Peace Project Water Use Plan

Williston Trial Tributaries

Implementation Year 4

Reference: GMSMON-17

Study Period: April 2014 to March 2015

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GMSMON-17: Williston Trial Tributaries
Year 4 – Final Report

Report submitted to:

BC Hydro, Water License Requirements **Attn: Toby Jones, Natural Resource Specialist**

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Cover photo: Spawning Rainbow Trout in Lamonti Creek, Williston Reservoir tributary; June 26, 2014. Photo © N. Shaw, DWB Consulting Services Ltd.

EXECUTIVE SUMMARY

Reservoir operations have created large unproductive areas within the drawdown zone of Williston Reservoir. The low productivity of this habitat limits the area's capacity to support fish and fish access to tributaries may be restricted at low reservoir levels. Fish access to tributaries is considered to be potentially restricted by debris accumulations at tributary mouths or by the exposure of barriers to fish passage at low water levels. To address these impacts, the Williston Tributary Access Management Plan was developed within the Peace Water Use Plan to improve tributary access through management of debris and alterations to stream morphology in the drawdown zone (Anon. 2003). An inventory of potential enhancement sites was completed under GMSWORKS-19 *Williston Reservoir Trial Tributaries*. The final site selection identified one site in the Finlay Arm (Ole Creek) with debris impacts and one site in the Parsnip Reach (Six Mile Creek) with drawdown impacts.

The GMSMON-17 project is a 10-year monitoring program to assess the effectiveness of the demonstration tributary enhancement projects at improving fish access to the selected tributaries. The focus of the effectiveness monitoring program is to determine the response of fish and selected indicator groups to the tributary enhancements. Fish, vegetation, amphibians, and birds were identified as the indicator groups for effectiveness monitoring with the focus on changes in fish diversity and abundance. This report presents the results from the fourth year of monitoring under GMSMON-17. The results provide a combination of additional baseline information and initial post-construction observations following completion of both enhancement project during the Year 4 (2014) monitoring period.

Remote collection of water level, water temperature, and air temperature data continued from the stream gauging stations on Six Mile and Ole Creeks. Manual discharge measurements were completed for both creeks on three separate occasions to allow for development of the stage-discharge curve for each stream. Environmental conditions in Year 4 were generally similar to Year 3 except for the lower water levels in July and August as a result of well below average precipitation.

Fish monitoring completed in Year 4 included habitat mapping of the drawdown zone reaches, fish sampling in the drawdown zone reaches, Rainbow Trout spawner surveys, juvenile fish population estimation by mark-resight, and fry surveys. Habitat mapping was completed on all streams prior to completion of the enhancement works and was supplemented by high resolution orthophotos. Fish species identified in the drawdown reaches included Bull Trout, Rainbow Trout, Slimy Sculpin, and Prickly Sculpin. Rainbow Trout were observed spawning in Lamonti Creek representing the first spawning observations in the study. The only other observation in the spawner survey was a pair of adult Rainbow Trout in Six Mile Creek. More fish were captured or observed in Year 4 during the mark-resight component than in previous years. The increase in sample size improved the population estimates. Density estimates were similar to those from previous years. Rainbow trout fry were only observed in Six Mile Creek despite the spawning observations in Lamonti Creek. Cooler water temperatures in Lamonti Creek may have resulted in later emergence of fry.

Vegetation mapping in Year 4 identified nine habitat classes and one non-vegetated (open water) habitat class at the four sites. The vegetation communities were similar at all sites and had similar distributions in the drawdown zone. Vegetation mapping also identified seven enhancement classes at the Six Mile and Ole Creek sites. No vegetation was observed on the enhancement structures except for planted live willow cuttings and some annual ryegrass on

seeded areas. The baseline data collected in Year 4 provides a better characterization of the vegetation types at the four study sites in comparison to vegetation data collected in previous years

More amphibian species were observed in Year 4 compared to previous years. All species known to occur in the region were detected. The CPUE values were comparable to previous years. However, the refined plot and transect survey methods showed that amphibians were not randomly distributed and cluster into identifiable habitats. The enhancement works at Six Mile and Ole Creeks may have had a direct impact on amphibian habitat. The impact was potentially negative at Ole Creek through removal of debris and potentially positive at Six Mile Creek through water level stabilization at an important wetland site. The refinements to the amphibian survey methods in Year 4 will assist in monitoring changes in the relative abundance and diversity in terms of habitat use, age classes, body condition, and spatial ecology.

The numbers of songbirds and waterbirds detected during the surveys in 2014 was relatively low with the highest number of species and detections at Six Mile Creek. Waterfowl and shorebird species detected included Common Merganser, a Goldeneye species, Common Loon and Spotted Sandpiper. The low numbers of species detected within the survey circles was likely due to the lack of habitat (vegetation) for songbirds at the survey points, which were located along the streams near the enhancement works within the drawdown zone. As the enhancement works, including planted vegetation, were recently completed, avian use of these areas may increase in future years. Additionally, the information collected in these surveys will increase the knowledge base for songbird and waterbird use of the drawdown zone and adjacent areas in Williston Reservoir.

The additional baseline data and initial post-construction observations collected in Year 4 of the GMSMON-17 project was generally consistent with previous years. At the two control sites (Lamonti and Factor Ross Creeks) the data contributes to the existing baseline data at these two sites. Construction of the two the tributary access enhancement projects (Six Mile and Lamonti Creeks) was completed during field data collection in Year 4. The data collected from these two sites is a combination of both baseline and initial post-construction observations. Construction activities may have had some influence on the data collected for all indicator groups (fish, vegetation, amphibians, and birds) and this will need to be considered in future analyses to assess the effectiveness of the projects.

MANAGEMENT SUMMARY: STATUS OF GMSMON-17 MANAGEMENT QUESTIONS AND HYPOTHESES – YEAR 4

Management Question	Management Hypothesis (Null)	Year 4 (2014) Status
Does fish abundance and diversity in tributaries increase as a result of enhancement?	H_{01}: Fish abundance and diversity in tributaries does not increase as a result of tributary enhancement;	Testing of this hypothesis is not yet possible as both tributary enhancement projects were just completed in spring 2014. Year 5 will be the first year of post-construction monitoring.
Is the area and quality of fish habitat created by the tributary enhancement maintained over time?	H_{02}: Total rearing area for fish does not increase following enhancement to tributaries	Testing of this hypothesis is not yet possible as both tributary enhancement projects were just completed in spring 2014. Year 5 will be the first year of post-construction monitoring.
Does riparian vegetation along tributaries increase in abundance and diversity as a result of enhancement?	H_{03}: Riparian vegetation abundance and diversity along the tributaries does not increase following enhancement to tributaries;	Testing of this hypothesis is not yet possible as both tributary enhancement projects were just completed in spring 2014. Year 5 will be the first year of post-construction monitoring.
Does abundance and diversity of song birds (passerines) around tributaries change as a result of enhancement?	H_{06}: Song bird abundance and diversity near tributaries does not increase following tributary enhancement.	Testing of this hypothesis is not yet possible as both tributary enhancement projects were just completed in spring 2014. Year 5 will be the first year of post-construction monitoring.
Does abundance and diversity of waterfowl and shorebirds around tributaries change as a result of enhancement?	H_{07}: Waterfowl and shorebird abundance and diversity near tributaries does not change following tributary enhancement.	Testing of this hypothesis is not yet possible as both tributary enhancement projects were just completed in spring 2014. Year 5 will be the first year of post-construction monitoring.
Does amphibian abundance and diversity in tributaries change as a result of enhancement?	H_{04}: Amphibian abundance and diversity in and near tributaries does not change following tributary enhancement	Testing of this hypothesis is not yet possible as both tributary enhancement projects were just completed in spring 2014. Year 5 will be the first year of post-construction monitoring.
Does tributary enhancement change the area and quality of amphibian breeding habitat over time? If so, is the area and quality maintained over time?	H_{05}: Total amphibian breeding area does not change following enhancement	Testing of this hypothesis is not yet possible as both tributary enhancement projects were just completed in spring 2014. Year 5 will be the first year of post-construction monitoring.

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Field work was completed by DWB and CBA staff. Fish sampling was completed by Jesse Laframboise (DWB), Nathan Shaw (DWB), Clayton Smith (DWB), and Vicki Prigmore (CBA). Vegetation sampling and mapping was completed by Allan Carson (CBA). Amphibian surveys were led by Mark Thompson (DWB). Songbird, waterfowl, and shorebird surveys were completed by Catherine Craig (CBA) with assistance from Allan Carson (CBA). The hydrological analyses (rating curves) were completed by Emily Cheung P.Eng. (DWB). Andrew MacInnis (CBA Senior Fisheries Biologist) was Project Manager with assistance from Mark Thompson (DWB Senior Ecologist) the Assistant Project Manager.

Additional field work support was provided by Chu Cho Environmental Services, a company owned by the Tsay Keh Dene Nation. Chu Cho Environmental staff that provided assistance in Year 4 were Mike Tilson, Nathan French, and Stephen Friesen.

High resolution orthophotos and digital elevation models for Six Mile and Ole Creeks were provided by JR Canadian Mapping Ltd using data obtained using their UAV (unmanned aerial vehicle).

The report was written by Andrew MacInnis, Mark Thompson, Jesse Laframboise, Allan Carson, and Catherine Craig.

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1 INTRODUCTION

1.1 Background

During consultations under the Peace Water Use Plan (WUP), the Consultative Committee recognized that reservoir operations created large unproductive areas within the drawdown zone of Williston Reservoir (Anon. 2003). The resulting limited aquatic habitats were hypothesized to have two primary impacts on fish: the low productivity limits the area's capacity to support fish and fish access to tributaries may be restricted at low reservoir levels. The large area (~450 km^2) of the drawdown zone between the low and high water levels, provides no fish habitat when exposed and little habitat for fish when inundated (Anon. 2003). The fluctuating water levels are also a major restriction on littoral zone productivity around the reservoir.

It was observed that when water levels recede during drawdown, significant accumulations of debris were stranded at the mouths of some tributaries (Anon. 2003). Low water levels during drawdown were also observed to expose barriers to fish passage in the tributaries. Debris accumulation and associated scour was also considered to be a limiting factor in vegetation development on portions of the tributaries (BC Hydro 2008). The effect these two factors on fish access to reservoir tributaries is unknown and variable, depending on the location. The Williston Tributary Access Management Plan was developed within the WUP to improve tributary access through management of debris and alterations to stream morphology in the drawdown zone (Anon. 2003). The components of the plan were an inventory of tributaries with either debris or other physical barriers to fish passage that were potentially suitable for enhancement, selection of two tributaries for implementation of demonstration access enhancement projects, and a monitoring program to test their effectiveness in improving fish access and habitat for fish and wildlife over the life of the project. If the projects were considered to be successful, then the potential for additional tributary access projects would be assessed (Anon. 2003).

