew the life of the swamp, the life of the creek; we named them and knew how they were interconnected. When we took, we gave back. That is the wisdom taught to us."

2.3.3.3 The Williston Reservoir

The creation of the W.A.C. Bennett Dam and associated Williston Reservoir has impacted the Tsay Keh Dene, the land, and the resources. The impacts are described in a 1985 document related to Sekani use and occupancy (Hudson 1985:55); Willie Pierre said, "the lake changed all our lives. It may seem there's no difference, but there is. Such as the hunting – all our hunting areas are gone. The campsites, the berry places, fishing holes, all the swamps that were the place to look for beaver and moose, also the small lakes. With all that gone, and the river gone, we can't do much." Respondents identified the Williston Reservoir as having caused a great amount of loss of wetland habitat known to the Tsay Keh Dene. Not only were several wetlands lost when the reservoir was inundated, but many of the wetlands near the reservoir seem to be continuously impacted.

The maps available from before the creation of the W.A.C. Bennett Dam do not provide enough information to gain a fulsome understanding of the exact number of wetlands that have been impacted or lost because of the flooding of the reservoir. Figure 3 is a map from the BC Archives (GR 1085 CM/E117 sh 65 38A) of the Finlay River in 1948. The riverbed is a twisting and turning watercourse that reflects the dynamic nature of the river. Furthermore, the map illustrates a number of small creeks that were once part of this watershed.

Before the creation of the reservoir, wetlands were located along all of these rivers and creeks. When asked how we could quantitatively determine the area or number of wetlands that have been lost, a respondent answered, "oh I tell you, every place there was moose standing all the way around every corner because that's where there's swamps. Wherever there's creeks, you go up and to the swamp there. So, we want to count the swamps? Count the creeks!" Further research of photo imagery of the region could help to better quantify the impact to wetlands, but until that time, the participants responses indicate that the impact has been substantial.

Figure 3. Map of the Finlay River 1948 (pre-reservoir) from the Royal BC Museum archives.

One respondent, Vera Poole, likened the reservoir to a giant creature. They explained that there had been prophecies about a giant creature coming and drying all the lakes up. They felt that the reservoir could be that creature. “There was a history of one of our Elders. Old timer said that, Wherever it is, a big creature, those lakes are going to dry up. Maybe he meant that body of water [reservoir]. They [old timers] have told us a lot of stories about what's in our future and stuff like that, and one of them was something big is going to cause those lakes to dry up, and that's what it is right there [the reservoir]. That's what I believe anyway.”

Specific descriptions of impacts to wetlands caused by the reservoir varied. Impacts included a change in weather patterns, fluctuations of reservoir levels, increase in dust and sand in the air, and a decrease in water levels in the area. These impacts are all somewhat related. The changes in weather are perceived to have affected moisture levels, and the decrease in moisture and water levels lends to the sandstorms.

The water levels of the reservoir fluctuate almost 20 meters above sea level (asl) between April and September (Arocena et al. 1996). During times when water levels are low there are dust storms as southeasterly winds carry sands from eroded shores. Over the last decade there has been intensive monitoring and dust mitigation treatments focused on the Finlay Arm of the reservoir (BC Hydro 2016). Jean Chalifoux explained how the increase in sandstorms may affect the wetlands, “dust settling on the wetlands choke the plants that grow around it, maybe that’s why they are disappearing.” Elsie Pierre spoke to the effects of the fluctuating reservoir levels, “they raise the water and they flood the wetlands out, then after that the water goes back down to the same thing as before, everything starts growing again, grass and everything, and it starts looking healthy again. Then the water come and do it all again.”

The changes in reservoir levels are hindering the establishment of liminal wetlands along the reservoir and the erosion caused by the changes in water levels is hindering the development of healthy wetlands as well as impacting existing wetlands.

Several respondents expressed concern about the changes in water levels, specifically concerns about areas that were once wet, which are now dried up. Jean Isaac provides some insight, “You know what’s really weird? You would think the wetlands should be flourishing with all this water [from the reservoir]. Maybe somehow the water don’t [sic] flow this way or that way, so they would go and drain it more because this whole thing drains, it’s got more pull, more undertow, so it drains most of the wetlands, and that’s why there’s hardly any wetlands where it used to be.”

Overall, the respondents expressed concerns over the loss of wetlands in the territory. Some losses were attributed to natural causes, but most concerns were related to losses caused by humans such as the creation of the Williston Reservoir and other industrial developments. Based on the important role that wetlands play in the health of the environment and their connection to providing a place of cultural heritage where traditional resources could be gathered and where people would regularly camp; their loss has had a profound effect on the Tsay Keh Dene and their ability to continue to pursue traditional activities.

2.3.4 Specific Places

There are a few recorded place names related to wetlands and swamps with the Tsay Keh Dene territory. Most notably is ts’əbecho, or ‘Big Swamp’, which is the name of several wetlands in the territory including the Fort Graham Swamp that was inundated by the Williston Reservoir (Sekani Dictionary 2019). There was an area west of Moodie mountain, just east of the Finlay River, that was called Big Swamp, which was a very important cultural area, used for camping, hunting, gathering, and sustenance.

The respondents were asked to identify locations where they could recall there being wetlands that have since disappeared or become degraded. Many of these locations have been lost because of the flooding of the Williston Reservoir. Attempts were made by field crews to assess those places that were not inundated but identified as still degrading. Figure 4, and Table 5 summarize these locations identified during the interviews.

Table 5. Summary of wetlands identified by respondents during the TEK interviews.

Site ID	Description
SP1	By the airport (Isola), used to see a little lake. Every spring ducks would come; now not so much
JI1	Police Meadow, used to be water all over
JI2	Areas closer to the reservoir, used to be swamps, now are little lakes. Wherever there are creeks
VP1	Swan Lake, used to be a place for swamps (flooded by reservoir)
VP2	Near 10th, used to be frequented by moose a lot. Always moose up there until the 80's
HP1	South of Collins
VP2	Near 10th, used to be frequented by moose a lot. Always moose up there until the 80's
HP1	South of Collins
HP2	Ospika Wetland
HP3	Between Pesika and Akie, big swamp along the Finlay
HP4	Police Creek, wetland there, was dry last time they went up
HP5	Grizzly bear corridor
EP1	Down at the old village; 2 little lakes that seem to be shrinking
EP2	Akie swamp; hardly any water in mid-summer
EP3	Ted Brown camp-the lake along the road going in looked to be dried up
MT1	Up Ospika, smaller creeks in the northern Ospika all dried up
MT2	Bruin Creek-Deer Creek gets smaller
MT3	Tobin Lake
MT4	Big swamp near Pelly; always lots of moose and stuff
JC1	Used to be a wetland going towards Old Ingenika Point
RI1	Dunne Cluth
RI2	Wanatsas
RI3	Big swamp
RI4	Big swamp
RI5	Chunaman (underwater); Big Swamp
RI6	Swan Lake, used to be a lot of moose. Completely gone
RI7	The long dam
RI8	Underwater swamp near Ospika
RI9	Ospika wetland, still some there, some flooded by reservoir
RI10	Swamps along east side of the reservoir

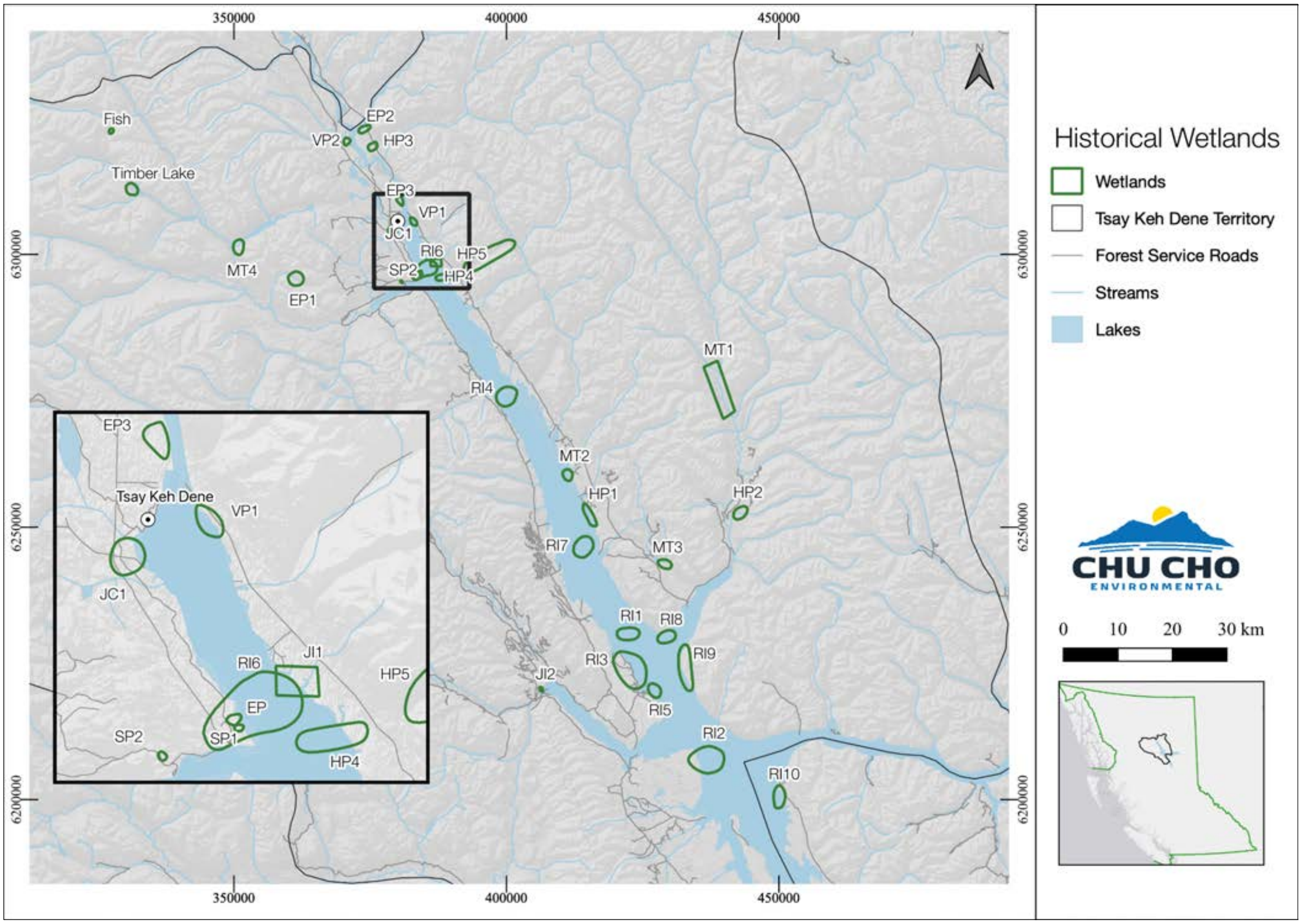

Figure 4. Map of wetlands recorded by interview participants during the TEK interviews.

It is interesting to note that more than half (16/28) of the places mentioned are wetlands that were inundated by the reservoir. There is a concentration of areas identified at the northern tip of the reservoir. This is likely a representation of people's familiarity with the area due to the proximity to the village, rather than a reflection of increased impact in that region.

2.3.5 Opportunities for Restoration

There was positive reaction to the opportunities for restoration, especially in terms of the benefits to wildlife. However, there was emphasis on restoration by supporting natural processes rather than intensive restoration activities. Furthermore, there was reference to working towards decreasing the developments that are impacting wetlands.

Most of the respondents felt that restoration and enhancement of wetlands would bring about positive opportunities, as the restoration could work to bring back the wildlife that has been noted to be depleted in the territory. There was also interest in the restoration occurring in areas that are accessible by road, so that they could be more easily enjoyed by people, particularly elders. Jean Isaac explains, “Yeah, yeah. It would be a good idea to enhance them. That way we have something that's natural, and you're just making it better.”

Based on the information provided by the respondents, along with a computer modeled prediction of potential wetland locations, CCE conducted rapid wetland health assessments of 15 wetlands in the Finlay Reach of the reservoir in 2019. As suggested by the respondents, wetlands surveyed were located in areas that were accessible by road, and many in areas that were recommended by the respondents.

Some respondents were apprehensive about potential restoration projects. After having taken the BCWF wetlands training course, they had a clear understanding that some restoration projects could be extremely invasive. The respondents were more interested in restoration projects that supported and encouraged natural processes as Jean Isaac describes, “You let the streams come back into that area naturally. You will help the stream to make it into that part and then it has water again.”

When asked about restoration, most of the respondents expressed concern about, and the need to address, the causes of the wetland degradation, namely resource development. There was a sense that without addressing the causes then restoration would only be a short-term fix. Elder Ray Izony expressed that to encourage restoration “we need to sit and talk and see how we can contribute their (industry) knowledge and resources in order to get this important work done.”

3 Wetland Assessments

3.1 Study Area

The Williston Reservoir is located in the northern interior of British Columbia and was created in 1968 following construction of the W.A.C. Bennett Dam, BC Hydro facility, on the Peace River. The reservoir is approximately 250 km long and is bounded by the Finlay River to the north and the Parsnip River to the south. The reservoir is divided into the Finlay, Parsnip, and Peace reaches (ILEC 2020).

Our 2019 study report (Khan et al. 2020; FWCP project PEA-F20-W-2966) describes the process of site selection for the study sites that we include in this report.

The project study-sites were located in the Finlay reach and their locations extended south from Tsay Keh Dene to the Omineca and Ospika rivers. The four chosen sites are an extension of 2019 work. In 2020, CCE focussed on four wetland sites to develop restoration prescriptions; Table 6 summarizes the locations of the four shortlisted sites assessed in 2020, and Figure 5 shows the locations of the sites in relation to Tsay Keh Dene. The full results of the 2019 study can be found in the final report for FWCP project: *PEA-F20-W-2966* (Khan et al. 2020).

Table 6. Locations of wetland sites assessed in August 2020.

Site ID	Latitude (N)	Longitude (W)
W7 – Finlay FSR 20 km	56.954300°	-124.990930°
W9 – 10,000 Road	56.977530°	-125.144370°
W14 – Rat Lake	56.820690°	-124.932500°
W16 – Teeth Creek	56.851565°	-124.966279°

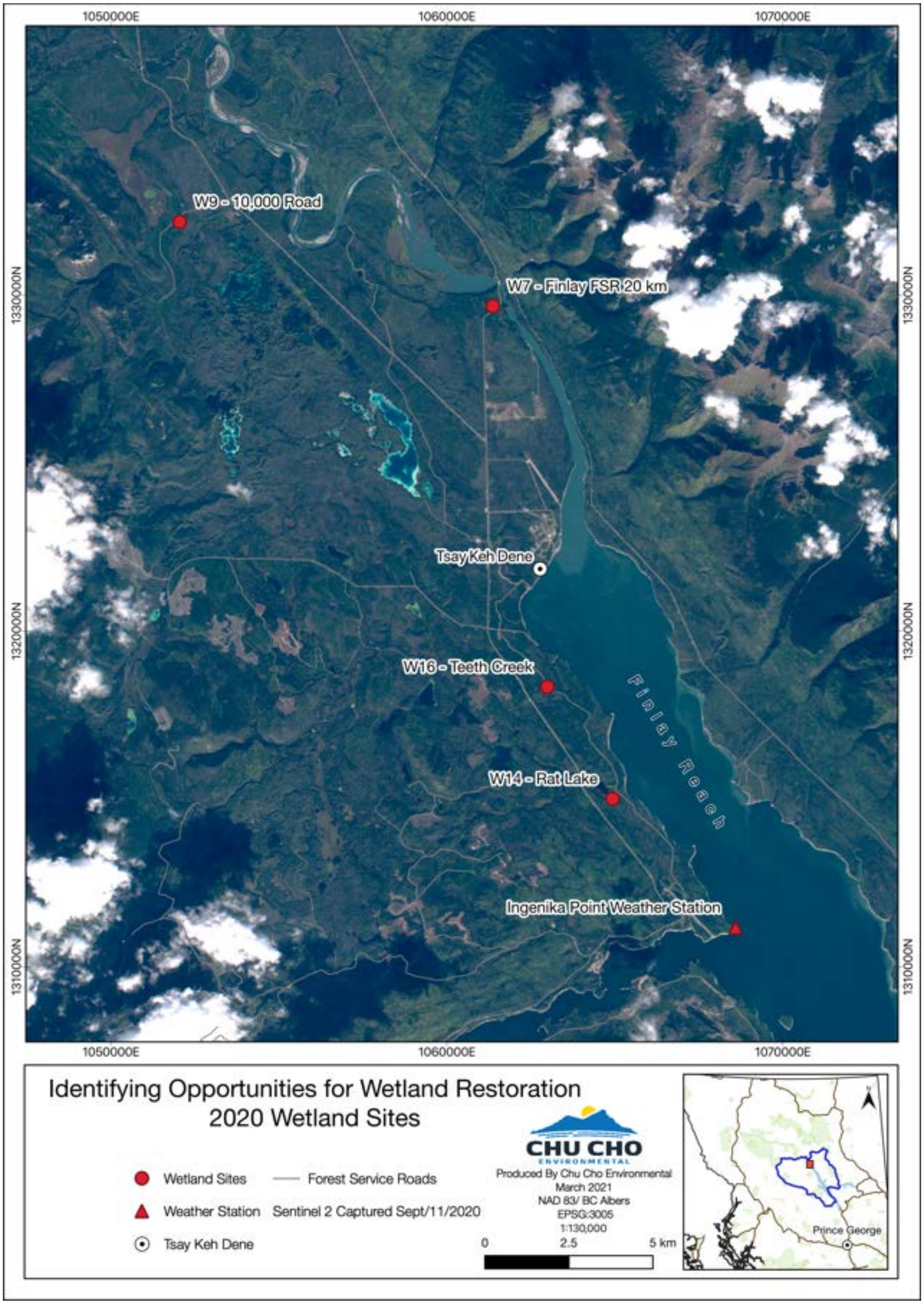

Figure 5. Location of wetland sites assessed in 2020 in relation to Tsay Keh Dene.