The inventory of potential enhancement sites was completed under GMSWORKS-19 *Williston Reservoir Trial Tributaries*. A total of 64 Williston Reservoir tributaries were reviewed to determine if they had access limitations due to debris or morphology by Cubberly and Hengeveld (2010). Of the 64 sites reviewed, nine candidate sites were identified for further investigation of the extent of fish access limitations and feasibility of access improvement demonstration projects. Conceptual designs were proposed for the two highest ranking sites representing two sites in the Parsnip Arm with drawdown impacts (Cubberly and Hengeveld 2010). The final site selection identified one site in the Finlay Arm (Ole Creek) with debris impacts and one of the originally selected sites in the Parsnip Reach (Six Mile Creek) with drawdown impacts. Monitoring of the effectiveness of the tributary access enhancement projects in improving fish access to reservoir tributaries will be completed under GMSMON-17 *Tributary Habitat Review*.

1.2 Monitoring Plan Overview

The GMSMON-17 project is a 10-year monitoring program to assess the effectiveness of the demonstration tributary enhancement projects at improving fish and wildlife habitat (BC Hydro 2008). This effectiveness monitoring program is designed to determine the response of fish and selected indicator groups to the tributary enhancements and to increase knowledge of wildlife use of the drawdown zone, particularly for birds and amphibians. The emphasis of the monitoring program is on determining the effectiveness of the tributary access enhancements in improving fish access and habitat. The access enhancements were also predicted to allow for establishment of riparian vegetation and potentially result in benefits for songbirds. Amphibians were also identified as an indicator group for the effectiveness monitoring program.

This report presents the results from the fourth year of the GMSMON-17 monitoring program. The results provide a combination of additional baseline information and the initial post-construction observations. Construction of both tributary access enhancement demonstration projects (Six Mile and Ole Creeks) was completed during the Year 4 (2014) monitoring period resulting in the collection of additional baseline data and some initial post-construction data on this project.

2 MANAGEMENT QUESTIONS AND HYPOTHESES

The monitoring objectives and hypotheses for GMSMON-17 were stated in the Terms of Reference for the project (BC Hydro 2008). These are restated below along with a brief summary of how the testing of each hypothesis is approached in the study design.

Six key management questions regarding the effectiveness of the wetland enhancements were identified for the Tributary Habitat Review monitoring program:

1. Does fish abundance and diversity in tributaries increase as a result of enhancement?
2. Is the area and quality of fish habitat created by the tributary enhancement maintained over time?
3. Does riparian vegetation along tributaries increase in abundance and diversity as a result of enhancement?
4. Does abundance and diversity of song birds (passerines) around tributaries change as a result of enhancement?
5. Does amphibian abundance and diversity in tributaries change as a result of enhancement?
6. Does tributary enhancement change the area and quality of amphibian breeding habitat over time? If so, is the area and quality maintained over time?

Based on these management questions, the study was designed to test the following null hypotheses:

H_{01}: Fish abundance and diversity in tributaries does not increase as a result of tributary enhancement.

H_{02}: Total rearing area for fish does not increase following enhancement to tributaries.

H_{03}: Riparian vegetation abundance and diversity along the tributaries does not increase following enhancement to tributaries.

H_{04}: Amphibian abundance and diversity in and near tributaries does not change following tributary enhancement.

H_{05}: Total amphibian breeding area does not change following enhancement.

H_{06}: Song bird abundance and diversity near tributaries does not increase following tributary enhancement.

DWB and CBA also proposed an additional management question and hypothesis that could be incorporated into the existing study design:

7. Does abundance and diversity of waterfowl and shorebirds around tributaries change as a result of enhancement?

H_{07}: Waterfowl and shorebird abundance and diversity near tributaries does not change following tributary enhancement.

The monitoring program collects annual data on fish abundance, diversity, and habitat; riparian vegetation abundance and diversity; amphibian abundance, diversity, and breeding habitat; songbird abundance and diversity; and waterfowl abundance and diversity. The focus of the trial is on enhancing fish access to the tributaries but it is expected that there may be some benefits to wildlife and wildlife habitat from channel stabilisation and debris reduction allowing for increased growth of riparian vegetation.

The effectiveness monitoring approach is annual sampling of the indicator groups at locations within each stream and in adjacent riparian areas at both the treatment and control sites. The fish population monitoring includes drawdown zone reach habitat mapping, rainbow trout visual spawning surveys, fish diversity and abundance in the drawdown zone reach of each stream by electrofishing, juvenile fish abundance using mark-resight, and visual fry surveys. Riparian vegetation is monitored using annual quadrat sampling and aerial photo analysis. Amphibians are inventoried using systematic surveys to determine relative abundance. Songbirds, waterfowl, and shorebirds are surveyed using breeding bird point counts, land-based observations, and nest searches.

3 STUDY AREA

Williston Reservoir is located in northeastern British Columbia and was created by construction of the W.A.C. Bennett Dam at the head of the Peace River Canyon, about 20 km west of Hudson’s Hope, B.C (BC Hydro 2007). The reservoir extends for about 260 km along the Rocky Mountain Trench from the Finlay River in the north to the Parsnip River in the south. The reservoir is generally divided into three geographic regions (from north to south): Finlay Reach, Peace Reach and Parsnip Reach (BC Hydro 2007).

The reservoir is located within the Sub-Boreal Spruce and Boreal White and Black Spruce biogeoclimatic zones (Meidinger and Pojar 1991). The Sub-Boreal Spruce zone is the dominant zone and occurs as two subzones and variants at lower elevations along most of the reservoir (Meidinger and Pojar 1991). The Boreal White and Black Spruce zone occurs only at the northern end of the reservoir in the Finlay Arm (Meidinger and Pojar 1991). The drawdown zone consists of large areas of mud, sand, and gravel flats with stranded large woody debris. Limited amounts of vegetation occur even following extended periods of drawdown.

The water level in the reservoir varies annually with reservoir filling and drafting. The annual reservoir levels for the first four years of this study (Year 1: 2011, Year 2: 2012, Year 3: 2013, and Year 4: 2014) are shown in Figure 1 along with the 20-year mean reservoir level. The lowest reservoir elevations typically occur in late April – early May and the highest elevations are reached in late July – early August. In 2014, the reservoir reached its lowest level of 658.3 m on April 26 which is similar timing to 2012 (April 25) and earlier than in 2011 (May 8) and 2013 (May 3). Water levels in 2014 increased relatively rapidly until the end of May when the rate of increase declined and the reservoir reached a maximum of 668.7 m on July 31 (BC Hydro CRO database). This is a lower maximum elevation than in the previous three years of the study and is just below long term mean levels (Figure 1).

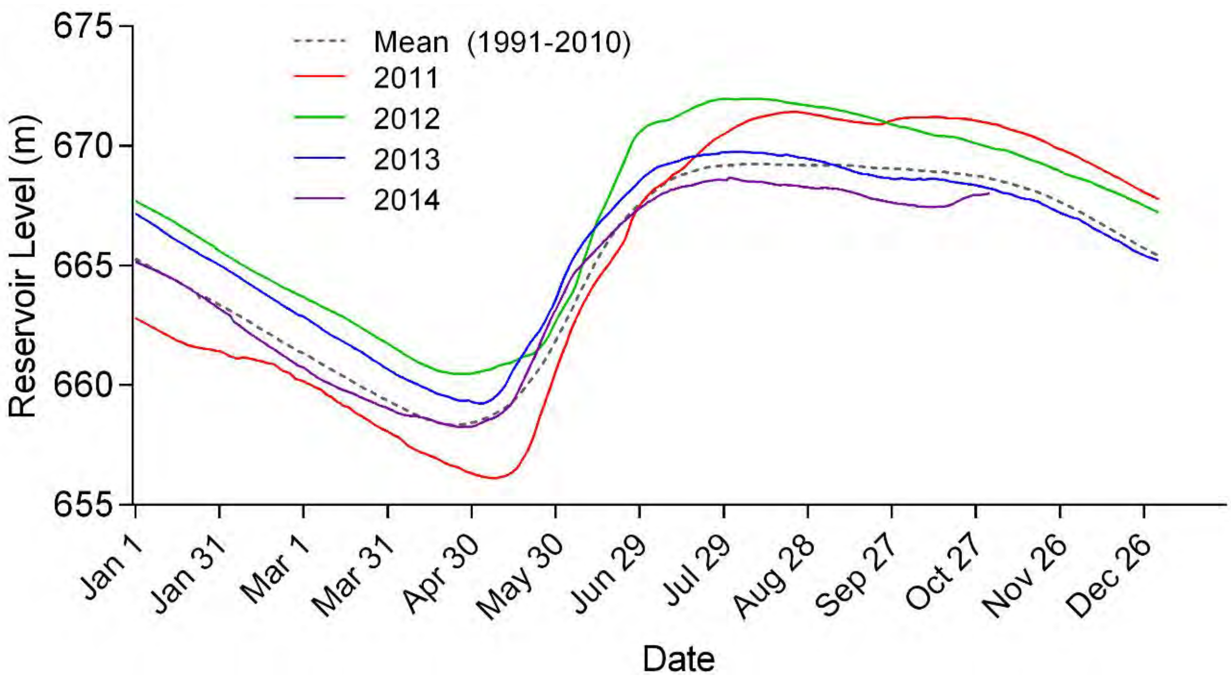

Figure 1. **Annual Williston Reservoir levels for 2011 -2014.**

The two locations identified for the tributary access demonstration projects are both located in separate reaches of the reservoir (Figure 2). The Six Mile Creek site is located approximately 40 kilometres north of Mackenzie and is located within Six Mile Bay on the east side of the Parsnip Reach of the reservoir. The Ole Creek site is located on west side of the Finlay Reach approximately 160 km north of Mackenzie. Both demonstration sites are paired with control sites that will receive no enhancement works. The control site for Six Mile Creek is Lamonti Creek, also located within Six Mile Bay. Factor Ross Creek is the control site for Ole Creek and is also located on the west side of the Finlay Reach, approximately 20 km further north (Figure 2).

Six Mile and Lamonti Creeks were both identified as creeks experiencing drawdown impacts (Cubberly and Hengeveld 2010). The portion of Six Mile Creek located within the drawdown zone was characterized as being homogenous and lacking habitat complexity compared to the typical riffle-pool sequence observed above the drawdown zone. The drawdown zone portion of the channel is shallow, braided, and lacking overhead cover. This was considered to limit upstream fish passage and increase the risk of predation for downstream migration of juvenile due to the lack of cover when this portion of the channel is exposed by low reservoir levels (Cubberly and Hengeveld 2010). Similar conditions were observed in Lamonti, although the length of channel exposed during low reservoir levels is shorter.