3.1.1 Site W7 – Finlay Wetland

This wetland is located approximately 18 km, by road, north of the community of Tsay Keh Dene at the 20 km mark on the Finlay Forest Service Road (FSR). The project area is the wetland basin shown in Figure 6, and is 2 hectares in size. The project area was dry when visited by the Chu Cho Environmental wetland rapid health assessment team in 2019. The 2020 visit found the wetland full of water and covered in emergent vegetation.

A review of available historical air photos show that this wetland may have been flooded in both 1939 and 1949 and was clearly flooded with water in the 1956 and 1981 photographs. It appeared to have some water in 2006.

This site was classified as a fen, with swamp-like components, by the Filatow et al. (2020) algorithm. Site observations and soil samples identified a thin organic layer over a deep mineral clay soil, indicative of a swamp (MacKenzie and Moran 2009). Desktop analysis showed a stream which flowed through the site, with a downstream connection to the Finlay river and upstream connection with a swamp (Figure 7).

Figure 6. Looking north towards the Finlay wetland. The Finlay Road curves around the south side of the wetland before crossing the Finlay River in the background.

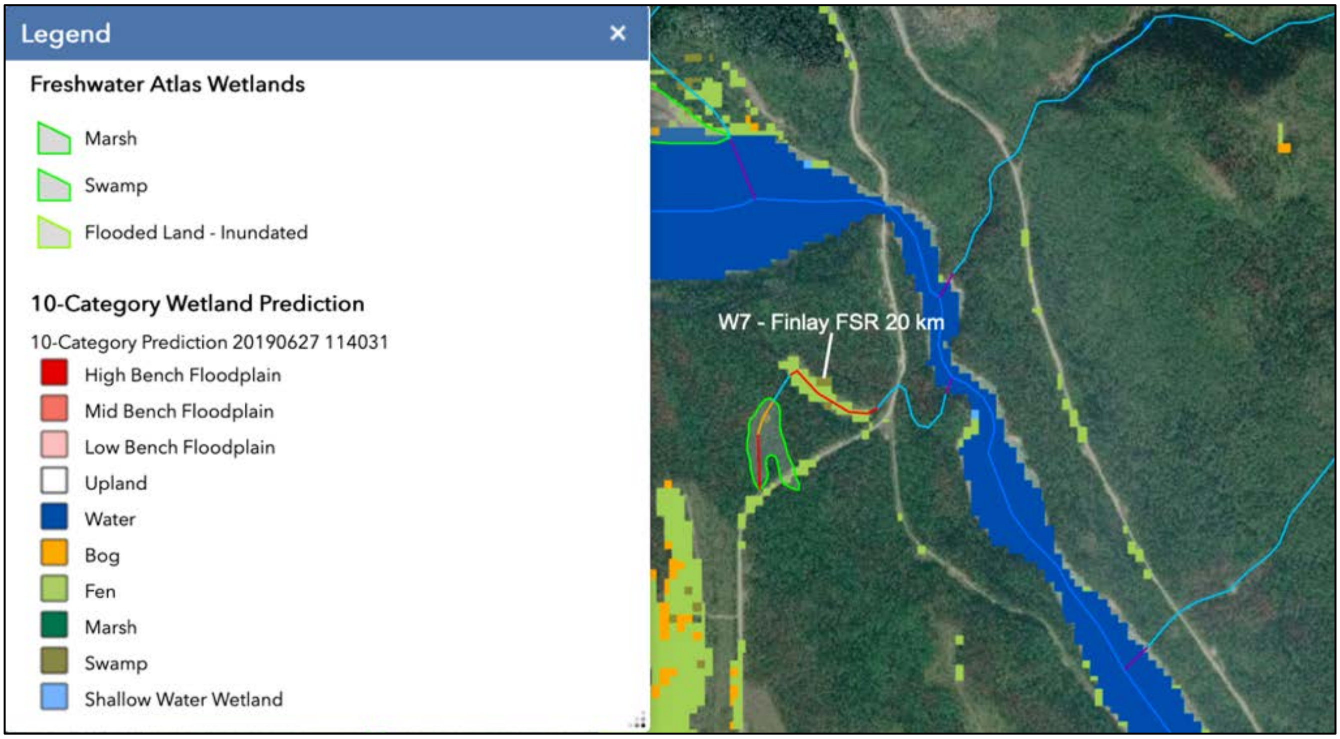

Figure 7. Williston Wetland Explorer Tool (WWET) screenshot of landscape surrounding site W7 – Finlay FSR 20 km.

3.1.2 Site W9 – 10,000 Road

The 10,000 Road wetland site is located 16.6 km by road northwest of the community of Tsay Keh Dene. Ed Bird-Estalla Lakes Provincial Park adjoins the site to the south. The 10,000 Road, a resource road, fragments a southern portion of this wetland from a larger northern section that surrounds a small lake (Figure 8). A review of historical air-photos for the years 1939, 1949, 1956, 1971, 1977, 1981, 1987, 1993 and 2006 shows the 10,000 road was constructed between 1987 and 1993.The road was first visible in 1992 and can be seen in a Google Earth Engine timelapse of the area (Gorelick at al., 2017).

This site was classified as a bog-fen by the Filatow et al. (2020) algorithm (Figure 9). It has a sluggish hydrodynamic index, and thicker organic soils in the deeper margins of the riparian zone. The site has the characteristics of a fen: one of the most common and widespread site associations in the province (MacKenzie and Moran, 2009).

Site observations showed that this wetland is part of the watershed to the north of the 10,000 Road. Water from the 10,000 Road wetland flows northwest into a 300-hectare wetland, and eventually into the Finlay River. The 10,000 Road wetland adds 5.4-hectares to the 300-hectare wetland, which already included in the BC Freshwater Atlas layer in iMapBC.

Figure 8. Site W9 in the foreground, and the larger 300-hectare wetland and small lake in the background. The 10,000 Road bisects the two sites.

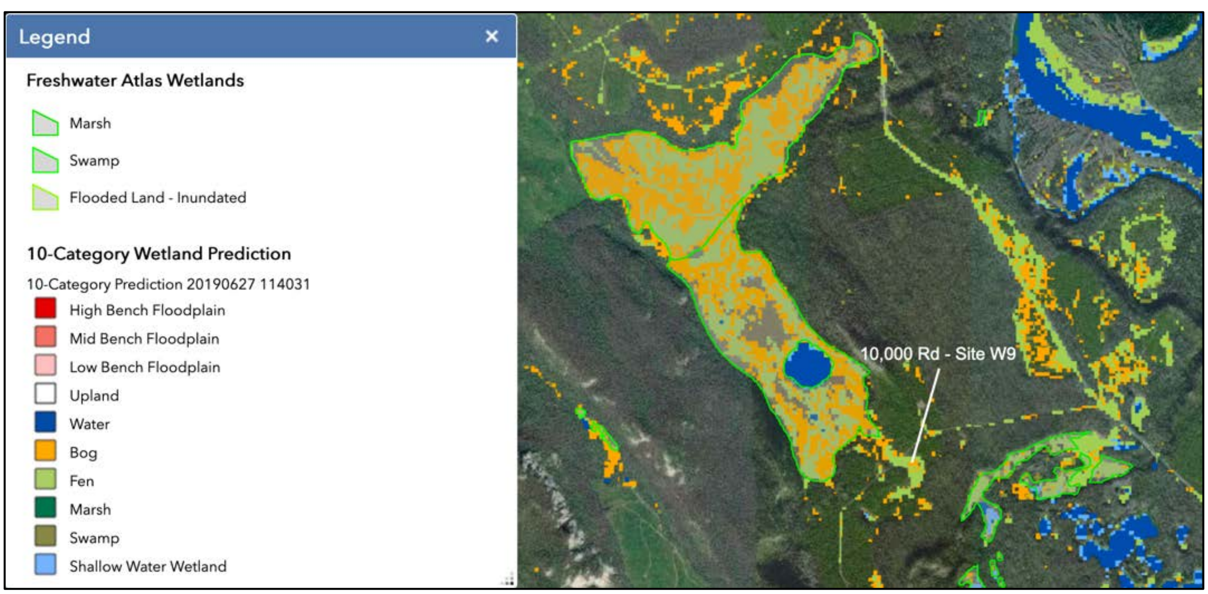

Figure 9. Williston Wetland Explorer Tool (WWET) screenshot of landscape surrounding the W9 – 10,000 Road wetland site.

3.1.3 Site W14 – Rat Lake

Site W14, the Rat Lake wetland, is located approximately 18 km by road south of the community of Tsay Keh Dene and is 4 km south of the Teeth Creek site (W16). The extended wetland area is south of Rat Lake and is shown in Figure 10. Site observations indicated high levels of disturbance (invasive plants, roadways, fencing, land clearing for agriculture). According to TKD Elders, Rat Lake was named for the large numbers of muskrat that used to live in the lake. The fur of the muskrat was once valuable for making clothing. It is also referred to as Harvey's Lake, because Harvey Simms used to have his cabin and a store here. Portions of the site were cleared for fields, and a ditch was dug for agriculture, by Harvey Simms in 1972.

The Filatow et al. (2020) algorithm identified this location as a predominantly open water site with some bog and swamp characteristics at its periphery (Figure 11). Based on air photo analysis, prior to inundation, this site might have been hydrologically connected to site W16 – Teeth Creek. This location has a thin organic layer overlapping sandy clay that becomes sandy below 1.2 m, indicative of a marsh. Some of this site was dominated by reed canary grass (*Phalaris arundinacea*), which is considered an alien exotic species in British Columbia, i.e., a species which has moved outside its natural range often due to anthropogenic activity (Klinkenberg 2019). Recent beaver (*Castor canadensis*) activity was evident at this site in 2020.

Figure 10. Looking southeast towards the 287-metre-long beaver dam (red arrow) that maintained water levels in Rat Lake in August 2020. The project area extends south of the beaver dam, with Williston Reservoir in the background.

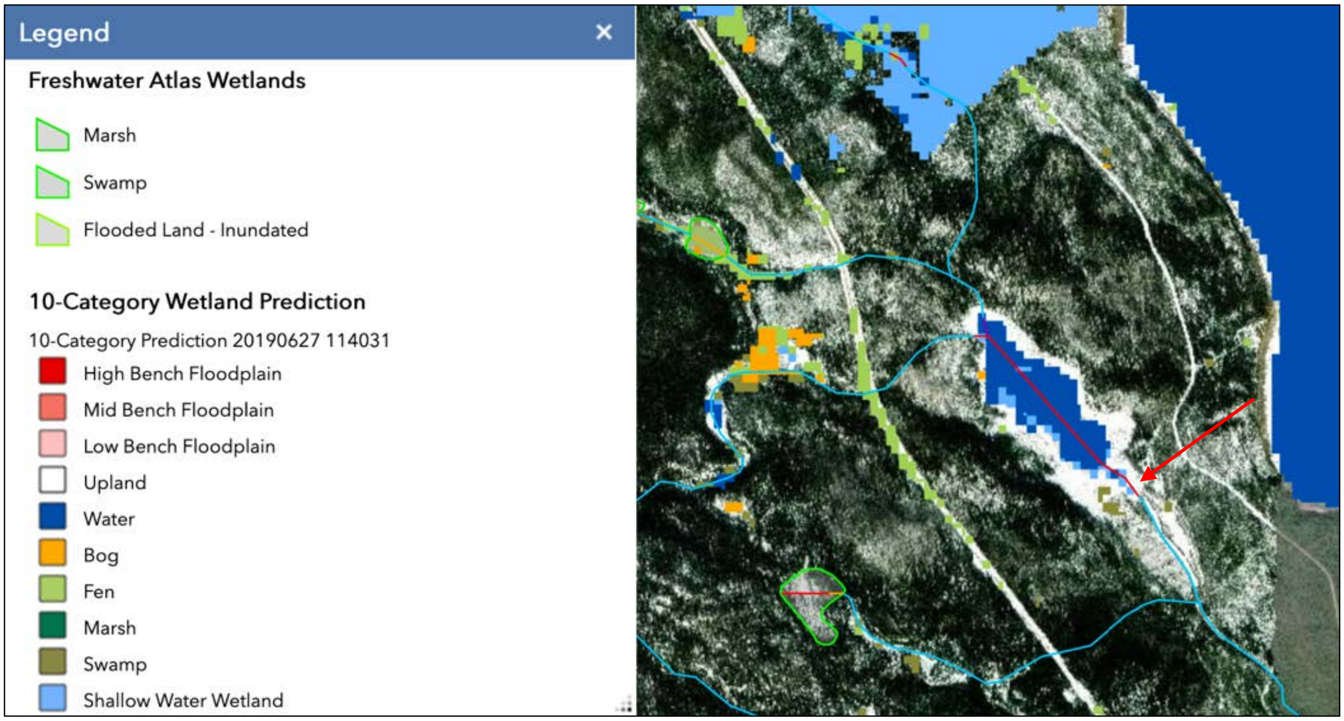

Figure 11. A screenshot of the landscape, streams, and wetland configurations surrounding site W14 – Rat Lake, from the Williston Wetland Explorer Tool (WWET). The red arrow shows the location of the large beaver dam.

3.1.4 Site W16 – Teeth Creek

The Teeth Creek site W16 is located approximately 3.6 km north of the Rat Lake site, and south of Tsay Keh Dene. The area of Teeth Creek that was assessed is a beaver-managed wetland complex that is over 6 hectares in size. A road was built across Teeth Creek by placing fill in the floodplain and lowering the base elevation of the floodplain to install two culverts to convey the creek through the road fill. When originally built, the road functioned as a dam across the floodplain, with the two culverts acting as breaches in the dam. Ditches were dug to channel water into the culverts. The road was visible in an air photo from 1971, indicating it was built shortly after inundation in 1968. This road was also used to access site W14, Rat Lake.

This site was classified as a mix of open water and shallow water with swamp and fen components, by the Filatow et al. (2020) algorithm (Figure 12). Site observations indicate that the site is a mix of open water with swamp and fen characteristics.

Figure 12. Site W16 - Teeth Creek, proposed restoration area. The breach is indicated with the red arrow. The old culverts are indicated with blue arrows.

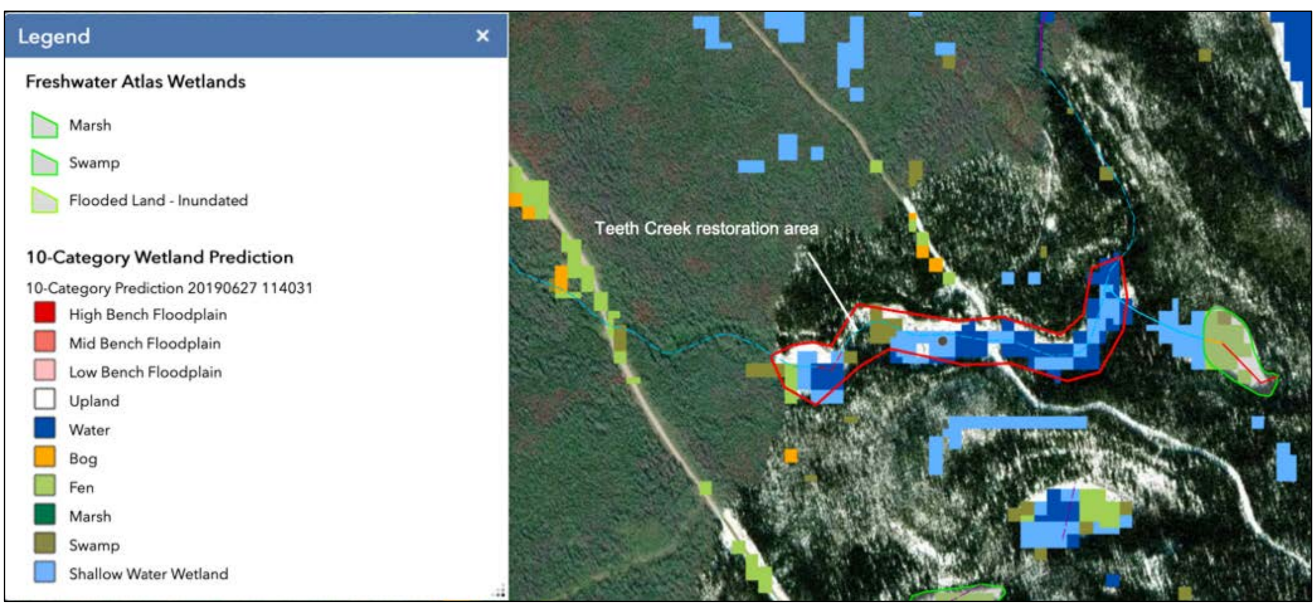

Figure 13 Williston Wetland Explorer Tool (WWET) screenshot over proposed restoration site W16 - Teeth Creek (outlined in red).

3.2 Methods

In August 2020, CCE crews, along with wetland restoration specialist Robin Annschild of Wetland Restoration Consulting, visited 4 wetland sites and conducted detailed site assessments. Data collected during these assessments included:

- Site photos
- Drone flights recording high-resolution images
- Site hydrology
- Elevation profiles
- Soil core samples
- Associated wildlife values
- Vegetation cover and species

Multiple soil samples were investigated at each site. Field crews surveyed for changes in soil compaction using a tile probe. Soil augers were used to sample into the soil profile, where marked changes in soil layers were located with tile probe. Crews traversed each site on foot and noted their observations on the ecosystem, such as the presence of beaver dams, the level of beaver activity, the presence of fish, amphibians, and birds, and their behaviours or use of the site. Water entry points and outflow patterns were noted, including presence of culverts. A rotary laser level was used to measure site elevation, topography, and slope in relation to the culverts and gravitationally directed water flow An overall assessment of factors affecting the health of the site was conducted, rather than a systematic assessment of wetland classes using classification keys.

Ecologic Consultants Ltd. (EcoLogic) managed a separate FWCP project "Amphibian Habitat Restoration and Priority Trials for Amphibians" (PEA-F21-W-3222) that overlapped geographically with the priority wetland restoration sites flagged by CCE. Therefore, it was considered economical and beneficial for EcoLogic to provide input on CCE's wetland restoration prescriptions in relation to amphibians. Their amphibian expert, Mark Thompson, surveyed the three wetland restoration sites shortlisted from 2019, collected data, and provided recommendations applicable to the management of amphibians for the restoration prescriptions.

Data was collected on amphibians and their aquatic habitats during each site visit. A full description of the methods, data, and analysis from these surveys are included in the year-end report for the amphibian FWCP project (*PEA-F21-W-3222*). Briefly, data and notes were collected on amphibians detected during timed visual detection and net sweep surveys, including life stage, measurements, and photographs. Additional ecological and environmental information pertinent to the life history and habitat requirements for amphibians were noted, including observations or recordings on aquatic invertebrates (orders), vegetation, and water chemistry (temperature, dissolved oxygen, pH, total dissolved solid, and conductivity).

Since site W16 – Teeth Creek was a new site identified in 2020, we were unable to collect amphibian data there. However, our project team intends to collect this data to fill any knowledge gaps, prior to any future restoration work.

3.3 Results

During the August 2020 field assessments of wetlands, it was noted that all sites visited which had been shortlisted in 2019 (W7, W9, W14), were inundated with water. Teeth Creek (W16) was a new addition for 2020 and was not previously assessed in 2019. Rapid health assessments were completed for all four sites in 2020, and Table 7 compares the rapid assessment health scores from 2019, to those from 2020.

Table 7. Comparison of rapid health assessment scores 2019-2020.

Site Name	2019 health score	2020 health score
W7 – Finlay FSR 20 km	78 %	89 %
W9 – 10,000 Road	64 %	70 %
W14 – Rat Lake	48 %	59 %
W16 – Teeth Creek	-	56 %

Figure 14 shows the total precipitation recorded at the Ingenika weather station between July 2010 – July 2020. This weather station is located near the Ingenika Point airstrip south of Rat Lake. It is possible that a succession of years with lower precipitation resulted in dry sites during the 2019 health assessments. Starting in July 2017, the annual precipitation appears to be lower, with more white spaces visible, indicating days with zero precipitation measured.

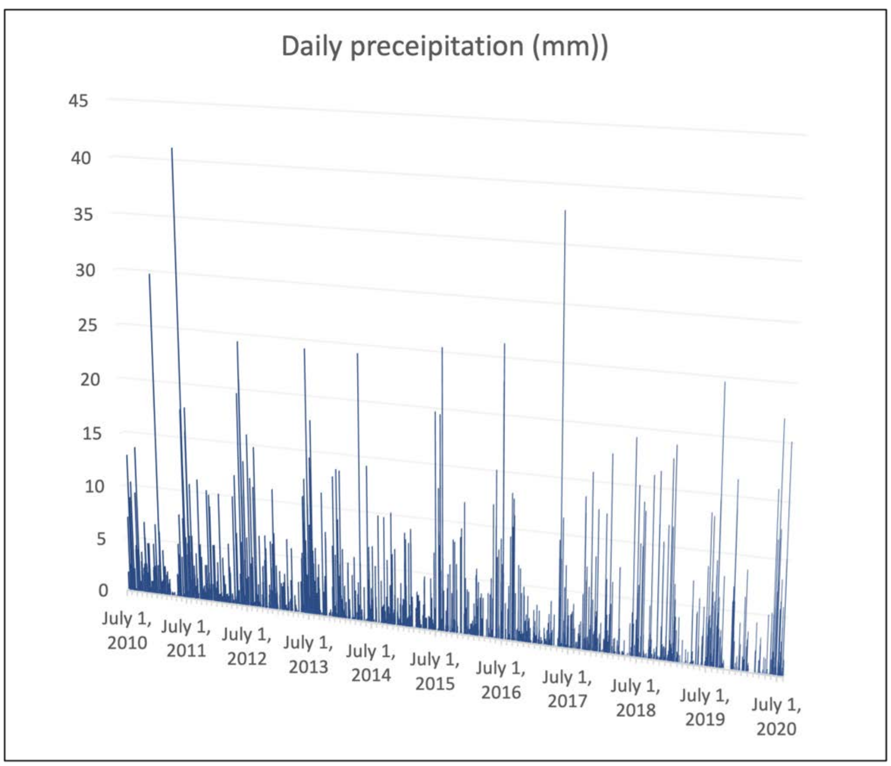

Figure 14. Annual precipitation measured at Ingenika point July 2010 - July 2020.

3.3.1 Site W7 – Finlay FSR 20 km

This site was dry when visited by the CCE wetland rapid health assessment crew in 2019, however the image on the left in Figure 15 suggests that there had been standing water in the wetland earlier in the 2019 season (red arrow). In 2020 the wetland was inundated with water as seen in Figure 15 (right).

Figure 15. Finlay Wetland dry on July 6th, 2019 (left) and inundated on August 8th, 2020 (right). The red arrow points to an area that appears to have had standing water in 2019 before the rapid health assessments.

The site was sedge dominated. Water smartweed (*Polygonum amphibium*) was also observed throughout the site, especially along the fringe of vegetation surrounding open water in the deepest areas (Figure 16). Some grassy pondweed (*Potomagetum gramineus*) were also present.

Water depth was measured along the centre of the wetland basin mapping each measurement location with a GPS (Figure 17). Water in the centre of the wetland ranged in depth from 0.19 metre at the southeast end of the wetland to 1.26 metres at the northwest end of the wetland (Figure 18). Using the wetland area of 2 hectares or 20,000 square metres, and an average depth down the centre line of 0.905 metres, the volume of water held in the Finlay wetland can be roughly estimated at 9000 cubic metres.

Figure 16. Sedge-dominated Finlay wetland has water smartweed (*Polygonum amphibium*) growing on the fringe of deepest open water pools. Image courtesy Robin Annschild.

Figure 17. Stephen Friesen and Arshad Khan wear chest waders to measure and map water depths in the Finlay Wetland on August 9th, 2020. Image courtesy Robin Annschild.

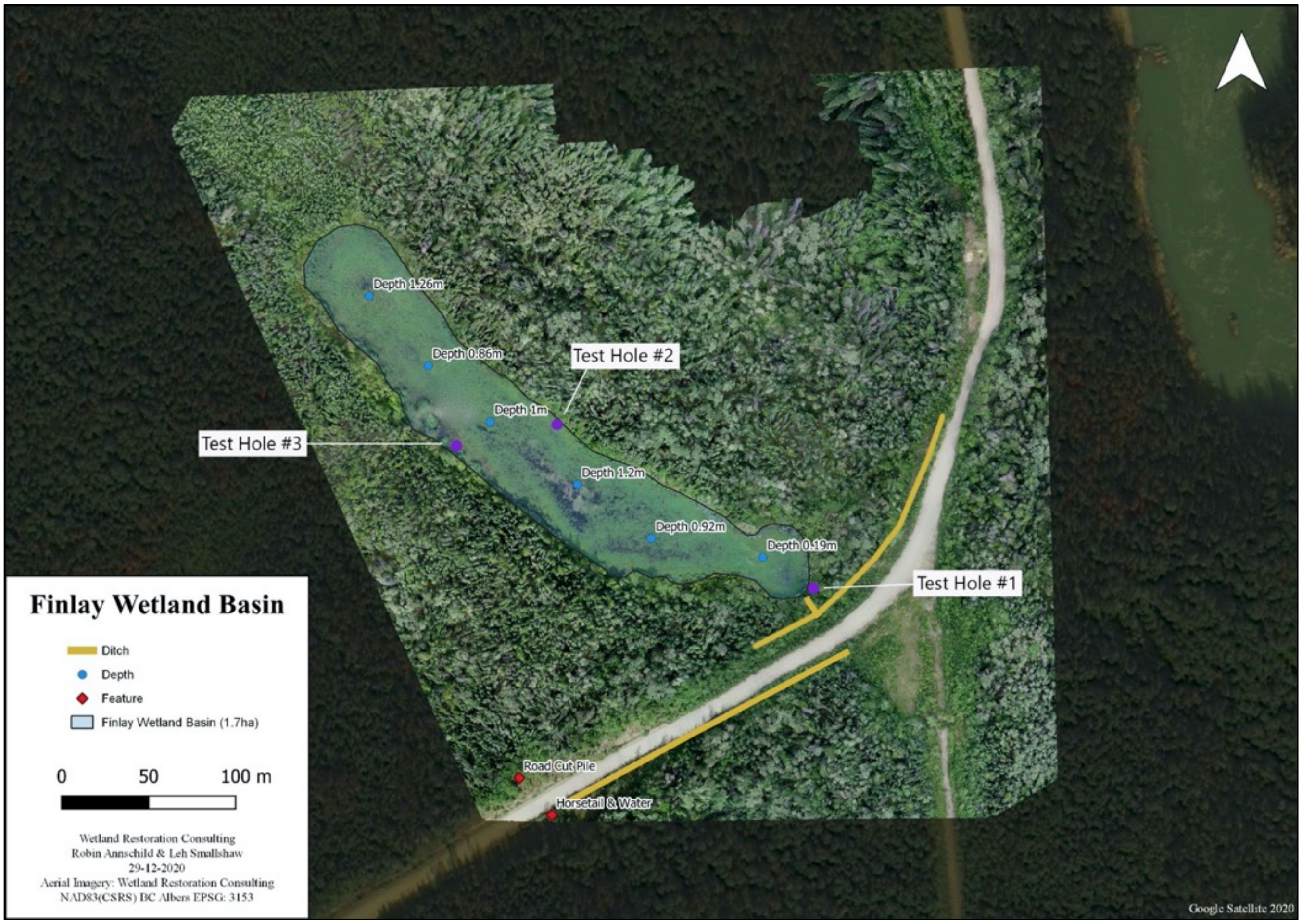

Figure 18. Water depths measured at site W7, and existing ditch lines along the Finlay FSR in yellow.

To measure soil texture and moisture levels, three test holes were dug (Figure 18). Test hole #1 was dug outside the area of standing water at the southeast end of the wetland near the access trail from the road. Test hole #2 was dug in 32 cm of standing water on the north side of the wetland. Test hole #3 was dug on the south side of the wetland where water level was at the surface. Test hole #1 consisted of a shallow organic layer (10cm) over saturated clay, with dry clay beneath. Detailed depth observations were not recorded as this test hole was dug with a large group of participants texturing soil on August 5th, 2020. The soil texture and moisture levels in test holes #2 and #3 is summarized in Table 8.

In all three test holes, saturated surface layers were underlain by dry clay. This indicates that the water held in this site is not ground water, but surface water perched on a layer of clay (Figure 19). The fact that only the surface layers of clay are saturated matches the 2019 observation that the wetland was dry when visited on July 6th, 2019. Surface water is slowing moving through the soil layers, saturating the clay as it percolates downward through cracks in the soil.

Figure 19. Organic soils over clay soils in test hole #2. Red arrow shows the approximate location where the soil changes from organic (top layer) to clay (lower).

Table 8. Site W7 – Finlay Wetland Soil Texture & Saturation

Finlay Wetland Soil Test Holes		
Test Hole #1	Test Hole #2	Test Hole #3
0 - 10 cm organic	0 - 12 cm silty organic	0 - 10 cm organic material
Saturated clay	12 - 22 cm gravelly silt	10 - 20 cm non-fibrous organic soil
Dry clay	22 - 42 cm silt	20 cm - 33cm well-decomposed organic soil
		33 - 38 cm saturated clay-silt
	42 - 59cm dry clay (10cm ribbon)	38 - 47 lighter saturated clay-silt
	59 - 69 cm mottled gravelly, silty clay	47 - 66 cm darker saturated clay-silt
	69 cm + bedrock, large rock or compacted gravel	66 - 111 cm brown clay dry and mottled
		111 - 130 cm brown clay dry and mottled with some gravel

Figure 20 shows a map of the Finlay watershed, adapted from the BC Freshwater Atlas map. The Finlay wetland watershed is outlined in white and is estimated at 41 hectares in size, excluding the 2-hectare Finlay wetland (Table 9). The estimated area of the watershed that is removed by the road is outlined in pink in Figure 20, and is over 4 hectares in size. This is a 10% reduction in the size of the watershed of the Finlay wetland.

Table 9. Estimated area of watershed removed by Finlay Road.