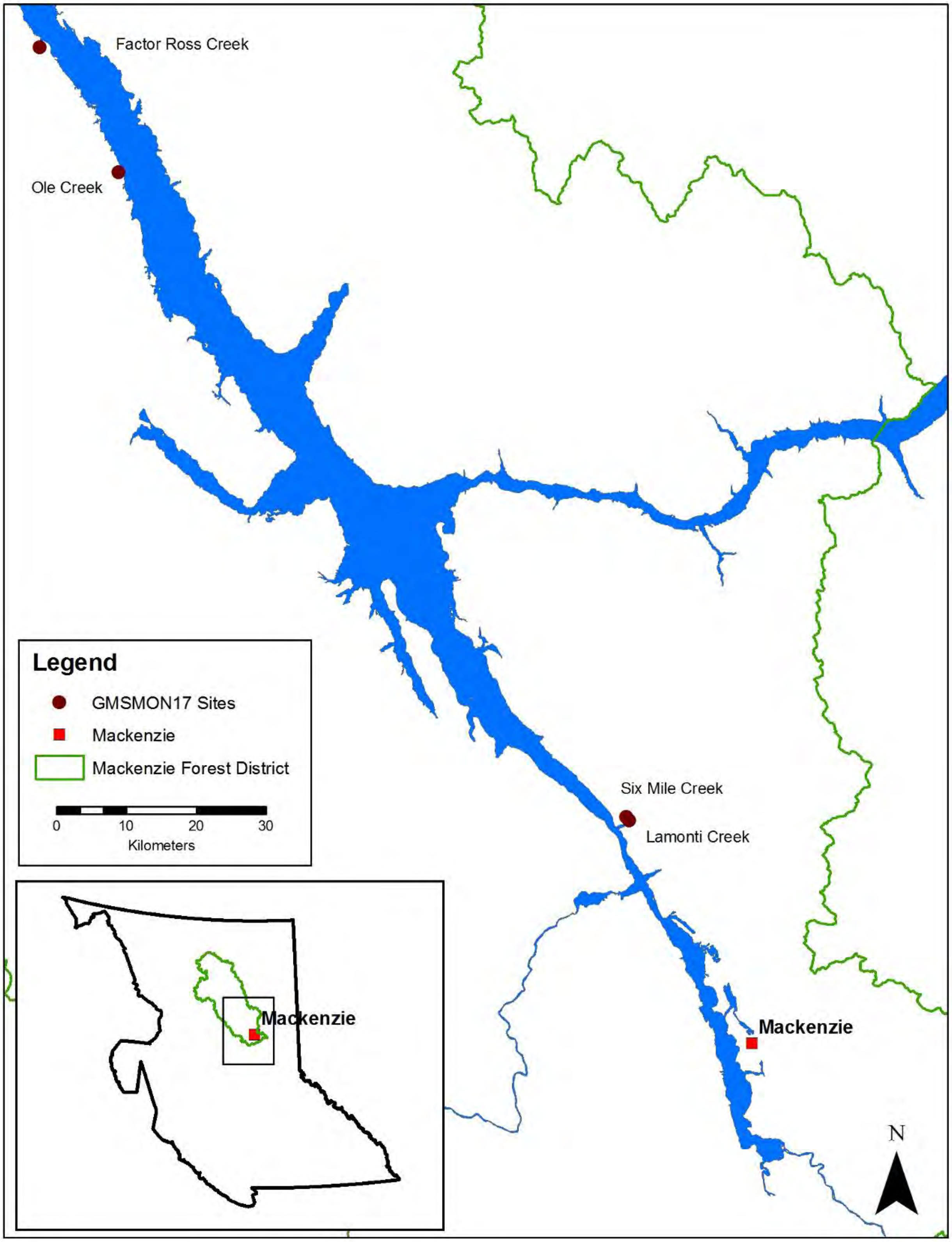

Figure 2. Location of the two tributary access enhancement treatment sites (Six Mile and Ole Creeks) and their respective control sites (Lamonti and Factor Ross Creeks) on Williston Reservoir.

Ole and Factor Ross Creeks were identified as sites with tributary access impacts primarily due to debris accumulation (Cubberly and Hengeveld 2010). Debris accumulation is typically higher in the Finlay Reach than in other parts of the reservoir due to the prevailing southeast winds, (Anon. 2003).

The access enhancement treatments proposed for both Six Mile and Ole Creeks are similar in concept and intended to stabilize drawdown zone reach of the respective streams and minimize debris impacts. The preliminary design for Six Mile Creek consisted of a series of constructed berms and log jams to close off channel braids and create habitat complexity within the main channel (KWL 2013). The higher elevation berms were also to receive revegetation treatments to enhance riparian vegetation. The preliminary design for Ole Creek also included the construction of berms to close off channel braids and create habitat complexity. However, the main features of the proposed design for Ole Creek were the construction of two berms and associated debris catcher to limit the accumulation of debris at the stream mouth. Removal of existing debris was also part of the prescription for this site (KWL 2013).

4 METHODS

4.1 Environmental Conditions

Environmental conditions specific to each survey type were recorded at the start of each survey and periodically during the surveys. Daily mean air temperature data and precipitation prior to and during the survey period (April – August) were obtained from Environment Canada and observed at the Mackenzie Airport weather station (Station names: Mackenzie A and Mackenzie Airport Auto) to obtain a record of the regional conditions.

Data on local environmental conditions were obtained from the satellite enabled satellite-enabled stream gauging stations located at Ole and Six Mile Creeks. The locations and installation dates for the two stations are provided in Table 1. For complete details on the installation and equipment at the stations refer to the reports from Years 2 and 3 of the project (Golder 2013, 2014). Data recorded by the stations includes water level, air temperature, and water temperature. A staff gauge for manually recording water level was also installed at each station and a Hobo Water Temperature Pro water temperature logger (Onset Computer Corporation) was also installed at each station as a secondary record of water temperature. Data for all variables was recorded at 15 minute intervals and set to be uploaded hourly to the data server by satellite. Data was downloaded at a minimum of once a month for later analysis. Water level and temperature data were reviewed frequently in May and June to determine the timing of the Rainbow Trout spawner surveys.

Table 1. Location and installation details for satellite-enabled stream gauging stations.

Site	Station #	Neon Serial #	UTMs			Date of Installation
			Zone	E	N	
Ole Creek	1	4870	10 V	404853	6257596	May 28, 2012
Six Mile Creek	2	5012	10 U	474511	6163771	May 27, 2012

The stream gauging stations were re-surveyed on May 8 and 9, 2014 at Six Mile and Ole Creeks, respectively, to confirm that the stations had not moved. Manual discharge measurements were completed in May, June, and August for development of the rating curves for each of the streams. Two replicate measurements were completed on each date.

4.2 Fish Surveys

4.2.1 Tributary Access Assessment and Fish Habitat

The foreshore area of the Williston reservoir was inspected during the three main field visits in May, June, and August to assess each stream for potential barriers to fish passage. Habitat in the drawdown zone reach of each stream was mapped during the May site visit from the full pool elevation (672 m) down to the confluence with the Williston Reservoir (May 8 elevation: 658.6 m, May 9 elevation: 658.7 m). Channel boundaries, habitat types, and stream area were delineated within the drawdown zone during low pool conditions of the reservoir. Features were located by tight chainage from a GPS reference point and photographed. Any debris clusters, riffles, pools, boulders, and significant gradient changes were noted and a visual inspection for fish was also completed. The habitat information was georeferenced and sketched onto orthophotos of each stream.

An initial Unmanned Aerial Vehicle (UAV) (or Systems-UAS) survey of the study sites was completed on June 16-19, 2014. High resolution digital orthophotos (with a target resolution of 5 cm ground sampling distance [GSD]), provided by JR Canadian Mapping Ltd from the UAV survey was used as the background layer for delineating stream features (e.g., debris clusters). Georeferencing interpretation was completed in 2-D softcopy using ArcGIS (version 9.3, ESRI 2008) and Artweaver (Boris Eyrich Software, 2014). Where 2014 orthophoto coverage was not available, previously collected 2011 orthophotos were utilized independently or in addition by conjoining data sets in Artweaver (Boris Eyrich Software, 2014).

Photo documentation from the established reference locations near the mouth of each study stream and using the same orientations as in 2012 and 2013 was continued (Table 2).

Table 2. Location of stream mouth photo reference sites and reference photo direction.

Site	UTMs			Height Above Ground (m)	Azimuth (°)
	Zone	E	N		
Six Mile	10 U	474658	6162760	1.6	165,60
Lamonti	10 U	475293	6161984	1.4	290,200
Ole	10 V	405814	6257625	2.0	10,80
Factor Ross	10 V	395397	6275823	1.4	340, 280,220

4.2.2 Drawdown Zone Fish Sampling

Fish sampling by electrofishing was conducted under Fish Collection Permit PG14-148579 issued by the Ministry of Forest, Lands and Natural Resource Operations. Electrofishing surveys of the of the drawdown zone reach of each stream were completed on June 16-18, 2014. As the streams contain Bull Trout, electrofishing could not commence until after June 15 in accordance with the permit conditions (no electrofishing from September 15 – June 15). The drawdown zone surveys were completed from June 16 to 18, 2014 when the reservoir elevation was approximately 666 m. This allowed for sampling of 130 m to 300 m of stream channel length in the drawdown zone depending on the stream (Table 3). Due to the higher spring flows, only the slower stream margins on the left and right banks could be safely and effectively sampled. The exception was Lamonti Creek where the stream was small enough that the entire channel width could be sampled. The length and width of the sampling areas in each stream was recorded.

Table 3. Dates and drawdown zone stream length sampled at the four sites in 2014.

Site	Date Surveyed	Approximate Stream Length Sampled (m)	Water Temperature (°C)
Six Mile	June 16, 2014	295	6.5
Lamonti	June 17, 2014	290	5.5
Factor Ross	June 18, 2014	165	6.0
Ole	June 18, 2014	133	6

Backpack electrofishing (Smith-Root LR-24B) consisted of a single pass with no enclosure. A three or four person crew was used with one crew member operating the electrofisher, one dip netter, and two using a 4 m apron seine (Elson 1962). The apron seine was used to increase capture rates in the relatively high stream velocities encountered in the drawdown zone. When operating as a three person crew only the apron seine was used with no dip netter. This approach was used in the higher velocity areas where the apron seine captured all of the fish.

All collected fish were held in buckets and maintained at stream temperature. Fish were quickly processed and enumerated by species, measured for fork length (FL) or total length (TL, sculpins and Burbot only), and weighed on a digital scale (nearest 1 g). Prickly and Slimy Sculpin were identified to species but were combined for the analysis as they are not a target species for enhancement. Fish were immediately released back into the stream following processing.

4.2.3 Spawner Surveys

Arctic Grayling and Rainbow Trout were identified in the Terms of Reference for this monitoring program as potential target species for the spring spawning surveys. However, since Arctic Grayling were not observed during spawner surveys in Years 1 and 2, it was recommended that the surveys be changed to focus on Rainbow Trout only beginning in Year 3 (Golder 2013). Spawning surveys followed the same methodology as used in Year 3 (Golder 2014).

Foot-based visual surveys were conducted by two observers with each observer walking along one bank of the stream. One of the observers was equipped with a dry suit, mask, and snorkel to conduct snorkel surveys in locations where depth and water velocity permitted. During the snorkel surveys the other observer was stationed downstream from the snorkeler and was equipped with a throw bag for safety. The snorkel surveys were a supplement to the visual surveys and were intended to increase the detections of adult fish. The minimum length of stream surveyed was equal to the distance surveyed in the previous year of the monitoring program. When time permitted, the survey area was extended upstream, as recommended by Golder (2014). Additionally, the survey area at Six Mile Creek was extended by including a portion of its tributary, Patsuk Creek.

The Year 4 spawner surveys were completed on the four systems from June 23-26, 2014. The timing of the spawner surveys was determined by monitoring water levels and temperatures from the remote gauging stations on Six Mile and Ole Creeks. The criteria for the timing of the surveys were declining water levels (better visibility) and water temperatures of 5-7°C (expected peak spawning activity).