Area of interest	Area (m^2)	Area (hectares)	% of total watershed
Watershed of Finlay wetland (excluding wetland basin)	—	41	100%
Finlay wetland	19893	2	5%
Watershed area removed by road	42329	4	10%

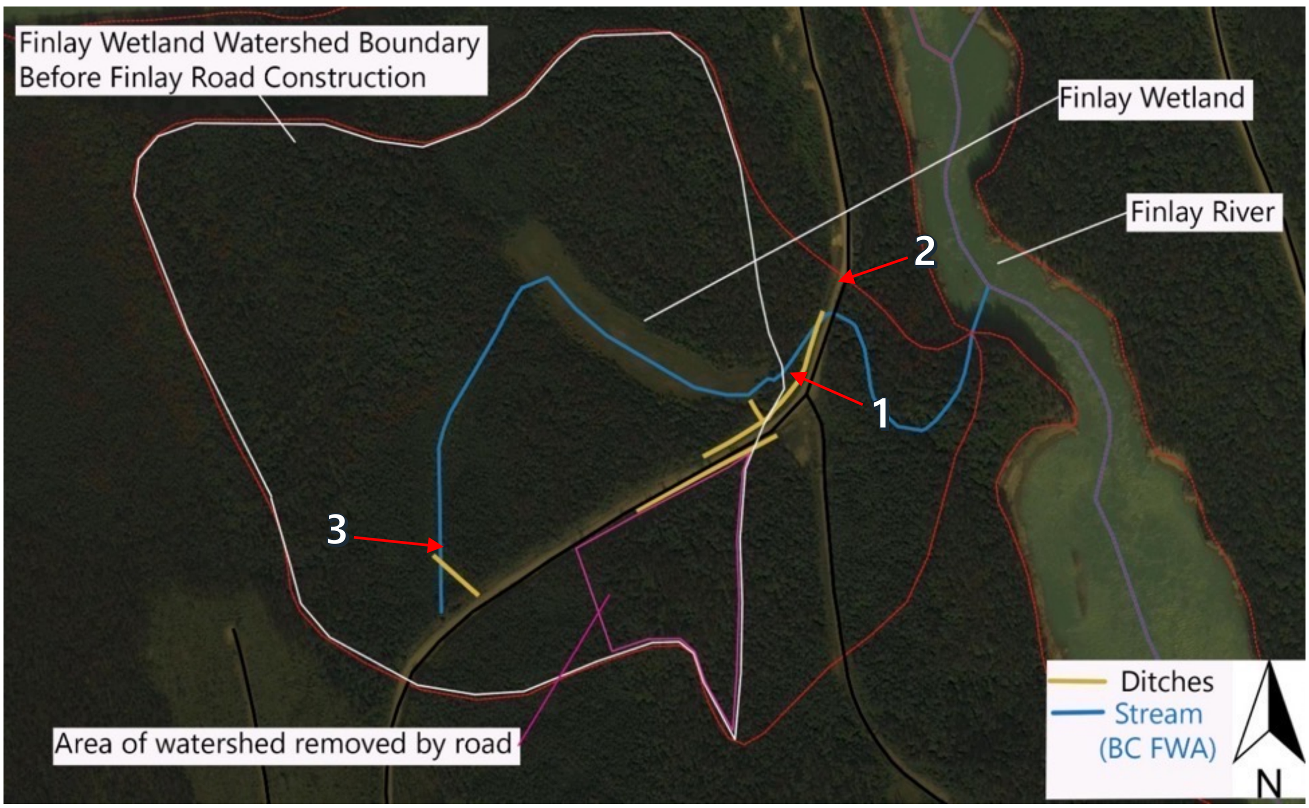

Figure 20. Finlay Wetland watershed area prior to Finlay Road construction is outlined in white, and area of watershed removed by the Finlay Road is outlined in pink. Red arrows show locations of culverts. Image courtesy Wetland Restoration Consulting.

3.3.1.1 Culvert 1

Culvert 1 moves water from the ditch on the south side of the Finlay resource road to cross under the road and flow through another ditch into the Finlay wetland (Figure 21, and Figure 23). Staining and moisture in the culvert show the ditch conveyed water at high flows (Figure 22). No water was flowing in the ditch on

August 8th, 2020. The culvert inlet on the south side of Finlay Road was damaged and partially blocked. The elevation of the inlet was set above the elevation of the base of the ditch, so that only high flows would enter. The difference in elevation was not surveyed, as the ditch is very thickly vegetated with young alder and birch. The elevation of the base of the ditch was over 2 metres below the elevation of the road surface. The crushed end and raised inlet of the culvert could also restrict animal passage under the road.

Figure 21. Culvert 1 inlet in on the south side of the Finlay FSR, approximately 2 m below the elevation of the road surface. It has been damaged, partially blocking the culvert entrance. Image courtesy Robin Annschild.

Figure 22. This photograph taken inside the culvert looking south shows that water was flowing through the culvert earlier in 2020. Staining shows that at high flows the culvert is approximately half full. Image courtesy Robin Annschild.

Figure 23. Culvert 1 outlet on the north side of the Finlay road and the ditch leading into the Finlay wetland. This culvert conveys high flows from the ditch on the south side of the Finlay Road into the Finlay wetland. Image courtesy Robin Annschild.

3.3.1.2 Culvert 2

A ditch was also observed on the north side of Finlay FSR, as shown by the red arrow in Figure 24, and was estimated at over 2 metres deep. The ditch had the appearance of being deeper because fill was placed to raise the elevation of the road at the base of the hill. The ditch might have been used as a borrow pit to provide material to use as fill in the base of the road. It was difficult to photograph due to a thicket of young alder growing in the ditch and on the roadside slope. However, the presence of the ditch 20 metres away from the wetland on the north side of the Finlay FSR may be acting to drain the wetland through the soil, shortening the hydro-period (the length of time standing water is present) of Finlay wetland.

Crews expected to find another culvert (culvert 2) in the area shown by the blue arrow in Figure 24. This would match the location of the outflow of the wetland as mapped in the BC Freshwater Atlas (Figure 20). However, there are inaccuracies in the Freshwater Atlas, especially at this scale. No overland ditch leading out of wetland was observed, nor was any surface outflow evident. No culvert was visible either, but there was the likelihood of any culvert in that location being buried and damaged.

Figure 24. The red arrow shows a deep ditch on the north side of Finlay Road. The blue arrow shows the approximate location where culvert 2 allows water to cross under the road.

3.3.1.3 Culvert 3

Culvert 3 was placed to convey water northward into a 64-metre-long ditch which followed a natural draw and led to the Finlay wetland (Figure 20). This was mapped as a stream in the BC Freshwater Atlas. However, beyond the end of the ditch, there was no evidence of surface flow along the mapped path of the stream, nor was there any evidence of surface inflow found anywhere along the entire edge of the wetland. This culvert and ditch did not appear to have a negative impact on the volume of inflow to wetland. Figure 25 and Figure 26 show the culvert 3 inlet and the outflow ditch of Culvert 3 respectively.

Figure 25. Inlet of culvert 3 on the south side of Finlay Road. Image courtesy Robin Annschild.

Figure 26. Culvert 3 outflow ditch conveys water from the towards Finlay Wetland.

The Finlay wetland provides important habitat for wildlife. A few small shallow water wetlands exist approximately 1.75 km SW of site W7, that could harbor additional amphibian breeding as part of a broader metapopulation. Adult wood frogs (*Rana sylvatica*) were present at this site. The discovery of an adult long-toed salamander (*Ambystoma macrodactylum*) here was significant (Figure 27) as there are few records of salamanders in this local area; the TKDN territory is part of the northern range-marginal extent for long-toed salamanders.

Figure 27. This long-toed salamander (*Ambystoma macrodactylum*) was found within 5 metres of the Finlay wetland on August 5th, 2020. Image courtesy Robin Annschild.

3.3.2 Site W9 – 10,000 Road

The 10,000 Road was built through the wetland, and the embankment of the road was approximated to be 12.8-meters wide by 50-metres long. A timber harvesting area approximately 130 hectares in size was visible in the 1993 air photos. The road displaced a wetland area of approximately 530 square metres (Figure 28). The volume of fill placed in the wetland was estimated by measuring and surveying 3 cross-sections of the road and averaging the results. An estimated 1,100 cubic metres of fill or 110 – 140 tandem dump truck loads were placed in the wetland and used to grade the road slope entering and leaving the wetland.

The footprint of the 10,000 road through the harvested area was calculated to be 2.5 hectares or 1.9% of the area (Table 10). Six spur roads were built off the 10,000 road to access harvesting areas. These 6 spur roads had a combined length of 2.6 km and ranged in length from 353 to 725 metres (Figure 29). The area or habitat displaced by the spur roads is 1 hectare or 0.8% of the 130-hectare harvest area (Table 10). However, the "the width of the habitat area impacted by a road, known as the 'road-effect zone' may be many times the road's actual width" (Ministry of Environment and Climate Change Strategy, 2020, p16). The spur roads appeared to have received little vehicle traffic, though ruts visible in some of the roads indicated occasional use. Road surfaces were compacted, limiting plant growth.

Figure 28. The orange polygon shows the 530 square metre area of fill placed in the wetland to build the embankment for the road. The road acts like a dam causing water to be backed up on the southeast (right) side of the road.

Table 10. 10,000 Road Harvest Area and Habitat Displaced by Roads.

Road type	Cumulative Length (m)	Average Width (m)	Area (ha)	Percentage of 130-hectare harvest area
10,000 Road	2090	12	2.5	1.9%
Spur Roads	2590	4	1	0.8%
Total	4680		3.5	2.7%

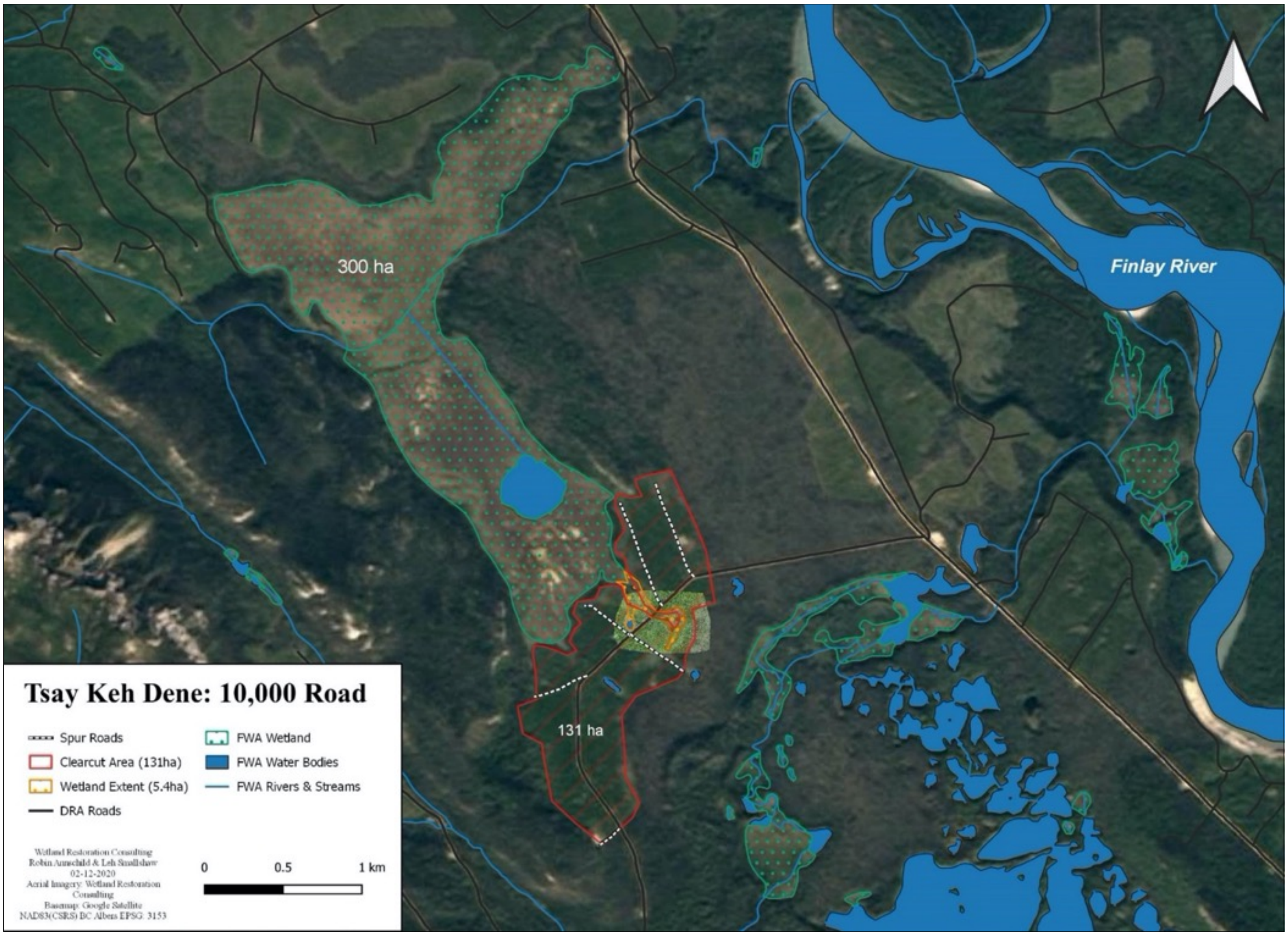

Figure 29. Site W9 - 10,000 Road wetlands, clear-cut areas, and roads.

Three culverts, measuring 500 mm in diameter (Table 11), were installed through the 10,000 Road embankment. Two of the culverts were crushed and blocking water passage. The south end of the northeast steel culvert and the plastic middle culvert were completely submerged on August 5th, 2020 (Figure 30). Standing water on the southeast side of 10,000 Road was 57 cm deep. A dip was visible in the road above the northeast culvert, and both the northeast and middle culverts appear to be crushed and completely blocked. The northwest culvert was not observed to have damaged, however, it was perched above the elevation of standing water, forming a barrier to aquatic organism passage (Figure 32). Standing water on the northwest side of 10,000 Road was 8 cm deep (Figure 33).

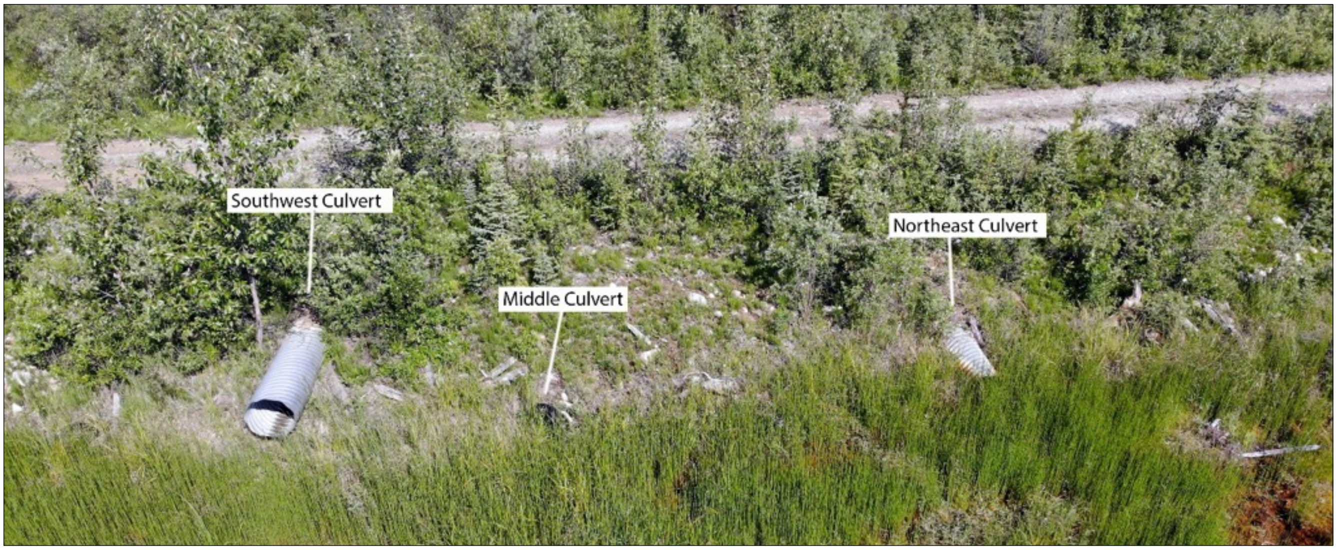

Figure 30. The three 10,000 Road culverts in 2019 when there was very little standing water south of the road.

Figure 31. The northeast culvert on the southeast side of 10,000 Road on August 5th, 2020. Standing water depth was 57cm. The culvert is crushed, preventing water from flowing through it. Image courtesy Robin Annschild.

Figure 32. The southwest culvert at 10,000 road was perched above the standing water elevation on August 5th, 2020. This creates a barrier to aquatic organism passage. Image courtesy Robin Annschild.

Figure 33. Measuring standing water depth of 8cm on the northwest side of the 10,000 Road in August 2020. Image courtesy Robin Annschild.

The wetland area immediately northwest of the 10,000 Road appears to be dominated by shrubs in the 1993 air photo and is currently dry enough for black spruce (*Picea mariana*) to have become established (Figure 34). Therefore, it appears that prior to the 10,000 Road construction, the area that is now southeast of the road was drier, and the area that is now northwest of the road was wetter, than they are currently.

Figure 34 also shows the areas that have become wetter and drier because of the presence of the road acting as a dam and backing up water on the southeast and uphill side of the road.

Table 11. 10,000 Road Culverts

Culvert Location	Culvert Type	Diameter (mm)	Length (m)	Status on August 5th, 2020
Northeast	Corrugated Metal Pipe	500	12.2	Crushed, southeast end entirely submerged.
Middle	Corrugated Plastic Pipe	500	12.2	Crushed, southeast end entirely submerged.
Southwest	Corrugated Metal Pipe	500	12.2	Culvert is sound. Invert perched above the elevation of standing water

The 10,000 Road impacted site hydrology by acting like a dam, interrupting the flow of surface and shallow sub-surface water, causing water to back up on the southeast side of the road. This resulted in a higher water table upstream (southeast) of the road, and a lower water table downstream (northwest) of the road. This can be likened to the rain-shadow effect which results in a drier area on the leeward side of a mountain range. The "road-shadow" effect caused a drier area on the downstream side of the road. The effect is greater since 2 of the 3 installed culverts have been crushed and no longer transport water.