The date, time, crew, effort, weather condition, water temperature, water clarity, substrate, number and species of fish observed, location of fish observed, estimated sizes of fish observed, and any evidence of spawning were recorded during the spawner surveys. For locations where snorkel surveys were completed, the additional data recorded included the area surveyed and relative underwater visibility. Locations of adult Rainbow Trout and redds were noted and marked using a handheld GPS (Garmin GPSMap 62s). Additional information recorded for each redd observation included dimensions (pot and tail spill), substrate (type, size), water depth (m), and water velocity (floating chip method). The locations (GPS) and areas of suitable spawning substrates were also recorded.

Surveys were conducted during a period of higher stream flows targeting Rainbow Trout (a spring spawning species), which reduced visibility due to a combination of water levels and suspended materials in the water column. The timing of surveys was adapted to avoid inclement weather conditions (i.e., immediately after a major rainfall). Dates and distances of survey length for each stream are shown in Table 4.

Table 4. Spawning survey details for Year 4 (2014).

Site	Date	Stream Length Surveyed (Km)	Start	End
Lamonti	June 26, 2014	1.4km	Stream mouth	~500m upstream from bridge crossing at Parsnip FSR
Six Mile	June 23, 2014	2.2km	Stream mouth	~665m upstream of confluence with Patsuk Creek
Patsuk Creek (Six Mile trib.)	June 23, 2014	0.8km	Confluence of Patsuk & Six Mile Creeks	Bridge at West Parsnip FSR
Ole	June 24, 2014	2.1 km	Stream mouth	~570m upstream from bridge crossing at Factor Ross FSR
Factor Ross	June 25, 2014	1.7km	Stream mouth	~980m upstream from bridge crossing at Factor Ross FSR

4.2.4 Juvenile Fish Surveys

The Year 4 juvenile and small-bodied fish surveys followed the mark-resight methods used in Years 2 and 3 of the project for estimation of the abundance (Golder 2013, 2014). Fish were captured by backpack electrofishing, marked with pink yarn tags, and released. Night snorkel surveys to visually observe marked and unmarked fish were then completed in the same locations a minimum of 24 hours later to allow marked fish to redistribute into the system.

As in previous years (Golder 2013, 2014), sampling sites in each of the four stream focused on low velocity and pool habitats. Pool and low velocity habitat was sampled because salmonids, the target species for this component of the study, have a strong preference for low velocity habitats (McPhail 2007, Korman et al. 2011). Sampling sites in each stream for the four study streams ran from the confluence with the reservoir (672 m elevation) up to 2.2 km upstream. All sites were marked with high visibility flagging tape labeled with the site name and number to assist in relocating the sites during the night snorkel surveys.

Night snorkel surveys were conducted at all sites where electrofishing was conducted, as recommended in the Year 3 report (Golder, 2014). The same tagging methods have also been applied to studies of juvenile salmonids elsewhere in BC (e.g., Schick et al. 2013). Visual surveys were used at a few sites that were not possible to snorkel because of limited water depth. A handheld GPS was used to record UTM coordinates for all electrofishing and snorkeling sites. The majority of sites sampled in 2013 were re-sampled in 2014. A small number of sites were added, altered, or deleted as the site no longer provided low-velocity or pool habitat due to natural changes in stream morphology.

Backpack electrofishing (Smith-Root LR-24) was used to capture fish for marking. The electrofishing crew consisted of one electrofisher operator and two dipnetters and a single pass with no enclosure was completed at each site. Electrofishing settings (voltage, frequency, duty cycle) were recorded along with the time electrofished in seconds (sample effort) and the area sampled (m^2).

All collected fish were held in buckets and maintained at stream temperature until electrofishing of the site was completed. Fish were quickly processed and enumerated by species, measured for fork length (FL) or total length (TL, sculpins and Burbot only), weighed on a digital scale (nearest 1 g), and tagged. Prickly and Slimy Sculpin were identified to species but were combined for data analysis as they are not a target species for enhancement. Captured sculpins can be easily identified but it is not possible to reliably identify observed but not captured individuals to species level.

Fish were marked with size 16-20 barbed fishing hooks (size of hook depended on size of fish) that had fluorescent yarn tied around the shank and were attached through the flesh directly behind the dorsal fin. The tagging method was based on the method developed by Hagen et al. (2010) and used in Year 2 of this monitoring program (Golder 2013). The scales of larger Mountain Whitefish were found to be too thick directly behind the dorsal fin, so these fish were tagged in the adipose fin. Approximately 1-2 cm of fluorescent yarn was left trailing from the fish hook after being attached. Fish were allowed to fully recover prior to release into the same area of the stream they were captured from.

Sculpin were not tagged in this study as they were too small for the tagging method and are not the target species for habitat enhancement. Besides sculpins, other fish <70 mm FL were not tagged because they were considered too small for the tagging method. Additionally, not all suitably-sized fish captured in Factor Ross Creek were tagged due to a shortage of tags as the number of fish captured was higher than anticipated.

The wetted dimensions of each sampling site were recorded. Previous habitat ratings for each site (Golder 2014) were reviewed and either confirmed or updated based on the type and abundance (%) of available cover. Habitat ratings were based on the total of all cover types (e.g., large and small woody debris, cobble and boulders, undercuts) and were ranked as low (<10% cover), medium (10-40% cover), or high (>40% cover).

The night snorkel surveys were completed by a three person crew. Two people were equipped with dry suits, waterproof flashlights, snorkels, and masks to conduct the survey while the third crew member carried out shoreline fry surveys and recorded the data. Equipment was prepared prior to arriving at each site and the sites were approached quietly to minimize disturbance to fish. A visual shoreline survey was first conducted to observe fish in shallow, near shore, and other instream areas where the bottom was visible. Each site was snorkel surveyed by a single crew member working from downstream to upstream. The second crew member independently surveyed the site as quality control of fish observations. Larger sites were snorkeled by both surveyors simultaneously while communicating to avoid double counting fish.

Snorkelers continued observations until they were confident there were no un-counted visible fish within a sampled reach. Total underwater observation time depended on the size of the site and complexity of cover but typically ranged from 30 seconds up to several minutes per observer. At debris jams and other high cover areas, observers positioned themselves at various angles to view as much of the area as possible.

Snorkel surveys were completed at as many of the sites where fish were marked as possible. However, a few sites could not be snorkeled due to debris build up, high flows, safety concerns, or pool depth was too shallow. Visual assessment was completed at all sites where snorkeling could not be completed. Sections that could not be effectively snorkel surveyed often matched sections where electrofishing was similarly restricted.

All marked and unmarked fish were counted and identified to species. Fork lengths were estimated. The same spatial area that was measured and sampled during electrofishing was surveyed by snorkeling. If some of the electrofishing site was not observed by snorkeling then the spatial area that was surveyed was estimated and recorded. All snorkel surveys were conducted beginning 30 minutes after sunset one day following the release of the marked fish.

4.2.5 Fry Surveys

Salmonid fry surveys were conducted at the same time as the night-time snorkel surveys by the crew member who was recording data for the snorkel surveys. Fry surveys were conducted adjacent to the snorkeling sites in areas that provided good habitat (based on professional judgment) for salmonid fry. Although habitat variables were not measured, habitats considered suitable for fry were characterized by water depths less than 0.2 m and water velocities less than 0.1 m/s, and were typically near the stream margin (McPhail 2007). Fry surveys were only conducted at sites where suitable habitat was present. Surveys moved from downstream to upstream using a flashlight or headlamp to scan the habitat for fry. A subsample of observed fry was captured with a small dip-net to confirm species identification. For each site, the number of fry observed, estimated fork lengths, and the linear distance of shoreline survey was recorded.

4.2.6 Data Analysis

The catch-per-unit-effort (CPUE) for electrofishing (drawdown zone and juvenile fish surveys) was calculated for each species and stream as the number of fish per second and the number of fish per unit area (number/100m^2). The CPUE for the snorkel surveys was calculated for each species and stream as the number of fish observed per unit area (number/100m^2) based on the total area surveyed in each stream.

For the fry surveys, the CPUE was calculated as the number of fry per linear meter of shoreline (number/m). Only Rainbow Trout <45mm and Bull Trout <55mm in length were considered to be fry and were included in the fry survey CPUE calculations. Fish larger than this observed in the fry surveys were considered to be older (age 1 or greater). Although age-length data from these stream is not available to support these criteria, they were selected based on other populations in British Columbia (McPhail 2007) and observations other fish of the same species during the surveys. Although sculpin were not the target species in the study, they were often observed during fry surveys and were included in the data summary to provide supporting information about potential changes in the fish community over time.

Estimates of relative (CPUE) and absolute abundance (mark-resight) are based solely off the habitat sampled, which was limited to pools and low velocity habitats that could be safely sampled and did not included riffles, rapids, and other non-suitable habitat features.

The mark-resight data was used to estimate the populations of juvenile salmonids in the four streams. A binomial Bayesian probability implementation of N using the same priors and WinBugs code used in Years 2 and 3 (Golder 2013, 2014) was implemented. A uniform prior of being in the sampled population was used. The estimation procedures are based on the following assumptions: (i) all marked and unmarked fish migrate within the area being sampled, (ii) there is no mark loss between release and recapture sites, (iii) there is no mortality between release and recapture sites, (iv) the catchability of a marked fish does not depend on the time spent in the river after release, and (v) marked and unmarked fish have equal catchability and equal aggregation patterns (Mäntyniemi and Romakkaniemi 2002).

Initial values for unmarked fish were set in a manner similar to those used by Golder (2013, 2014). Species and stream strata that were included in the model were as follows: 6Mile-RT=125, 6Mile-BT=100, 6Mile-BB=10, Lamonti-RT=125, Ole-RT=80, Ole-BT=150, Ole-MW=80, Factor-RT=25, Factor-BT=100, Factor-MW=350. The following data list was inserted into the code: s=10, N = c(7, 3, 2, 20, 2, 24, 2, 4, 4, 12), n = c(4, 0, 0, 8, 0, 10, 0, 2, 1, 3), u = c(53, 30, 1, 47, 8, 65, 13, 2, 9, 79). R-stats (R Core Team 2014) version 3.1.2 and version 1.4.3 of WinBugs (Lunn et al. 2000) were used for the analysis including re-entry and compiling of previous years data. The FSA (Fisheries Stock Assessment) package (Ogle n.d.) was used to estimate the Petersen mark-recapture estimates of abundance, including the binomial method for obtaining confidence intervals for a closed population.

4.3 Vegetation Surveys

A combination of air photo interpretation and ground sampling of terrestrial vegetation was used to describe terrestrial vegetation communities at the project sites (Province of British Columbia 2010, RISC 2010). The TEM standards (Province of British Columbia 2010) were used to complete ground sampling of terrestrial vegetation as the plant species assemblages and soil profiles identified within the project sites were not consistent with the wetland classes described by Mackenzie and Moran (2004). Mackenzie and Moran (2004) describe naturally recurring wetlands within British Columbia that are relatively stable in terms of their hydrologic cycle and plant species composition and have established over long periods of time. Due to variability of flood events in the drawdown zone from dam operations, the plant species assemblages identified in this project are in constant transition to a stable state.