In June and August 2020, wood frog (*Rana sylvatica*) tadpoles and adults were observed at this site, which is adjacent to and hydrologically connected to a smaller satellite wetland that has been subject to investigation in Thompson (2019). Wood frogs (*Rana sylvatica*) were confirmed at this satellite location and surrounding smaller wetlands which had been surveyed.

Aquatic vegetation at this site was dominated by beaked sedges (*Carex utriculata*), marsh cinquefoil (*Comarum palustre*), willows (*Salix* sp.), and horsetails (*Equisetum* sp.). Lodgepole pine seedlings (*Pinus contorta*) are found scattered in the wetland site along with a few dead black spruce (*Picea mariana*) snags.

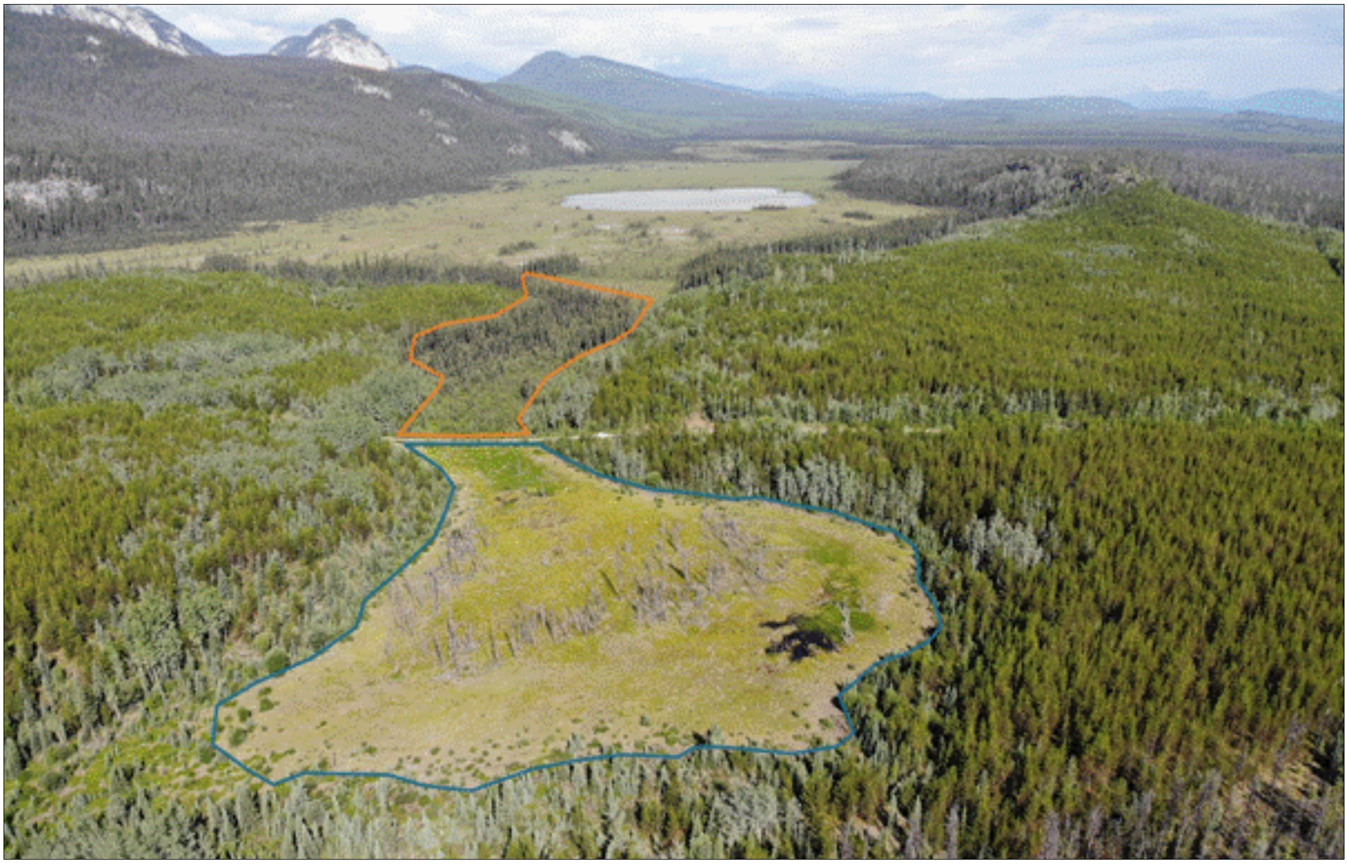

Figure 34. The blue polygon shows the estimated area that has become wetter since the 10,000 Road was built. The orange polygon shows the area that has become a drier, forested wetland, since the road was built.

3.3.3 Site W14 – Rat Lake

This site was dry downstream of the beaver dam when visited by the Chu Cho Environmental wetland rapid health assessment team in 2019 (Figure 35). In 2020, the site was observed to be in the early stages of beaver-led restoration. It was flooded by 2 new beaver dams built downstream of the dam observed in 2019 (Figure 36; Table 12).

A test hole dug at the edge of the flooded field found shallow topsoil (10 cm) over silt. This led to the conclusion that the site would not likely have perennial standing water without the presence of the beaver dams. This inference is supported by the fact that the site was dry in 2019 prior to the construction of the middle and lower dams and corresponds with what is known about the ecology and ecosystem engineering capabilities of beavers.

Figure 35. Rat Lake Floodplain dry in 2019 (left) and flooded by beaver in 2020 (right). Old clearings marked by red arrows can be seen to the left and right of the ditch.

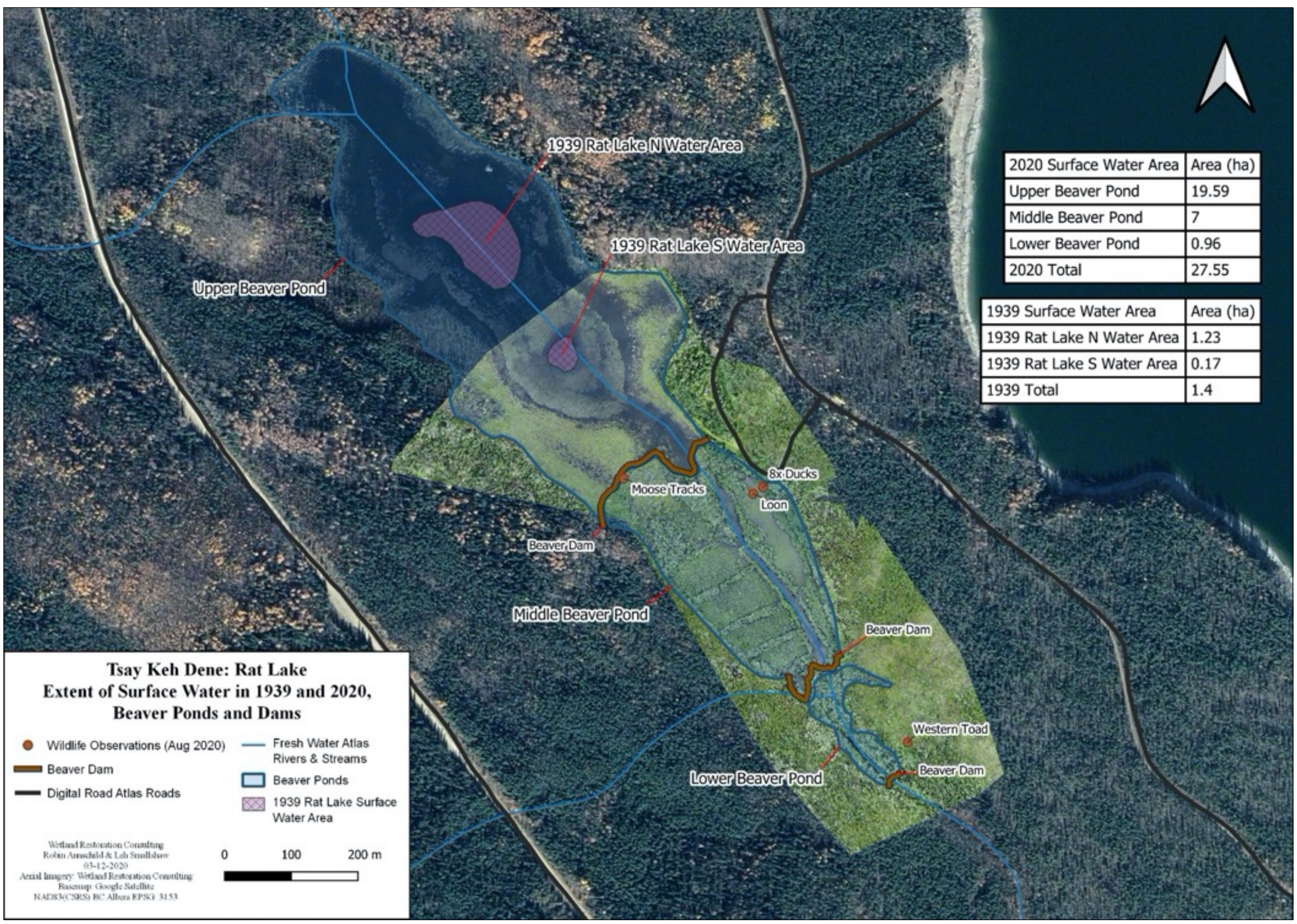

Figure 36. Rat Lake beaver-led wetland restoration.

The fields which were created in the floodplain of the stream that flows south from Rat Lake, as well as the ditch can be seen in Figure 45. The field cover approximately 7.3 hectares to the left of the deep drainage ditch. The fields were clearly visible and in active use in the 1978 air photo. The deep drainage ditch was dug down the center of the floodplain, and the floodplain was cleared, smoothed, and leveled into fields surrounded by ditches. The drainage ditch shows up clearly in the current Bing satellite imagery (Figure 37).

Figure 37. The deep drainage ditch dug down the center of the Rat Lake outflow stream floodplain is clearly visible in current Bing satellite imagery viewed in December 2020.

On August 7th, 2020, the bottom of the ditch was measured as 70 cm deeper than the fields to the east of it (Figure 38). However due to the middle beaver dam flooding the entire area, standing water was 110 cm deep in the ditch and 38 cm deep were measured in the field. The fields to the southwest of the Rat Lake outflow stream appeared to have been abandoned a decade or more earlier and have grown into a dense canopy of willows surrounded by ditches (Figure 39) and interspersed with approximately 2.4 hectares of aspen and alder. The flooded aspen and alder provide access to an important and preferred food source for the beaver population at Rat Lake (Figure 40, Figure 41, Figure 42).

Figure 38. Arshad Khan standing in the deep ditch that drains the floodplain south of Rat Lake, extending his arms to show the direction of the ditch. Image courtesy Robin Annschild.

Figure 39. The red arrow shows a drainage ditch that was dug along the base of the hill. The ditch is filled with water backed up by a beaver dam. Dense willows grow in the fields on the west side of the Rat Lake floodplain on the right in this image.

Figure 40. The 7-hectare area flooded by the middle dam includes 2.4 hectares of aspen, a preferred beaver food.

Figure 41. The middle beaver dam is 163 m long and floods an area approximately 7 hectares in size, including 2.4 hectares of aspen forest.

Figure 42. Adventitious roots grow from the stem of these aspen flooded by the middle dam. These roots contain spongy tissue called aerenchyma that help the aspen obtain oxygen under flooded conditions. Image courtesy Robin Annschild.

The fields on the northeast side of the drainage ditch were dominated by reed canary grass (Figure 43). The middle dam (Figure 41) had flooded the fields, creating wetlands with low habitat complexity. The reed canary grass will eventually be displaced by species more tolerant of continuous flooding such as cattails, sedges, bulrushes, and water smartweed (Figure 44). However, the flooded fields lack natural diversity of water depths, coarse woody debris, perches, and cover for wildlife, and could become dominated by cattails.

Figure 43. The fields on the northeast side of the drainage ditch are wetlands that lack habitat complexity.

Figure 44. Sedge and water smartweed (*Polygonum amphibium*) growing in deeper areas of the flooded field.

Figure 45 shows the beaver dams and the areas of the beaver ponds impounded by each dam. The size of the areas flooded by the beaver dams was measured by delineating areas of open water in QGIS, using a high-resolution orthophoto created by taking ortho-images on site combined with available satellite imagery. Since 2019, beavers had built two new dams 163 m long and 25 m long, flooding an additional 7.96 hectares.

Figure 46 and Figure 47 show the extent of open water at Rat Lake in the 1939 air photo, where two small pools of open water had a combined total area of 1.4 hectares. Rat Lake was mapped as 11 hectares in size when the BC Freshwater Atlas was compiled in 2009. In 2020, the surface area of Rat Lake was 19.6 hectares, 14 times greater than in 1939. The total area flooded in 2020 (including the two lower ponds) is 27.6 hectares (Figure 36), or 19.7 times the area of surface water in Rat Lake in 1939. Maintaining healthy populations of beaver at Rat Lake will ensure adequate habitat for wetland-dependant species at this site (Hossack et al., 2015).

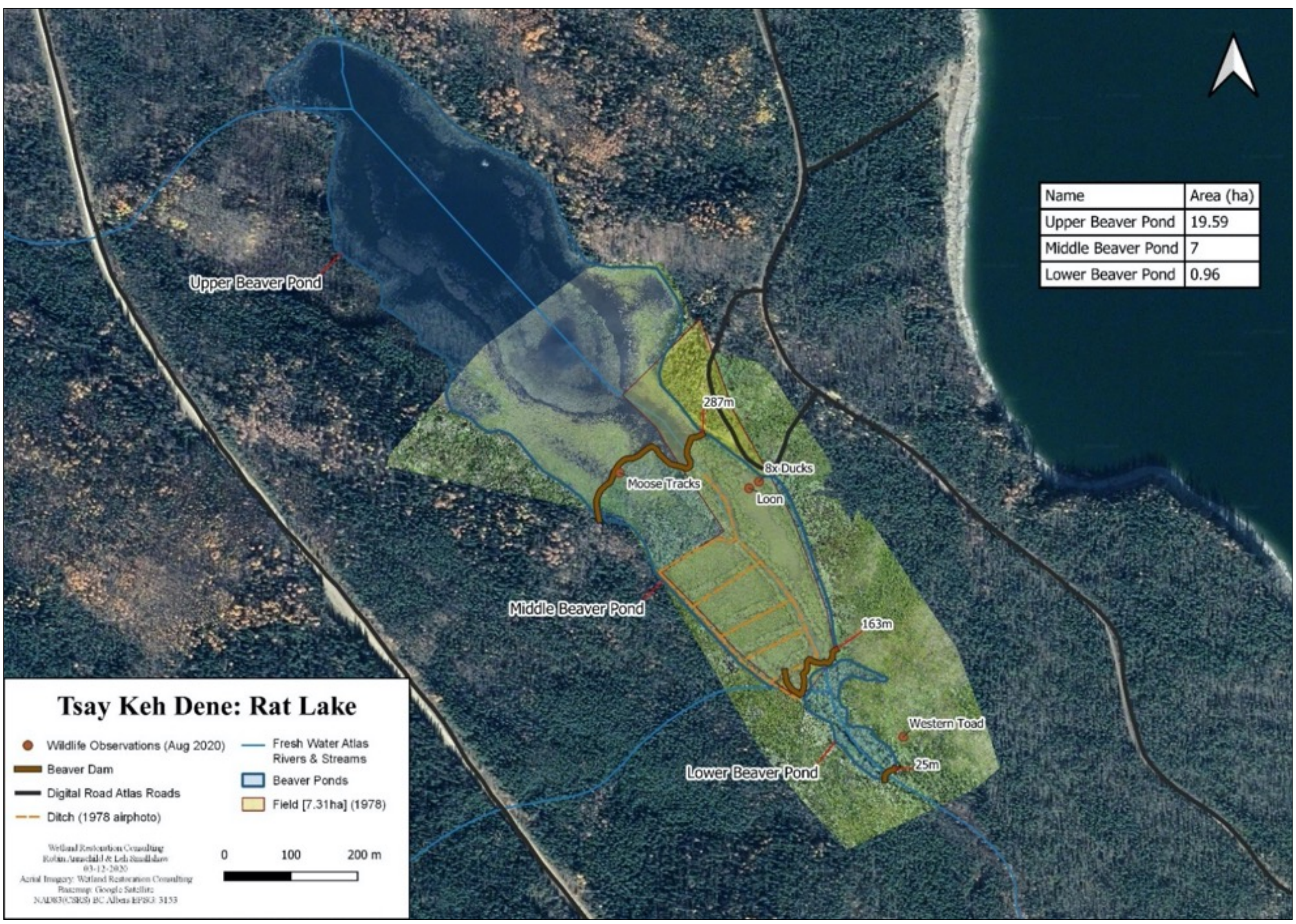

Figure 45. Rat Lake Beaver Dams and flooded areas August 2020. The lighter green area is the ortho-image taken in 2020. Image courtesy Wetland Restoration Consultants.