All photo interpretation was completed in 2-D softcopy using ArcGIS (version 9.3, ESRI 2008). Digital ortho-rectified low and high resolution air photos taken of the project sites, provided by BC Hydro (approx. 100cm pixel resolution; 2011) and JR Canadian Mapping (5cm pixel resolution; 2014), were used as the background layers for delineating polygons. Field notes and photographs on vegetation composition and structure from informal inspections of the study sites prior to the air photo interpretation assisted with establishing and updating habitat classes.

A habitat classification scheme based on RISC (2010) was developed to capture all the habitat classes in the study area visible at the air photo resolution available. Habitat classes were first determined from an overview of the study area to identify the larger vegetation features. As the study area was viewed at finer scales during photo interpretation, more vegetation features were identified. As new vegetation features were encountered, additional habitat classes were created to accommodate them. Each habitat class was identified based on a common plant species assemblage or substrate and elevation position within the drawdown zone. The spatial arrangement of habitat classes often followed a similar pattern.

In addition to habitat classification, an enhancement classification scheme was also developed for Six Mile and Ole Creeks, using the high resolution air photos collected during Year 4. The objective of the classification scheme was to identify and differentiate artificial structures and surfaces from undisturbed habitats at the enhancement sites. Any new structures, or areas were ground disturbance resulted in alterations to surface materials, were identified as enhancement structures and were designated with an enhancement class.

Due to the relatively small area of the study sites, a map scale of 1:1000 was used as the initial resolution for polygon typing. Where required, a larger scale was used to differentiate similar or small area polygons. Overall, the scale varied roughly between 1:1000 and 1:200 throughout the interpretation process depending on the size of the habitat polygon and the resolution of the air photo.

Although habitat mapping was originally planned to be completed only within 50m of the main channel on each side of the tributary, the area mapped was extended to include habitats outside of the riparian zone of the main channel (but within the drawdown zone) in order to monitor any changes to these habitats over time. Thus, delineation of habitat and enhancement class polygons included all non-flooded areas within the drawdown zone (from an elevation above the full pool level to below the pool level present during ground surveys and air photo collection).

Ground sampling of terrestrial vegetation was conducted to support the interpretation of habitat classes and provide a description of plant communities (e.g., species diversity) at the sites. Ground sampling was completed along established vegetation transects at each of the sites in early June. The timing of ground sampling was selected to aid in the identification of plant species by attempting to observe species as close to the date of flowering as possible (as inflorescence is often required to identify a species), but prior to the sites being flooded by rising reservoir levels.

In Year 4 (2014), ground sampling was completed on a total of 13 vegetation transects. Three transects were established at the Six Mile, Ole and Factor Ross Creek sites and four transects were established at the Lamonti Creek site. At each location, transects were located on identified riparian habitats (e.g., gravel bars and riparian benches) and on constructed enhancement structures (e.g., berms). Ground sampling of the vegetation transects was completed between June 8-14, 2014 as forecasted reservoir levels were low and flooding of the upper areas of the drawdown zone at the sites was not expected to begin until late June. Prior to commencing ground sampling, a list of plant species commonly known to occur within the area was developed and reviewed. In addition, a list of red- and blue-listed species know to occur in the Mackenzie Forest District was created using the BC Conservation Data Base (Conservation Data Centre; May 2014) and reviewed. The species lists for GMSMON 15 project sites during Year 3 surveys (Airport Lagoon and Beaver Pond) were also reviewed (CBA 2014).

As the habitats being surveyed were often linear in shape, a transect-based method for vegetation sampling was selected over a grid-based method (using design components from LGL (2007) and US EPA (2002)). A 20 m long belt-line quadrat transect consisting of ten 2 m x 0.5 m rectangles was laid out (Figure 3) using a 30 m tape and 2 m measuring rod. UTM coordinates were recorded for the transect start and endpoints, and a spray-painted washer and large spike was driven in the ground at both points. A photograph was taken at the start point and end point of each transect, with a view of the area.

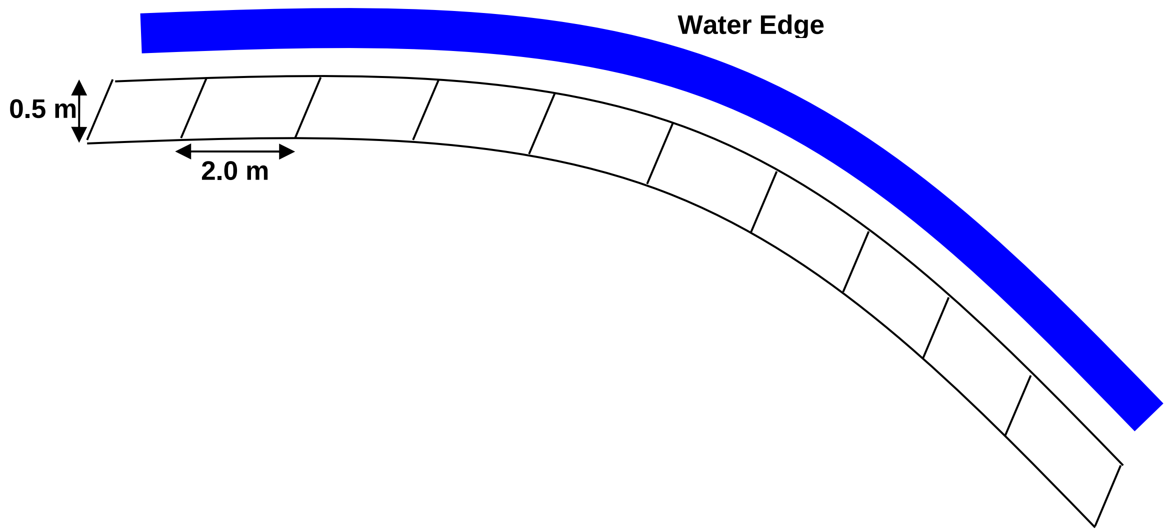

Figure 3. Belt-line quadrat transect for a sample site laid out adjacent to the riparian area.

Site and soil characteristics for the entire transect were recorded on provincial ecosystem field forms (Province of British Columbia 2010), including seral and structural stage characteristics. Site characteristics representative of the whole site were recorded and a representative location was chosen for the soil pit. Within each quadrat, vegetation was identified to species or genus and the percent cover of each detection was recorded. The terrestrial ecosystem keys (Province of British Columbia 2010) were used to describe soil characteristics and MacKinnon et al. (1999) was used as a reference for species identification. Where identification of species was not possible or uncertain, samples were taken and identified in the botany laboratory of the University of Northern British Columbia (UNBC) using the Illustrated Flora of British Columbia (Douglas et al. 1998) and Flora of the Pacific Northwest (Hitchcock and Cronquist 1973). Where species identification was still problematic or where correct identification was particularly important (i.e., with a potential red-listed species), a plant taxonomy expert from UNBC was asked to confirm the initial result. Plants listed as rare or endangered at the provincial or federal level were recorded on a Rare Plant Observation Form and submitted to the BC Conservation Data Centre.

4.4 Amphibian Surveys

The 2014 amphibian survey design was based on the RIC (1998) standards. Standard methods used in the Year 4 surveys included time-constrained searches, systematic search and sampling design techniques for relative abundance estimates, a stratified randomized approach for mark-capture-recapture, and morphometrics including weight and length (snout-to-vent = SVL). The survey area was expanded beyond the area of potential direct impact from the enhancement works that was used previously (Golder 2014).

Ecological studies of amphibians require a landscape-scale analysis to effectively answer research questions pertaining to habitat alteration (Trenham and Shaffer 2005). Incidental observations of amphibians during the fish surveys and other visits to the study sites were included in the amphibian mapping. These incidental observations plus the stratified random approach for setting out plots and transects in Year 4 (2014) broadens the survey scope to a landscape level. This approach allows for the detection of upland effects and a better understanding of the spatial ecology of amphibians as it relates to the management questions and hypotheses.

In addition to the RIC (1998) standards, photographic identification methods (PIMs) were employed with captures from the active searches rather than traps. While toe-clipping is a commonly used method for amphibian mark-recapture studies, PIMs have become more common in amphibian studies (e.g., Carafa and Biondi 2004, Gamble et al. 2008, Caorsi et al. 2012) and have been proven more effective than toe-clipping in some studies (Caorsi et al. 2012). Computer-assisted matching can also assist with mark-recapture using PIMs (e.g., Bolger et al. 2012). A further advantage of PIMs is that additional information on the biology of captured individuals such as the body-mass-index (Davis et al. 2008) can be obtained. Traditional SVL and weight measurements also provide information on body condition and may be improved by use of PIMs. Data on body condition is important for studies related to habitat alteration and abundance, because it is an indicator of environmental stress, habitat quality, and demographic variables (Wright and Zamudio 2002, Bancila et al. 2010). A PIMs approach was included in Year 4 to provide better accounting of the amphibian populations in relation to the management questions and hypotheses.

4.4.1 Terrestrial Surveys

Time-constrained and systematic surveys for amphibians were conducted at the four study locations. The design of the systematic search strategy for amphibians was revised for the post-enhancement phase of this project. Much of the 2014 amphibian field season involved reconnaissance for suitable habitat and locations to establish study plots and transects for post-enhancement monitoring at the landscape level. Previous pre-enhancement surveys (Years 1-3, 2011-2013) were spaced into two sampling intervals, spring and summer in Year 1, and a single spring survey for Year 2 and 3. Surveys were executed for several hours (2.5 – 6.5 hours) over broad and very general search areas (1,300-7,700 m^2) (Golder 2014). The Year 4 surveys were spaced into three sampling intervals (mid-May, mid-June, mid-August) and search efforts were focused on specified plot, transect, or wetland survey areas.

Circular terrestrial plots were established at 200 m^2 in size and search times were recorded for each plot survey. Natural cover objects (rocks, logs-limbs, bark) that were light enough to be flipped by hand were turned over. Qualitative accounts of habitat features were noted at each plot visited including exposure, general vegetation type, ground cover conditions, and slope. Flipped materials were returned to their original positions to minimise disturbance. In each survey interval, plots were extended into an undisturbed (i.e., not previously searched) area that was immediately adjacent to the plot that had previously been searched. This process increases the size of a plot in 200 m^2 increments with each survey interval and potentially avoids bias from searching previously disrupted habitat. General searches were repeated around the amphibian point locations identified in Golder (2013), including ponded areas in the drawdown zone.

Occasional pieces of debris were flipped while traversing between plots, but the intensity of the search effort along transects was reduced relative to the level of search effort in the plots. GPS waypoints were recorded for each plot and tracking data was also recorded to estimate search lengths and times along paths traversed. Waypoints and tracking information were downloaded into Google Earth and the search times were obtained by reviewing the files.

The pattern of plot and transect establishment was field fit and varied according to topography, access, and habitat considerations. Plots were separated by a minimum of 40 m (as measured by GPS) and spatially arranged to sample near the tributary enhancement area, approximately 50 m into adjacent forested area, and 200 m into adjacent forested area. A similar plot spacing was used in a survey area located >500 m upstream from the tributary enhancement works. Transects were located in the intervening spaces separating plots. Drier sites judged as suboptimal habitat with little canopy or effective ground cover were excluded from the plot and transect design.