Table 12. Beaver dam lengths & flooded areas.

Beaver Dam Location	Year observed	Dam Length (m)	Area flooded (hectares)
Upper Beaver Dam	2019, & 2020	287	19.6
Middle Beaver Dam	2020	163	7
Lower Beaver Dam	2020	25	0.96
Total		475	27.6

Figure 46. Surface water at Rat Lake in 1939, in the BC Freshwater Atlas, and as mapped in 2020. Bing satellite imagery viewed in December 2020.

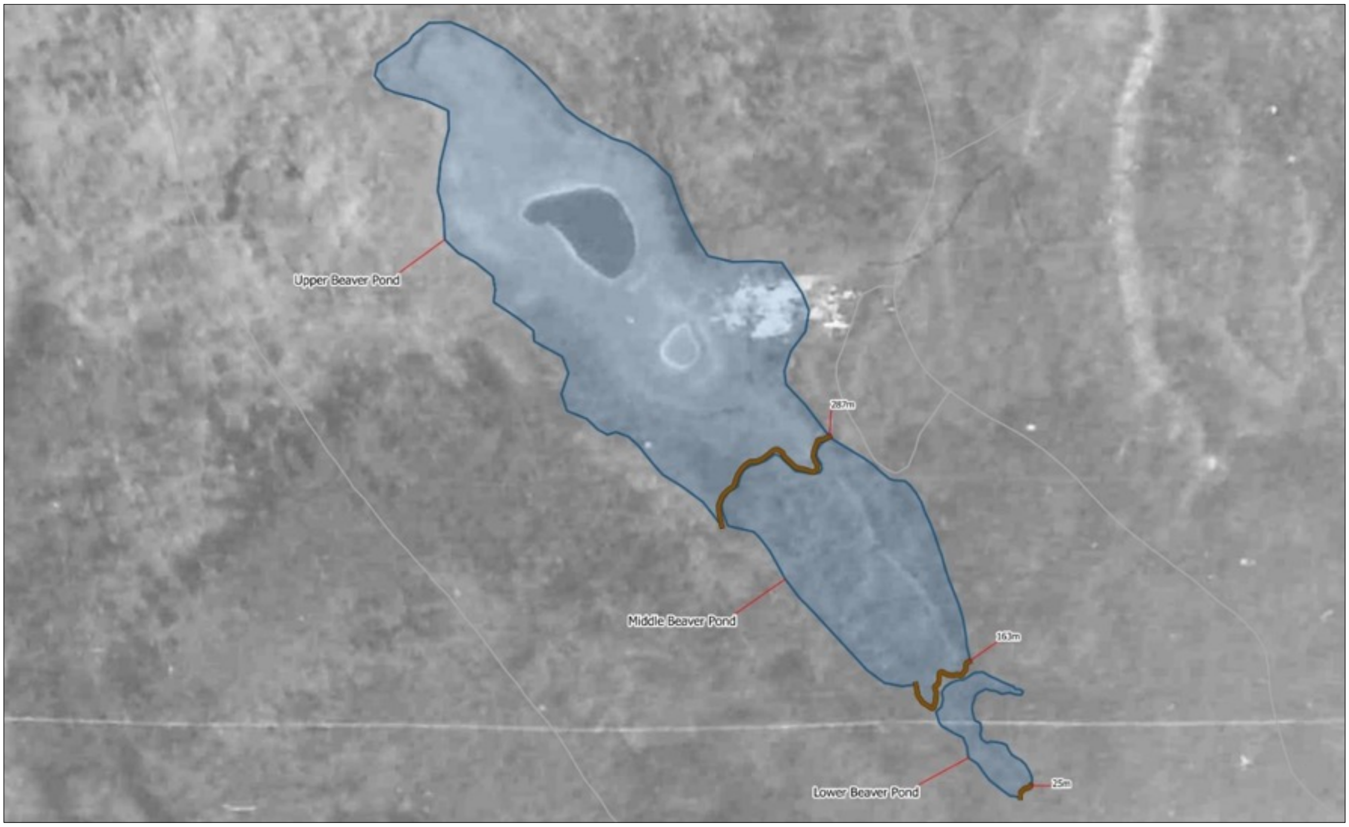

Figure 47. Rat Lake in 1939 (air photo A12195-3) has two small pools, one of which has already dried up. The 2020 beaver dams and extent of open water are overlaid on the 1939 photo. The white area to the right of the smaller pool are clouds captured in the air photo.

Despite the historical disturbance at this location, there is an active presence of breeding wood frogs and possibly long-toed salamanders; potential egg casings of the long-toed salamander were identified but this would require further assessment to confirm presence of this species. Our team also documented an active invertebrate community consisting of scuds, snails, predatory diving beetles, caddis fly larvae, and dragon fly nymphs.

Damming by beaver of the outflow stream from Rat Lake has created over 27 hectares of wetland habitat that supports a diversity of wildlife species, including moose, bear, waterfowl, great blue heron, and amphibians. Moose tracks were observed on the site, as well as a loon and ducks (Figure 45). Many small toads were observed dispersing on the access road on August 6th, 2020, which indicates Western Toad were breeding in the wetlands. An adult Western toad was observed east of the lower beaver pond on August 6th, 2020, (Figure 48).

Figure 48. This adult Western toad was observed 27 m east of the lower beaver pond on August 6th, 2020. Image courtesy Robin Annschild.

3.3.4 Site W16 – Teeth Creek

It was observed that beavers had plugged the culverts, causing the road to wash out at the north end of the floodplain. The culverts were subsequently removed and placed to the south side of the floodplain (Figure 12). Ruts in the road follow a path that by-passes the washed-out portion to divert into the floodplain creek downstream and east of where the culverts had been removed.

Following the washout and removal of the culverts, beaver worked to dam the washout and the breach in the road where the culverts used to be. The road surface was 1.25 to 1.5 metres above the floodplain. In order to match the elevation of the existing road, the beaver-built dams 1.25 to 1.5 metres high. These dams were considerably higher than the height of other beaver dams observed in the Teeth creek floodplain (Figure 49) and made them vulnerable to washing out.

At high flows, the force of the current caused a section of beaver dam to fail. The remains of the dam were visible downstream of the breach when the site was visited in August 2020.The sections of the road remaining in the floodplain made it difficult for beaver to manage and repair this dam.

Figure 49. Beaver dam at the Teeth Creek site, 1.25 m to 1.5 m tall.

The sections of the road that led from the top of the bank to the edge of the floodplain, to the north and south of the floodplain, are sloped at 11% (north) and 10% (south) and consist of highly erodible silt. The silt road surface was being washed into Teeth Creek, negatively impacting fish habitat. The sections of washed-out road remaining in the floodplain were also observed to be eroding into the creek. If left as it is, the remaining road fill will gradually erode into the creek, further negatively impacting fish habitat.

Damming, by beaver, of the breach in the road created a large wetland pool that was used by moose, bear and other wildlife (Figure 59). When the dam was breached by high flows, this pond was mostly drained. Moose tracks were observed in several locations throughout the site. Bear tracks were also observed in the wetland above the road. Juvenile fish were observed using the shallow warmer waters at the edge of the floodplain in Teeth Creek. Wood frog, western toad, a pine marten (*Martes americana*) and unidentified species of kingfisher were also observed using this site.

Beavers have built 10 to 12 beaver dams, stair-stepping down the valley over a linear distance of 980 meters, from the upstream edge of the upper observed beaver pond to the downstream end of the lowest beaver pond, documented using a drone. Locating and mapping any additional lodges and monitoring beaver activity at Teeth Creek will assist Tsay Keh Dene Nation in protecting and managing this valuable habitat.

Since this site was identified in August 2020, during engagement with Tsay Keh Dene community members, no amphibian surveys were conducted here. It is the intention of the project team to complete the amphibian surveys as well as fisheries surveys prior to any future restoration work at Teeth Creek.

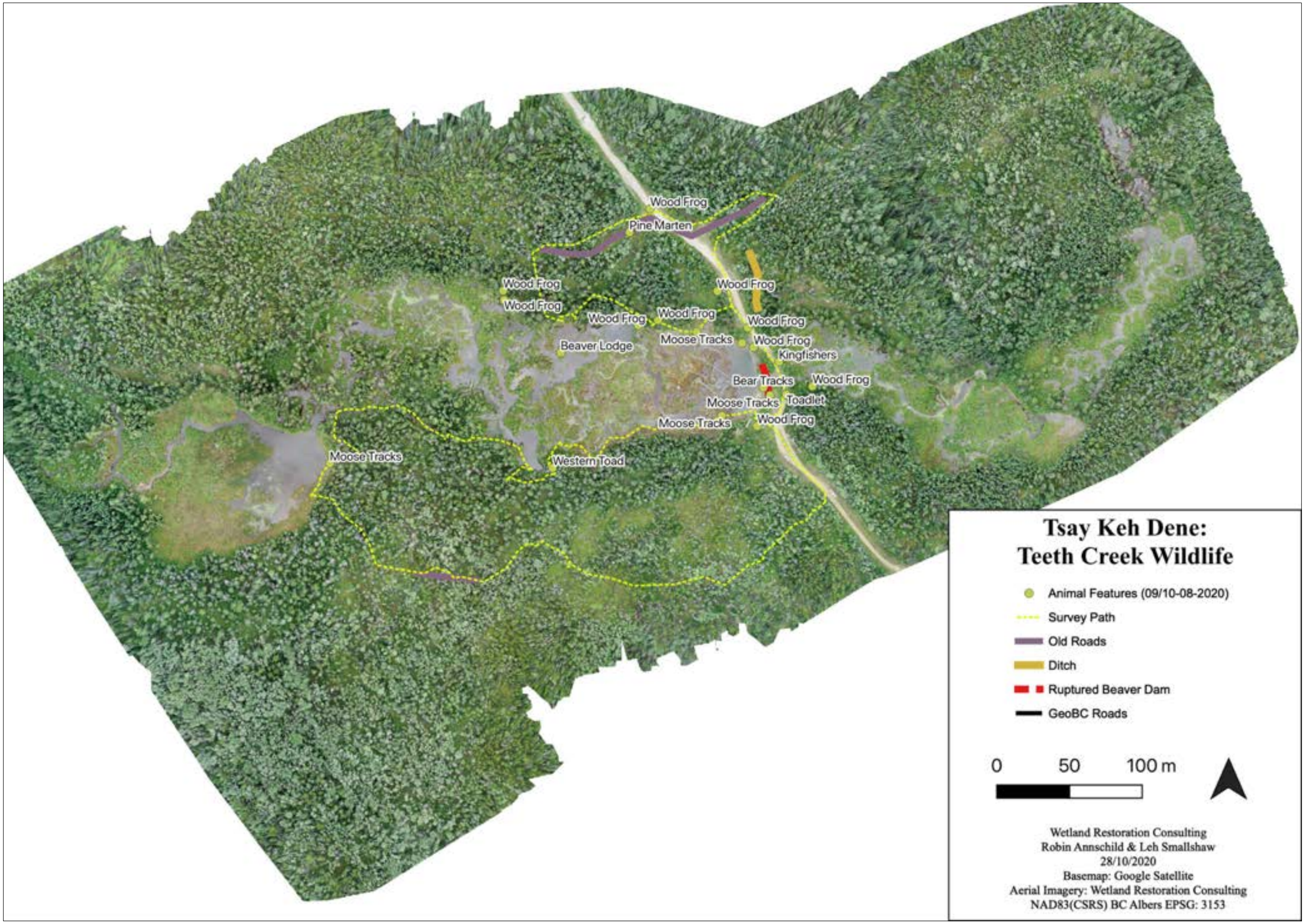

Figure 50. Map of the Teeth Creek wildlife sightings during site visit

3.4 Discussion

Detailed wetland assessments were completed in 2020 at 4 shortlisted sites. Each site had unique characteristics, which were a factor in developing site-specific restoration options. During the August 2020 field visits it was noted that all the sites visited were inundated with water. This was a marked difference from the 2019 site visits, during which all the sites visited were dry. Site w16 Teeth Creek was not assessed in 2019, however based on local knowledge, it would have had flowing water in 2019.

3.4.1 Site W7 – Finlay FSR 20 km

The Finlay wetland is an ephemeral wetland, generally filling with snowmelt in the spring and drying in late summer to fall. Ephemeral wetlands do not usually support fish; however, they are of great importance to wildlife and likely provides important breeding habitat for the amphibians (Chandler et al., 2017). Ephemeral wetlands also supply a diversity of crustaceans including fairy shrimp, clam shrimp, and isopods. An abundance of crustaceans found in ephemeral wetlands provide major food resources to migrating and resident waterfowl.

The surface water in the Finlay wetland can be expected to be warmer than that found in groundwater supplied wetlands. The warmer water is of critical importance to the development of amphibian and invertebrate eggs and larvae.

The diversity of sedges in the Finlay wetland most likely provides food for the grizzly bear, elk, moose, and deer. Small mammals living in the sedges would provide food to hawks, owls, and the red fox. The sedges are probably used by rails and waterfowl for nesting. The opening maintained within and around the wetland would also be used as a rendezvous site by wolves.

In 2020, which was noted to have been very rainy through the early summer and through end of July, water had saturated this wetland. In years when rainfall was abundant, the diversion of water caused by Finlay FSR and the potential shortening of the hydro-period caused by the presence of a deep ditch near the wetland outlet do not appear to impact the wetland's hydroperiod. Once the wetland is saturated, it can hold no more water, no matter how much it rains, so diversions that reduce the water inflow would have little consequence. This was likely the case in 2020, when abundant rainfall filled this wetland.

However, the presence of dry clay under the saturated clay layers indicated that the site had held little water for several years. After a higher precipitation year, it would take several more years for the clay layers 40 to 60 cm and deeper to dry out. The fact that this site held less water for several years is confirmed by vegetation on the site. Young cottonwood (*Populus trychocarpa*) that had begun encroaching on the wetland in dry years were showing signs of stress from the inundation in 2020 (Figure 54). Young pine and fir that had grown on the edges of the wetland were in standing water in 2020 (Figure 55, and Figure 56). By counting the whorls of small fir and pine on the wetland edge, their age was estimated to be approximately

5 – 7 years old. This indicates that the wetland has held less water in preceding years, allowing the conifers seedlings to grow.

When the Finlay resource road was built in this location, between 1987-1988 (Gorelick et al. 2017), it was cut through the crest of a hill (Figure 51 and Figure 52) and fill was placed to make a more gradual slope at the base of the hill where the road curves left and north. A deep ditch was placed on the south side of the road from the top of the cut to the base of the fill. Topsoil from the cut that was not suitable for use in the road was piled on the north side of the road, parallel to the road.

The ditch on the south side of the road was designed to remove water from the road surface, but would also draw sub-surface flows from the higher ground on the south side of the ditch. Once the subsurface flow of water entered the ditch, it would flow northeast along the road, instead of north towards the Finlay wetland (Figure 51). On August 8th, 2020, water was visibly flowing in the ditch, while the road surface was dry (Figure 53). This confirmed that the water flowing in the ditch was from sub-surface flow from uphill on the south side of the road.

The Finlay FSR removes 10% of the Finlay wetland's watershed, except during high flows, when some of the water diverted by the ditch will flow north through Culvert 1 into Finlay wetland. The deep ditch along the north side of Finlay Road may act to lower the elevation of water in the Finlay wetland, though the presence of dense clays underlying the wetland make this less likely. It is possible that the cumulative impact of diverting 10% of the inflow to Finlay wetland is enough to cause the wetland to dry slowly over time.

Figure 51. The blue arrows illustrate inference on historical surface and sub-surface water flow from the ridge into the wetland. The red arrow shows how water is intercepted by the road with uphill topography leading into the southern drainage ditch.

Figure 52. The tile probe is in the ditch on the south side of the Finlay Road (red arrow). The piles of overburden are visible on the right side of the road (blue arrow). The road appears to receive considerable vehicle use.

Figure 53. Northern scouring rush (*Equisetum variegatum*) grows in water flowing in the ditch on the south side of Finlay Road. This water is being diverted by the road and the ditch instead of flowing down the slope and into the Finlay wetland.

Figure 54. Cottonwood encroaching along the wetland edge that has been dry for several years exhibit signs of stress on the leaves, from being flooded in 2020.

Figure 55. Trisha Case points to a young pine tree in standing water that grew while this area of the wetland was dry for several years. The shrub and trees on Trisha's right and left are showing signs of stress.

Figure 56. Counting the whorls on this young fir tree, estimated it to be 5 -7 years old. Image courtesy Robin Annschild.

It could be possible to make relatively small modifications to the ditches and to culvert 1 to increase the amount of water that enters the wetland. An obvious modification would be to remove the crushed piece of culvert that partially blocks the entrance to culvert 1. However, it may be possible to modify the elevations in the ditches on one of both sides of Finlay FSR to increase the inflow into the wetland and help to mitigate the impact of the Finlay Road diversion in the Finlay Wetland's water supply.

Water leaves Finlay wetland through evaporation, percolation and potentially through surface flow, though no evidence of water overflowing the wetland was found in August 2020. Evaporation would not be sufficient to drain the wetland during a season at this latitude, though evapotranspiration would help to dry the wetland. The greatest loss of water from the Finlay wetland will be through percolation of water into the soil.

Test holes showed the Finlay wetland is underlain by a layer of clay and clay silt 30 cm to over 100 cm thick, with sufficiently clay content to be impervious if it is compacted. If lack of water or short hydro-periods in the Finlay wetland are an ongoing problem that cannot be addressed by the less invasive methods of increasing inflow though modifications to ditches and culverts; another option is to line the wetland with a layer of compacted clay. This is possible because the clay that would be needed is already in place —removing and placing the clay back in more compacted layers could make the wetland impervious. This would require stripping the top layers of vegetation and organic soil and setting them aside. The clay would be mixed and compacted in layers to 300 PSI.

Figure 57 shows part of a 25-hectare wetland restoration project completed in the floodplain of the Kootenay River in Ktunaxa Territory near the communities of ?aq'am and Cranbrook, BC. The largest wetland build with a compacted clay liner as part of this project is 2.8 hectares in size. It would be technically possible to build a compacted clay liner in the Finlay wetland; however, this technique is usually reserved for sites where wetland habitat has been ditched and drained for agricultural use. It would require all the vegetation on the site to be removed, in order to compact the clay liner, then replacing the vegetation back into the basin.

Figure 58 shows the final stages of construction of a clay liner. The excavator is placing topsoil mixed with wetland plant propagules on the clay liner. This technique is appropriate in areas where wetlands which were previously converted to farmland are being restored for wildlife.

Figure 57. Compacted clay liner wetlands built by the author in Ktunaxa Territory in the floodplain of the Kootenay River. The wetlands in this photo are 2 and 3 years old. Image courtesy Robin Annschild.

Figure 58. Placing topsoil and wetland plants back into the wetland basin on top of the compacted clay liner, October 2018. Image courtesy Robin Annschild.

3.4.1.1 Finlay Wetland Recommendations

The following information should be collected to help determine whether restoration actions are needed at Finlay wetland:

Culvert 2:

- Confirm the location of Culvert 2;
- Photograph the inside of the culvert to document staining and moisture;
- Inspect the inlet and outlet for damage and signs of flow and potential erosion;
- Walk the outflow downstream of culvert 2 to the Finlay River and document erosion and head cuts, and;
- Monitor wildlife use of the wetland, and animal mortality on the road near the culvert.

North Ditch:

- Monitor this ditch for flow during spring runoff and after heavy rain, and;
- If water is flowing in the ditch, determine where the water is coming from.

South Ditch:

- Monitor this ditch for flow during spring runoff and after heavy rain.
- Does water pool in the depression below the culvert inlet after heavy rain?
- Does water flow out of this depression toward the Finlay river, or percolate into the ground?
- How often does water flow through the ditch into the Finlay Wetland and for how long?

Finlay wetland Hydroperiod:

- Monitor water level in Finlay wetland in 2021 and ongoing. Does the wetland get saturated? If it dries, when does it go dry?
- Document wildlife use of the existing wetland.

Animal Passage:

- Monitor the Finlay Road for amphibian migration to determine the extent to which the road is a barrier to animal passage.

There is no reason to take more extreme restoration or enhancement measures while the wetland is filling-with and holding water, even though it may dry completely in some years.

3.4.2 Site W9 – 10,000 Road

In 2019 when the 10,000 Road wetland was visited, there was very little standing water on the southeast side of the 10,000 Road, close to the road embankment. In 2020, there was standing water 57 cm deep close to the road, and likely deeper in the center of the wetland area. Open water on the landscape is important for moose, bear, frogs, bats, and many other wildlife species. Currently, the presence of the

10,000 Road combined with the crushed culverts, helps to maintain open water in the wetland on the southeast side of the road.

The presence of the road increased the size of the wetland on the southeast side of 10,000 Road by impounding water. The extent of the wetland that occurred on the southeast side of the 10,000 road at the time the road was built was visible in the 1993 air photo. A narrow perimeter of trees was left uncut as a buffer around the wetland. The remains of this perimeter of uncut trees can be seen on the site today as a ring of standing dead trees. These are outlined in blue in Figure 59.

Figure 60 shows the extent of the original wetland compared to the size of the wetland today. Using the perimeter of standing dead trees as a guide, the extent of the wetland in 1993 was estimated at 5,970 m^2, and in 2020 is 8,100 m^2. The size of the wetland on the southeast side of the road has increased by approximately 35% or 2,130 m^2 in the 27+ years since the road was built.

Figure 59. The inner blue polygon shows the extent of the wetland that was present before the 10,000 Road was built. The ring of snags (red arrow) is the perimeter of trees that was left uncut as a buffer around the existing wetland when the area was logged.

Figure 60. Site W9 - 10,000 Road wetland in the past, and present.

While the 10,000 Road remains in place and acts as a hydrological barrier, this can be used to maintain open water on the southeast side of the road. Care will need to be taken if and when the crushed culverts are replaced to do so in a way that maintains open water on the southeast side of the road, provides for aquatic organism passage, and provides sufficient road drainage.

The 10,000 Road roughly parallels the watershed divide between the 300-hectare wetland to the northwest and an area with a high density of wetland habitat within and adjoining Ed Bird – Estella Provincial park to the southeast. This corridor between two large areas of wetland habitat is approximately 3.1 km^2 in size. (Figure 61).

The 10,000 Road wetland likely provides breeding habitat for several species of amphibians, including Western Toad (*A. boreas*), long-toed salamander (*A. macrodactylum*), and wood frog (*R. sylvatica*). These species are directly impacted by roads through habitat loss, increased predation, and mortality from vehicle traffic.

Road densities below 0.6 km/km^2 are recommended to: protect grizzly bear habitat, maintain habitat usage by wolf and elk, and protect caribou winter range (Salmo Consulting et al. 2003). Bull trout populations benefit in watersheds with road densities below 1.55km/km^2. Prior to the construction of 10,000 Road and spur roads the road density was nil. Building 3 km of the 10,000 Road through the area resulted in a road density of 0.97 km/km^2. Adding 2.6 km of spur roads raised the road density to 1.8 km/km^2. Removing the spur roads would reduce the road density in the corridor between the 300-hectare wetland and Ed Bird-Estella Provincial Park, to 0.97 km/km^2, however road density would remain above the maximum threshold of 0.6 km/km^2.

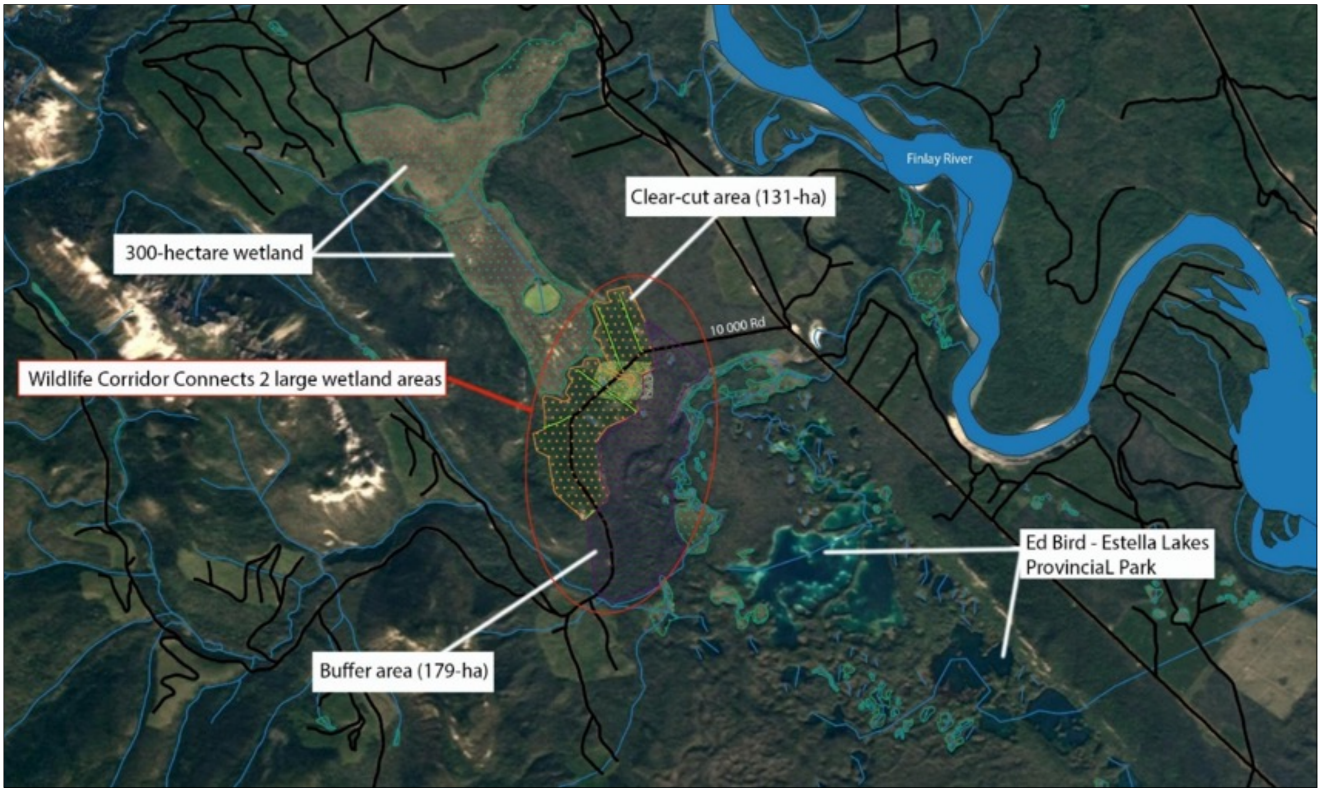

Figure 61. The spur roads are shown in bright green in the clear-cut area. Removing the spur roads would significantly reduce road density in a corridor between two areas of wetland habitat.

3.4.2.1 10,000 Road Recommendations

- Clarify current & future road use plans and maintenance schedule with respect to culverts:

Establishing communication with stakeholders responsible for road maintenance, to clarify current and future use plans for the road as well as any intended maintenance with respect to the culverts. Any maintenance work should follow the best management practices as specified in the Guidelines for Amphibian and Reptile Conservation During Road Building and Management Activities in British Columbia (Ministry of Environment and Climate Change, 2020).

- Ensure culvert replacement maintains the wetland on southeast side of 10,000 Road:

Ensure that future maintenance of culverts on the 10,000 road does not drain the wetland on the Southeast side of the road. The elevation of new culverts should be set to maintain the elevation of water in the Southeast Wetland. Ditches should not be dug when installing new culverts, to prevent draining the wetland. Culverts should be installed so there is no drop off at either side.

- Use wildlife-friendly culverts to restore passage for aquatic organisms and small mammals:

Use wildlife-friendly culverts when the existing culverts are replaced, to provide connectivity through the culvert. Build a soil ramp to make a gradual slope up to the culvert on both the inlet and outlet sides, and place soil and small woody debris in the culvert to provide a moist substrate and cover from predators for amphibians and small mammals. This will provide high water aquatic organism passage through the road without draining the wetland. Installing culverts at a minimum of 50 m intervals is recommended (Ministry of Environment and Climate Change, 2020), so only one culvert would be required in the length of the 10,000 Road that crosses the wetland. A concrete box culvert would be ideal because little road cover is required and may be installed high enough to maintain water elevations in the wetland without raising the road surface. There would be significant costs to purchase, deliver and install the box culvert on the site. An alternative would be to install two or more smaller double-walled plastic culverts. Double-walled plastic culverts are preferable to steel because they do not have temperature fluctuations that can be lethal to amphibians. Placing one or more cameras in the culverts would allow for their use by amphibians and small mammals to monitored.

- Remove spur roads to reduce road density & improve habitat quality:

If the community of Tsay Keh Dene does not use the spur roads for access, the 2.6 km of spur roads could be removed using the rough and loose technique. This can be done cost-effectively using a 200-series excavator such as a CAT 320 or equivalent. A skilled operator can remove 150 m to 300 m of 5 m wide road per day, depending on slope and the thickness of the road embankment.

- Consider eventually removing the10,000 Road:

If and when there is no further need to maintain the 10,000 Road, the road could be removed including the fill that was placed in the wetland to build the road. Removing the entire 10,000 Road is of significantly greater benefit than simply de-activating the road entrance, which reduces road-use, but does not restore the habitat productivity of the road footprint.

- Consider establishing road density thresholds:

Establishing thresholds for road density in various habitat types throughout the Tsay Keh Dene Territory will help guide when resource roads should be removed and when they may be left in place. Unless resource roads are used by Tsay Keh Dene community, there are wider benefits to removing them, especially when they are near wetlands or cross areas that provide connectivity between areas of significant wetland habitat, as is the case with the 10,000 Road and associated spur roads (Figure 61).

3.4.3 Site W14 – Rat Lake

If the beaver and their dams remain at Rat Lake, the project site water levels may be successfully maintained, and a novel wetland ecosystem may develop in the old farm fields. Using heavy equipment to disable the ditches at Rat Lake would contribute to the restoration of the wetlands. Disabling the ditches would increase the hydroperiod in the wetlands and reduce the possibility of the wetlands draining, should the beaver dams fail.

While they are flooded, the northeast fields at Rat Lake can no longer be used for farmland, and currently provide poor-quality wetland. Restoring dips, ridges, scrapes and mounds and adding coarse woody debris to the old fields in the floodplain would increase the diversity of wetland plant vegetation and animals that will be able to colonize the site. Restoring the natural micro-topography in the field would vary the depth of water, which is currently uniform across the field. This action would improve habitat for wildlife and reduce the possibility of cattails dominating the site.

The beaver dams could be left in place and monitored. If the beaver dams fail, it would be possible to remove the ditch and restore a more diverse and natural-appearing topography to the floodplain, reversing the work that was done to drain and smooth the fields. Figure 62 shows how a series of wetland basins could be dug to disable the ditches. Soil from digging the basins would be used to fill the ditches between the pools.

Another option would be to breach the two lower beaver dams to drain the area, then remove the ditch and restore the floodplain micro-topography, and finally re-build the beaver dams. The success of this approach is questionable and depends on the beavers' cooperation. It is possible the beaver would not immediately repair the breached dams, which would provide an opportunity to restore the floodplain. It is also possible the beaver would immediately begin repairing the dam. This could only be considered if breaching the two lower dams would not threaten the beaver lodge, which is likely located in Rat Lake, above the upper dam. It would be counterproductive to threaten the survival of the beaver at Rat Lake by draining their lodge pond.

Beavers are not able to completely block water flowing in a ditch. A significant amount of water can be expected to be flowing beneath the beaver dams.

It is possible that the beaver dams at Rat Lake could fail due to spring run-off or if the beaver become unable to maintain the dams due to hunting, trapping, predation by wolves, or illness. In this case, the ditches that are now flooded would once again drain Rat Lake.

Figure 63 shows an example of wetland restoration projects completed in old fields that were made by draining wetlands.