Three surveys were conducted in Year 4 on May 12-15, June 16-19, and August 13-15. No amphibians were handled until a Wildlife Act permit was obtained (Permit No. PG14-94627). Prior to issuance of the permit, amphibians were photographed in the locations where they were found with a measured object for relative scale included in the photograph. Adults captured in a plot were identified to species, weighed (nearest 0.01g), photographed, investigated for body health and measured (snout-to-vent length) after the scientific research permit was issued on May 22, 2014.

Larger adults (>1.5 g) were anesthetized using Oragel™. Anesthetized adults were placed into a diffuser box for photographing. The rectangular diffuser box was fully enclosed except for a circular hole for camera access. The inside of the box was lined with linear LED lights and white reflector diffuser fabric was attached to all sides. The diffuser box was placed onto a metal clip board with plastic 1 mm graph paper background as a standard reference.

4.4.2 Wetland Surveys

Pre-enhancement surveys included visual inspection of ponded areas in the drawdown zone in Years 1 and 2 and near the stream mouths in Year 3 (Golder 2014). Reconnaissance and surveys of potential breeding wetlands continued in Year 4, including ponded areas in the drawdown zone and a repeated survey of places listed in Golder (2012). Historical orthophotos, Google Earth, and aerial photographs of the study area were reviewed to identify potential wetland breeding areas in proximity to the study locations. Identified wetland areas were targeted in the field-based search effort.

The primary goal for the final August 2014 survey was to survey the identified wetland areas. Peripheries of wetlands were searched using visual surveys with polarized lenses and random dip net sweeps to sample in murky or densely vegetated areas. Larger, definable wetland types were photographed and classified according to MacKenzie and Moran (2004). Waypoints of smaller wetlands or open water sources were recorded. Temperatures were recorded at the wetland sites at the time of survey and habitat features noted.

Larvae captured during the August survey were weighed on a digital scale and photographed. Larvae were placed into a trough carved into a paraffin wax block with 1 mm plastic graph paper embedded in the background for scale; adapting the method of Davis et al. (2008). Larvae were patted dry on a piece of paper towel prior to being transferred onto an electronic scale for measuring weights (nearest 0.01 g).

4.4.3 Amphibian Data Analysis

Surface areas of wetlands at Six Mile were calculated using orthophotos from 2011 and 2014 respectively. These were scaled and calibrated using measured georeference points. Images were imported into ImageJ (Ferreira and Rasband 2012) for calculating surface areas.

Digital photographs of amphibians were catalogued and then uploaded into ImageJ or Artweaver (Boris Eyrich Software 2014) for processing, visualizing and analysis. Photographed individuals were double checked for species identifications that were recorded in the field. Sizes of amphibians photographed without handling prior to obtaining the permit were measured by scaling images in ImageJ using the photographed scale object in the photograph. ImageJ was used to obtain measurements and the body mass index of salamander larvae and adults per the methods of Davis et al. (2008).

Data on weights and snout-to-vent lengths from previous study years (Golder 2012, 2013) were graphed and compared to the current year. R-stats (R Core Team 2014) was used for statistical analysis, including log transformation and Pearson's product-moment correlation tests on weights and allometrics of salamanders. Detection and search effort data were used to calculate catch-per-unit effort values for each study site, tabulated and compared to previous study years. Distances along transects for the 2014 season were calculated by mapping GPS tracking into Google Earth and measuring distances travelled. New transects were overlaid onto the tracked sections, numbered sequentially, and mapped to establish the strategic survey design for subsequent years.

4.5 Songbird and Waterfowl Surveys

Songbird surveys were conducting according to methods modified from the provincial Forest and Grassland Bird Inventory Standards (RIC 1999). All surveys were completed from June 10-13, 2014 within a four hour period commencing at sunrise. Each survey was 30 minutes in duration and the total survey time at each point was recorded. Two replicates were conducted at each site on two consecutive days.

A centre point for each survey was established along each tributary within the drawdown zone. Upon arriving at the survey point, an initial scan for waterfowl and shorebirds was completed to note any birds that may have taken flight due to the observer's arrival at the station. All observations of songbird activity within a 75 m radius of the centre point and waterfowl and shorebird activity at any distance from the centre point were recorded and mapped. Species and activity were recorded for each observation. For songbirds, species outside of the 75 m radius were recorded but not mapped. At Six Mile Creek, an additional 30 minute transect survey was also completed along the willows planted as part of the access enhancement project to look for evidence of avian use of this vegetation.

Environmental conditions including survey start and end time, percent cloud cover, ceiling height, wind speed (Beaufort scale), precipitation, and temperature were recorded at the beginning of each point count. Based on previous experience conducting point count surveys in the cool, wet northern BC spring, surveys were conducted according to 'modified' RIC standards (RIC 1999) for environmental conditions. Acceptable conditions for surveys are as follows: wind speed ≤Beaufort 3 (gentle breeze, leaves and twigs constantly move), no precipitation >'very' light rain, and temperature > 3˚C.

4.6 Data Entry and Analysis

Immediately after a field survey was completed, data sheets were scanned into .pdf documents and stored in a redundant file storage system. Digital photographs taken during field surveys were labelled and filed by survey type. All data were entered into a customized database designed to minimize data entry errors by restricting the permissible range of values for a field or by using selections from drop-down lists.

Data were exported from the database to MS Excel to provide data summaries for each component of the monitoring project. Fish capture data was summarized by species and CPUE. Data from each vegetation transect were summarized to provide an overview of the vegetation community at each site. The vegetation percent cover data from each of the ten quadrats in a belt-transect were pooled to provide an average percent cover for each species. Amphibian survey results were summarized by survey date and site. As the intent of the songbird and waterbird surveys was to provide a snapshot of the breeding bird community at a site, data from both replicates were pooled to provide summaries on species richness and relative abundance.

The collection of baseline data is complete and adequate information to describe the baseline conditions at the four sites is now available. For some indicator groups (vegetation, songbirds, and waterfowl), limited baseline data is available and future analyses will need to focus more on differences between the treatment and control sites than before and after comparisons. More detailed analyses are planned as additional years of post-construction data become available.

5 RESULTS

5.1 Environmental Conditions

Environmental conditions were generally average during the 2014 sampling period. Reservoir levels were close to average through the drawdown and filling stages with a slightly below average peak reservoir level at the end of July (Figure 1). Reservoir levels began increasing again in late October and were approaching average levels again (Figure 1). As just over half of the annual reservoir inflows come from snow (BC Hydro 2007) the average to slightly above average snow pack in the region is an important component of the average reservoir levels observed in 2014. Snow pillow data from the two stations located closest to the Parsnip and Finlay Reach sites were downloaded from the BC River Forecast Centre. For the Parsnip reach sites (Six Mile and Lamonti Creeks) the nearest station is Pine Pass (4A02P). In 2014 the snowpack at Pine Pass was just above average compared the close to average values in 2013 (Figure 4). The Aiken Lake station (4A30P) is closest to the Finlay Reach sites (Factor Ross and Ole Creeks) and shows average snowpack conditions in 2014 compared to the below average conditions in 2013 (Figure 5).

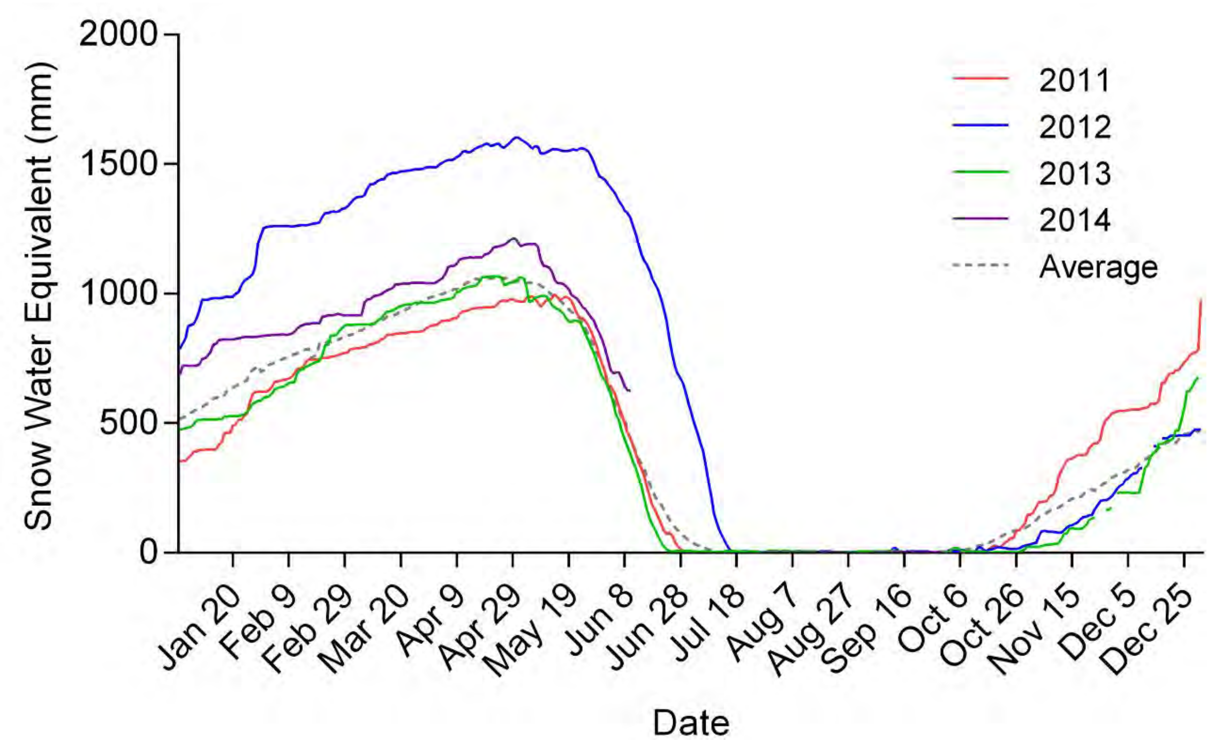

Figure 4. **Snow water equivalent for the first four years of the project from the Pine Pass (Station 4A02P) automated snow pillow monitoring station (data obtained from the BC River Forecast Centre).**