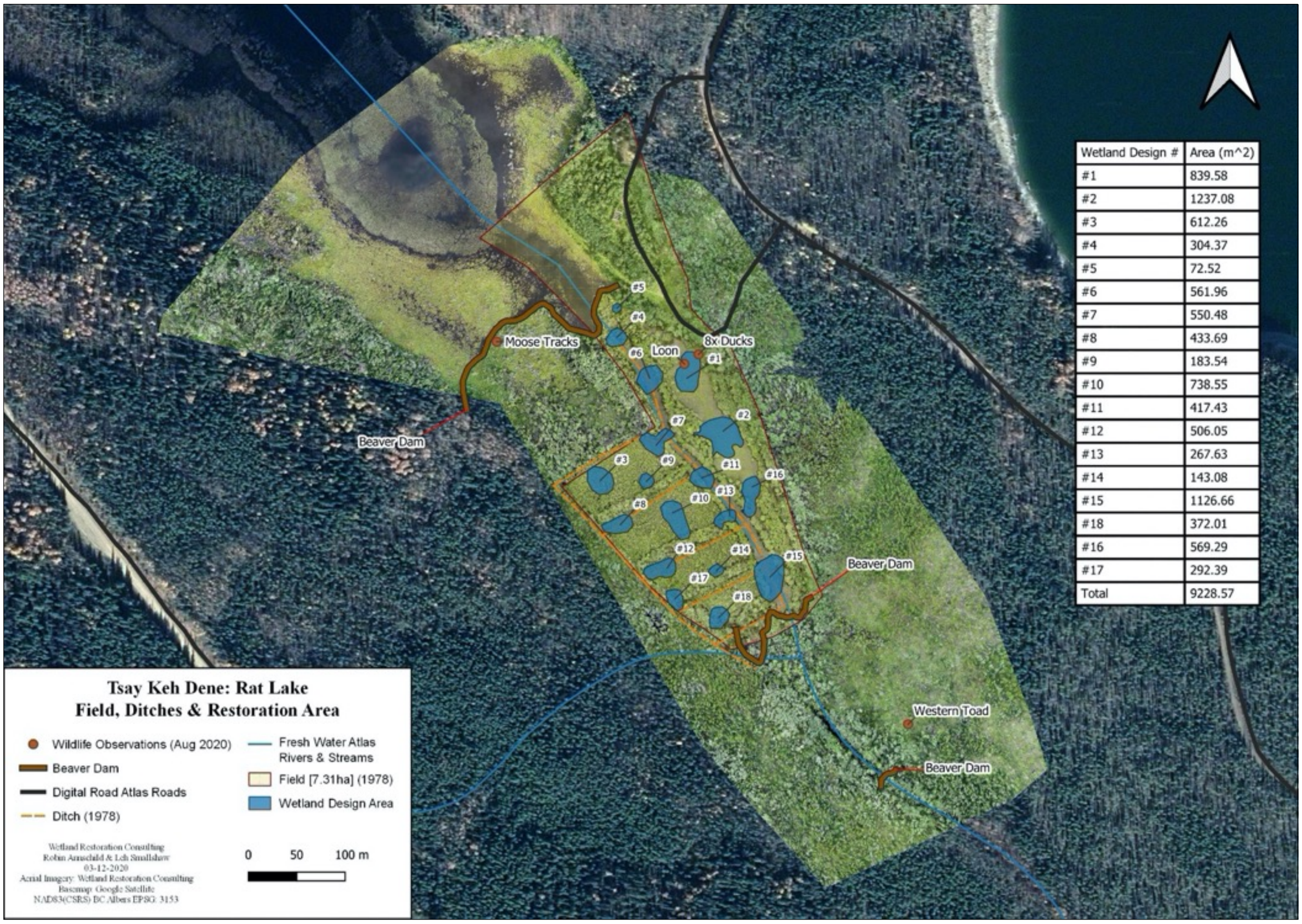

Figure 62. Rat Lake fields and restoration design.

Figure 63. Wetlands restored in 2018 in old fields in the floodplain of Mather Creek in Ktunaxa Territory near the communities of ?aq'am and Cranbrook. Photo by Robin Annschild.

3.4.3.1 Rat Lake Recommendations

Option 1: Monitor beaver, beaver dams & water levels in the Rat Lake wetland.

- **Advantages:** This allows the beaver to continue their management of the site undisturbed, while monitoring for opportunities to remove the ditches should the beaver dams be breached and abandoned by the beaver at some point in the future.

- **Disadvantages:** The ditches remain in place and will drain the floodplain if and when the beaver dams are breached and not repaired by beaver.

Option 2: Complete some wetland restoration while working in the standing water.

- **Advantages:** This method will maintain the existing wetland values that are beginning to develop in the new beaver ponds while allowing the ditches to be disabled.

- **Disadvantages:** It would be difficult to access the site with heavy equipment. Logs would be required for flotation. It would be difficult to see in the murky water to work. It would not be possible to fill ditches with soil that is compacted.

Option 3: Disable the ditches and restore site topography if and when the beaver dams are breached and not repaired by beaver.

This option involves monitoring the site for beaver activity and the presence of beaver dams and ponds. Should the beaver dams fail or be breached, resulting in the draining of the two lower ponds, restoration of site micro-topography and removal of ditches could go ahead.

- Advantages: Maintains the existing wetland values that are beginning to develop in the new beaver ponds without additional site disturbance.

- Disadvantages: It would be difficult to plan for an opportunistic project such as this unless the beaver were to abandon the site for several years, allowing enough time to raise the funds for the project and implement it while the site remained dry.

Option 4: Breach the beaver dams to drain & restore floodplain and then immediately repair the beaver dams.

- Advantages: Allows the ditch to be removed, and floodplain micro-topography to be restored. Makes it easier to plan and implement the restoration, as the dams could theoretically be breached ahead of time to dry the area so the earthworks could be completed in dry conditions.

- Disadvantages: Breaching the two lower dams would involve releasing the water currently stored in the middle and lower ponds, which have a combined surface are of 7.96 hectares (Figure 36). Assuming the average depth of the ponds is 0.4 meters the volume of water released into the small stream that flows out of Rat Lake would be approximately 32,000 m^2. This would flow in the small outflow stream a distance of 1.7 kilometres before flowing into the Williston Reservoir. It may not be possible to do this without causing significant erosion in the outflow stream. It may also be challenging to do this if the beaver are still active in the area and repair the dam while the area is being drained.

A combination of Option 1 and Option 3 is recommended. While disabling the ditches and restoring natural micro-topography to the fields would be ideal from a restoration perspective, it is difficult to justify breaching the dams and disturbing the beaver while they are actively maintaining and extending wetland habitat on the site and have recently flooded large areas.

Figure 64 shows Snk'Mip Marsh in Sinixt Territory at the north end of Slocan Lake. It is a 12-hectare novel marsh wetland ecosystem restored and maintained by beaver on a site where a wetland had previously been drained and converted to agricultural fields. The red arrow shows the location of the main drainage ditch, which has not functioned since beaver first built a dam across the outlet of the ditch to block it prior to 1945. While the beaver dams are maintained at Rat Lake, the deep ditch down the centre of the valley and smaller ditches surrounding the fields will not function to drain the floodplain.

If the beaver at Rat Lake area able to maintain the dams for several decades, as they have done at Snk'Mip Marsh, over time the old fields would likely become dominated by a combination of cattail and open water, as the reed canary gradually becomes displaced by species that are more tolerant of continual inundation.

Figure 64. Snk'Mip marsh in Sinixt Territory developed in a field where beaver have maintained flooded conditions for over 76 years. The red arrow shows the flooded drainage ditch that beaver built a dam across to block between 1939 and 1945.

3.4.4 Site W16 – Teeth Creek

As its state is currently, the Teeth Creek washout will continue to erode the remnants of the old road, especially at the breach where water velocity was visually observed to be higher. Continued usage of the path through the floodplain by vehicles will also add to environmental damage and raise the risk of contaminants entering the stream. While beavers are continuing to use and maintain dams upstream of the breach, this site would benefit from enhancement. Addressing knowledge gaps to clarify, which fish species are present in Teeth Creek, would be the next step at this site.

3.4.4.1 Teeth Creek Recommendations

Option 1: Repair the road.

The road could be repaired by re-installing culverts and re-building the washout at the north end of the floodplain. The beaver can be expected to begin plugging the culverts immediately. The use of beaver co-existence tools such as “beaver-proof” culverts or beaver exclusion fencing would be required. A pond-leveler would be needed to reduce the frequency of road flooding. Alternatively, an open bottom structure (bridge, box culvert) could be installed. This would allow access over Teeth Creek, while reducing the area of the road in the floodplain and enhancing fish habitat and passage.

- **Advantages:** Road access would be restored across the floodplain of Teeth Creek. Some of the floodplain could be returned to wetland habitat if a bridge is installed. Fish and amphibian passage would be maintained since an open bottom structure would have to be installed.

- **Disadvantages:** The area of the road in the floodplain would continue to displace valuable wetland habitat. The sloped sections of road through the riparian zone from the top of the bank to the edge of the floodplain would continue to erode into the creek. The road would act as a dam, blocking fish passage. Maintaining new structures would require a considerable amount of time and effort. Any beaver co-existence tools would require ongoing maintenance. Even with the use of beaver-coexistence tools, the road would be at risk of flooding. The cost to repair the road and if necessary, replace the culverts, would be high. Potential sources of funding for this are unknown. The cost to install a bridge could be high. Depending on the bridge design, the road would still dam some of the floodplain, however some habitat could be restored to wetlands. Beaver management might also still be required and would be dependent on the bridge design.

Option 2: Remove the road & restore the riparian area.

The floodplain could be restored by removing the remaining sections of road. The fill used to build the road could be placed back into the borrow pits on the north and south side where it was likely mined when the road was built (Figure 65). This way the floodplain would be restored to its natural elevation. The floodplain is sufficiently wide and flat at this location that the road fill could simply be removed, without concerns about causing erosion within the floodplain. Small, low-profile hummocks could be left in the floodplain and staked with willow and/or cottonwood. This would mimic the small hummocks of soil observed in other areas of the floodplain and facilitate beaver building sections of dam from hummock to hummock. A beaver dam analogue consisting of posts pounded into the ground 1 m-apart across the floodplain could be installed at the location of the road, once the road is removed. This would provide anchor points for beaver dam building. However, given the lack of gradient at this location and the high level of existing beaver activity, this is not necessary. The same benefits could be achieved by leaving hummocks across the floodplain as described above.

The riparian zone could be restored by loosening the compacted road surfaces on the slope from the top of the bank to the edge of the floodplain (Figure 65). Road fill removed from the floodplain and placed back on the slopes would be left rough and loose to facilitate vegetation establishment and reduce erosion into the stream. The loose soils would be seeded with native species and a non-persistent agronomic cover crop such as fall rye or winter wheat.

Removing the remains of the road would restore the 790 m^2 footprint of the road to wetland habitat and facilitate beaver-led management of this section of the floodplain. An additional 1450 m^2 of riparian habitat would be restored.

- **Advantages:** Approximately 790 m^2 of wetland habitat displaced by the road would be restored. An estimated 280 $m^2$of sediment from road fill would be prevented from washing into the stream. Silt currently washing into the creek from the sloped road surface in the riparian area to the north and south of the floodplain would be prevented from doing so. Habitat for fish, beaver, kingfisher, moose, bear, western toad, wood frog and many other species would be restored.

- **Disadvantages:** There would be no vehicle access across the floodplain. Vehicles would need to access the site from the north or from the south but could not cross the floodplain.

Figure 65. Site W16 - Teeth Creek restoration plan, Option 2.

If Tsay Keh Dene Natron decides to restore the floodplain, it will be important to identify any values on site to be protected during the restoration work. For instance, there is a flat spot on the north side of the floodplain that showed evidence of use as a campsite. This site could be left undisturbed during the restoration, or a new camping spot could be shaped from the soils removed from the floodplain.

4 Conclusion

Clearly, all of the wetland sites assessed in 2020 have restoration potential. The rapid health assessments conducted in 2019 (Khan et al. 2020), and 2020 provided snapshots of wetland health, and the field assessments in 2020 provided a more detailed analysis of the factors impacting the four shortlisted sites.

Three of the four amphibian species that inhabit Tsay Keh Dene Nation territory have been identified and occur in the target restoration wetland sites. There are incidental citizen science records (iMAP BC Frogwatch forms) for the fourth undetected species, spotted frog (*Rana luteiventris*), but local presence of this species may require further scrutiny as the species may have been confused with wood frogs. Despite multiple years of survey in the local area, Thompson (2019) found no evidence of spotted frogs locally with the most northern record of this species in the Middle Creek area. It is important that work continue on the ecological site associations of wetlands as may have important bearing on the life-history and habitat requirements of amphibians in terms of survival, fitness, and resilience in context of restoration efforts that are being advanced.

Long-term monitoring of the Williston Reservoir trial wetlands, at Airport Lagoon and Beaver Pond, have indicated positive findings. Early seral vegetation has established itself, and fish habitat complexity has increased as have fish populations. Amphibian diversity appears to have decreased but this could be a result of more fish using the sites. This project has increased wetland habitat, by successfully together smaller wetlands which were isolated previously (d'Entremont et al. 2020).

Given the noticeable difference in water levels at the sites, it is apparent that some sites are in the process of natural restoration (Finlay FSR 20 km wetland, and Rat Lake), and any proposed restoration work should take into account the positive impacts the beaver are having at Rat Lake, as well as the feasibility of restoration work at this stage. For the 10,000 Road site, engagement with forest licensees will be required to determine their future use of the resource road, and possibilities for culvert replacement. The Teeth Creek wetland provides a good opportunity to restore wetland habitat in the floodplain of Teeth Creek, while enhancing fish habitat as well.

Further research of historical air photos of the Finlay, Peace, and Parsnip reaches of the reservoir could help to better quantify the impact to wetlands, but until that time, the participants responses indicate that the impact has been substantial.

Boreal wetlands in Canada have suffered from the cumulative impacts of decades of resource extraction and the associated changes to landscapes and ecosystem functions. Often, the impacted habitats are home to species at risk (Mansuy et al. 2020).

The four wetland sites identified in this report all provide excellent opportunities for wetland restoration. Community engagement with Tsay Keh Dene Nation citizens work is essential to moving forward with any future restoration work.

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7 Appendices

7.1 Appendix 1 – The Mosquito People

The Mosquito People (Tlotona Indians) Diamond Jenness 1925, P. 70

A certain chief had no sons and only one daughter, whom he loved exceedingly. A stranger once entered his camp and offered to hunt for him, taking the place of a son. The chief consented, and for a long time the stranger hunted for him very successfully. At last he asked for the girl in marriage and her father consented.

One day the chief bade his son-in-law kill a beaver, as he had a longing for beaver meat. The stranger killed a large beaver, but it was late in the day he left the meat and carried away only the stomach. Darkness came on, and, unable to see his way, he floundered through ice and damp snow; but travelling slowly, he reached camp a little before midnight. When no one would eat his beaver stomach, he asked his wife, wonderingly, "why does not your father eat what I brought him?" "Why did you not bring home some meat?" she asked; and he answered, "when I fell through the ice, I lost all the meat and could save only the stomach."

Now the youngest man in the camp went out and examined the stranger's snow-shoes, which were covered with mud and ice from the swamps. "You must have been very successful", the youth said, "for your snow-shoes are covered with blood." He carried them into camp for the people to examine, and they said to one another, "why has he not announced that he killed many animals? Why has he concealed the meat?" The Chief's daughter heard their remarks and said to her husband, "the people accuse you of killing many animals and concealing the meat." "That is not true," he answered. "That is not blood on my snow-shoes, but mud from the swamps through which I passed." But his wife said, "guide the people tomorrow to the place where you killed the beaver and show them the meat."

In the morning, the stranger guided the people to the swamp where he had killed the beaver, in order to show them their mistake. They travelled nearly the whole day, and when at last they reached the swamp he said, "there is a dark scum of the swamp that was on my snow-shoes. I did not conceal any meat." His wife's youngest brother said to him "flatten a stick at one end, push it into the swamp and draw it out again." The stranger did so, and drew out three frogs, whereupon the people exclaimed in delight. "That is what we wanted, not beaver meat. Push your stick in again." Again and again, the stranger drew out frogs until he had amassed a large pile. His companions began to carry them home, but none of them could carry more than a single frog. The stranger, wondering how a single frog could be so heavy, and why anyone should want to eat such meat, asked his wife, but she answered "Hush. Frogs are their food." He pushed a stick through forty frogs and packed them on his back, amazing the people by his strength. But when he reached the camp a little mouse approached him, saying "My grandmother wants to see you." It guided him to a house where an old woman sat in a corner. She said to him "put some fringes from you coat on the fire." For each fringe that he placed in the fire she pulled out an entire blanket, the payment for her advice. When she had enough blankets, she said "run away from these people, for they are not human beings at all, only mosquitoes. If you eat their frog meat you will surely die. These mosquitoes have carried you away." The man then left the old woman and returned to his wife. When all the people had entered the camp he said to her "these frogs I brought home for you. Now I am going up that mountain yonder to get a mountain goat for myself." But instead of going up the mountain, he fled far away and returned to his own people on the Stikine River.