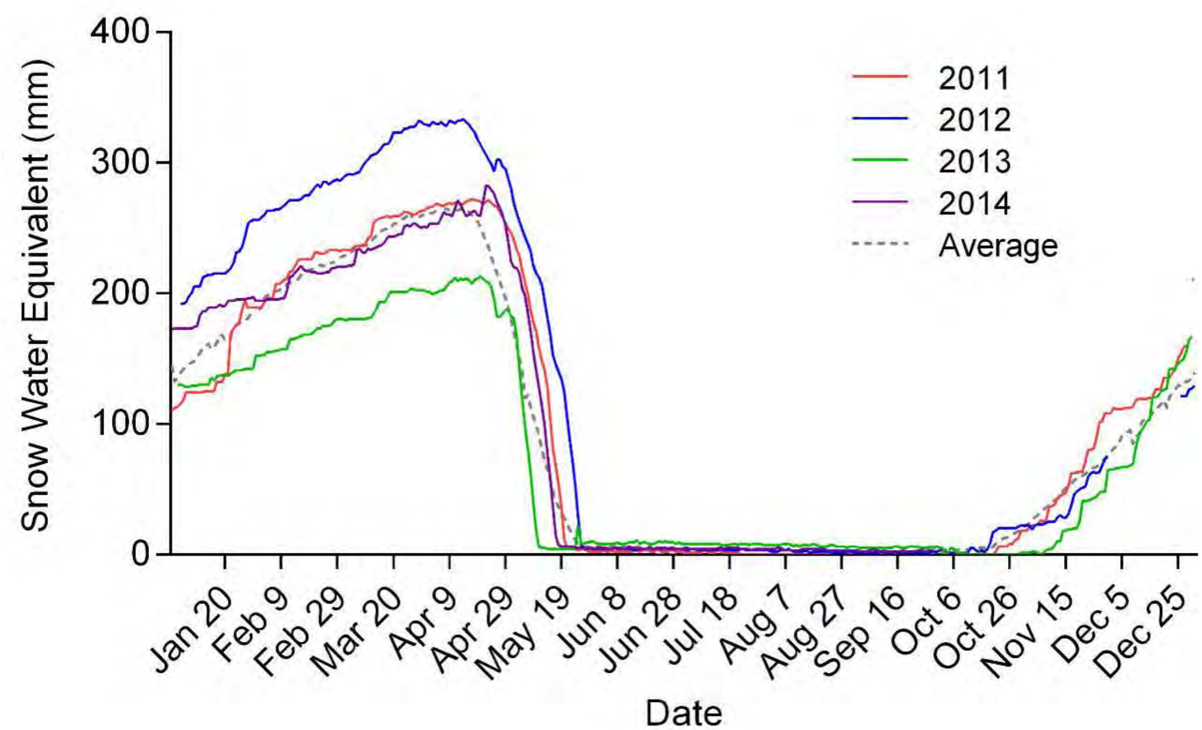

Figure 5. **Snow water equivalent for the first four years of the project from the Aiken Lake (Station 4A30P) automated snow pillow monitoring station (data obtained from the BC River Forecast Centre).**

The similar snowpacks in 2013 and 2014 also contributed to similar water levels in Six Mile and Ole Creeks in both years. The 2013 and 2014 water levels recorded by the gauging stations for Six Mile and Ole Creeks are shown in Figures 6 and 7, respectively. Peak flows in both streams occurred at similar times in both years and declined at similar rates. Data from 2012 is not shown as the record is incomplete and there are a large number of erroneous values from the Ole Creek station due to a malfunctioning water level probe. The lower flows in both streams from approximately mid-July on are associated with the very dry conditions that occurred in summer 2014. Based on precipitation data from the Mackenzie Airport (Station ID: Mackenzie Airport Auto) as an indicator of regional trends, precipitation in May, June, and July 2014 was well below average (Figure 8). Precipitation in August 2014 was also below average but it should be noted that most of this fell in a single event on August 19 (30.4 mm) and there was no precipitation recorded from July 31 to August 17, 2014.

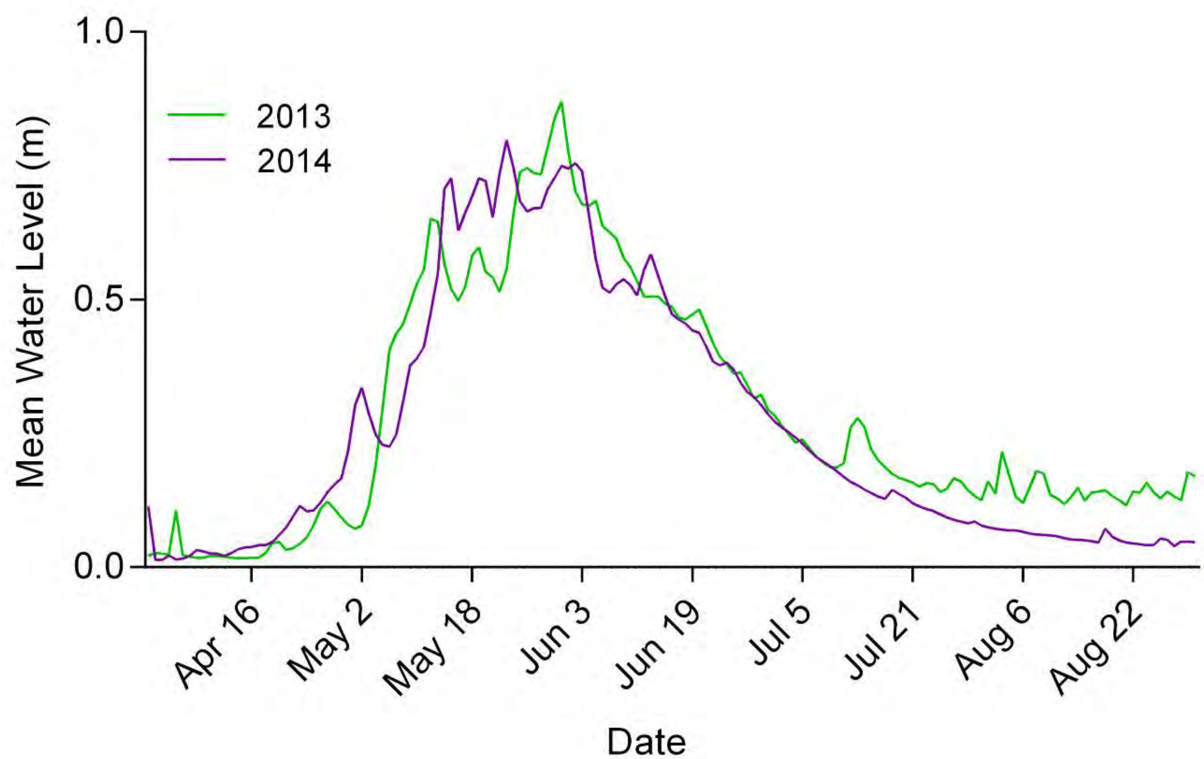

Figure 6. Daily mean water level at the Six Mile Creek gauging station in 2013 and 2014.

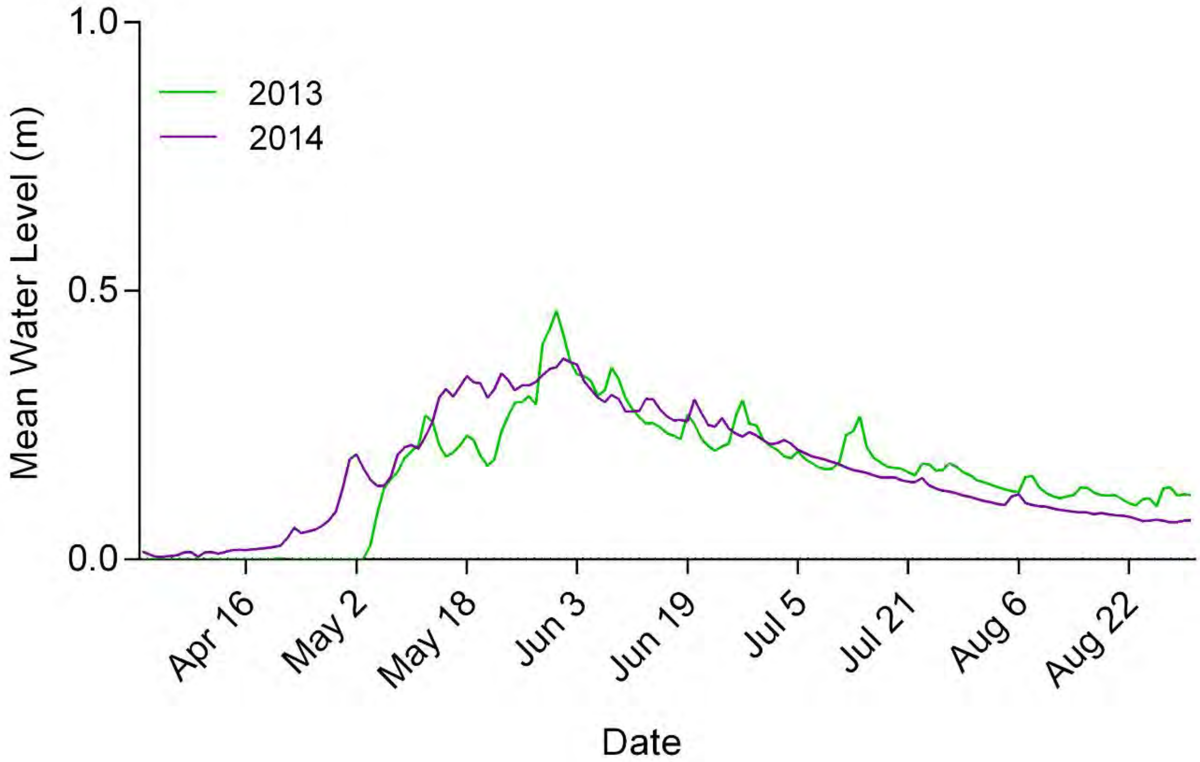

Figure 7. **Daily mean water level at the Ole Creek gauging station in 2013 and 2014.**

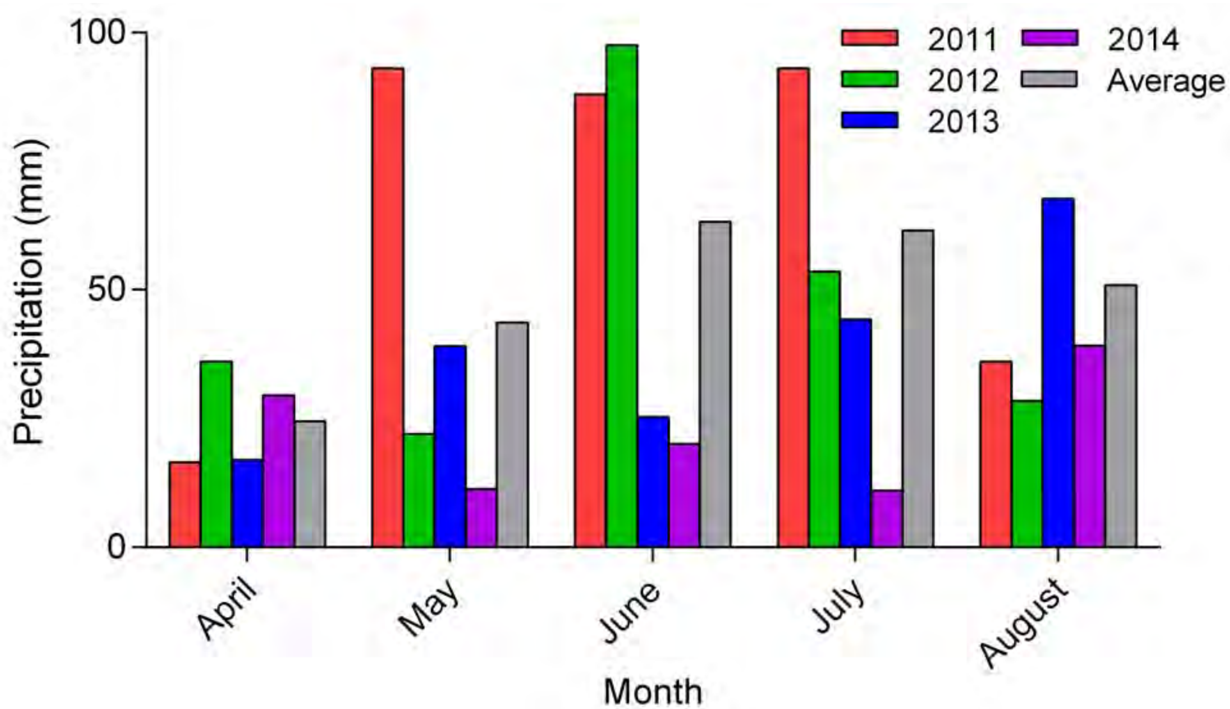

Figure 8. **Total monthly precipitation during the first four years of the project and the long term averages in the study region. Data from Environment Canada and observed at the Mackenzie Airport weather station (Station names: Mackenzie A and Mackenzie Airport Auto).**

The stream gauging stations also recorded air and water temperature. There was little difference for either variable between 2013 and 2014 during the sampling season. Air temperatures for Six Mile and Ole Creeks are shown in Figures 9 and 10. Temperature trends at both sites are similar with Ole Creek being slightly cooler and with less variation than at Six Mile Creek. Water temperatures at both sites are included in Figures 11 and 12. Water temperatures in Six Mile Creek (Figure 11) are generally warmer and with more variation than in Ole Creek (Figure 12). However, water temperatures in both creeks reach mean temperatures above 5°C on similar dates in June. The increase in temperature after this is slower than observed in 2013. Air temperatures were lower during this period in 2014 than compared to 2013 (Figures 9 and 10).

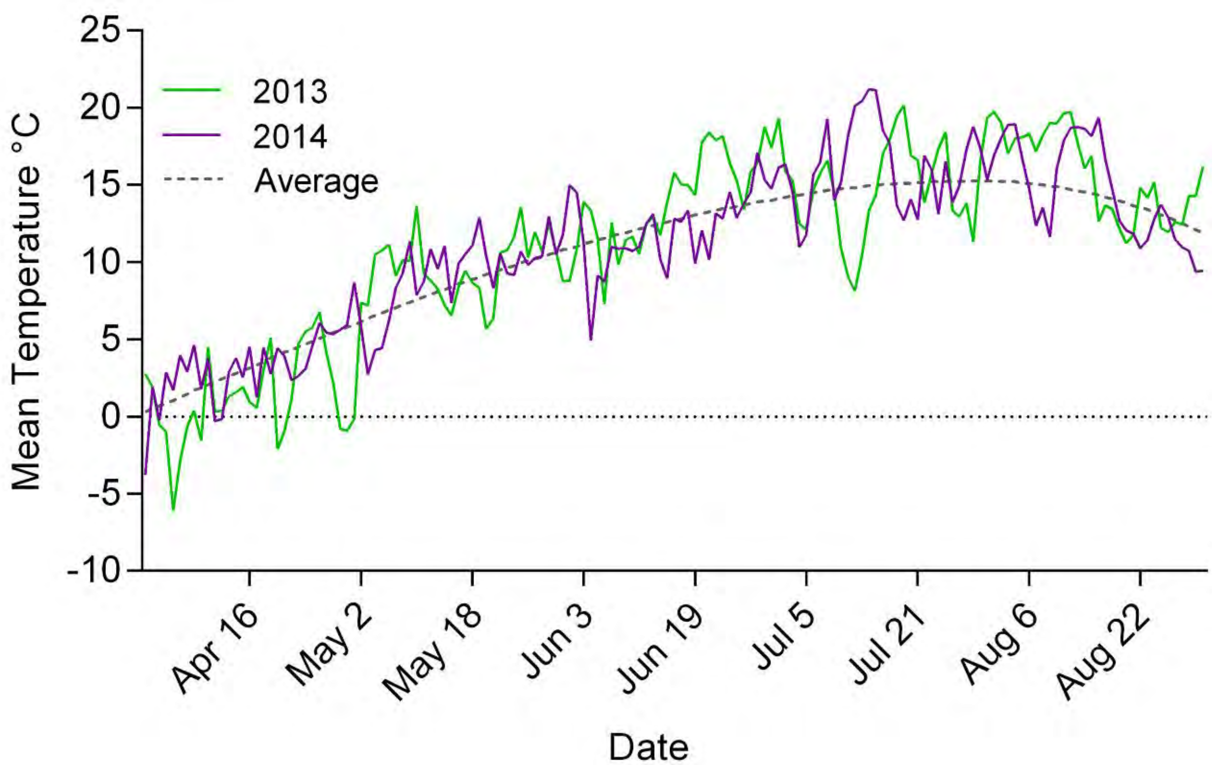

Figure 9. **Daily mean air temperature at Six Mile Creek in 2013 and 2014. Average temperature at the Mackenzie Airport included for reference (Environment Canada).**

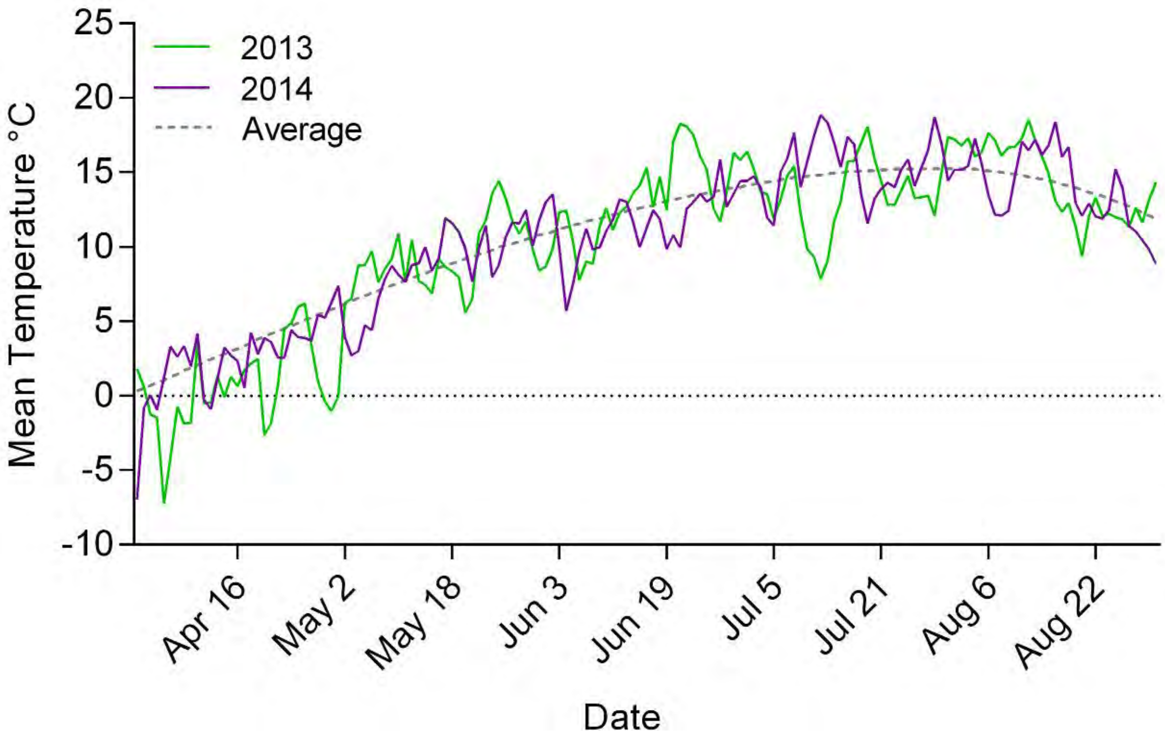

Figure 10. **Daily mean air temperature at Ole Creek in 2013 and 2014. Average temperature at the Mackenzie Airport included for reference (Environment Canada).**

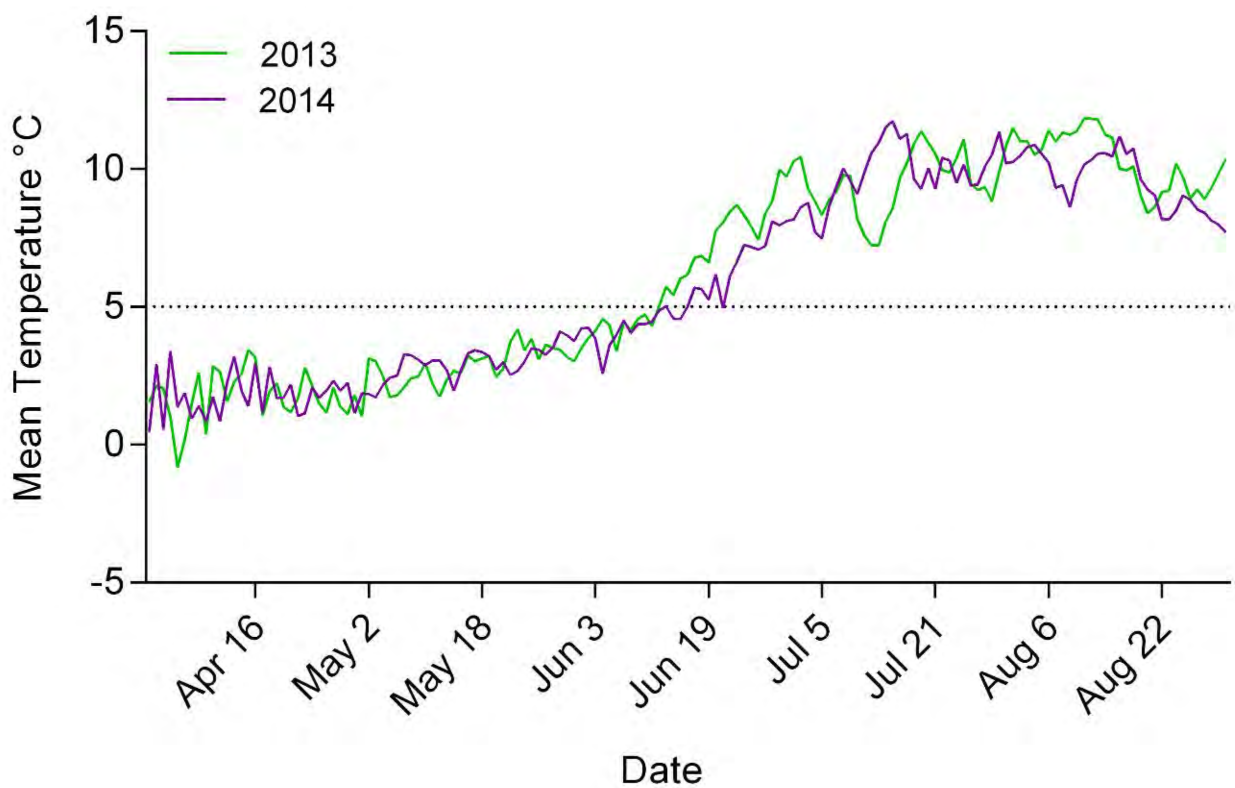

Figure 11. **Daily mean water temperature in Six Mile Creek in 2013 and 2014.**

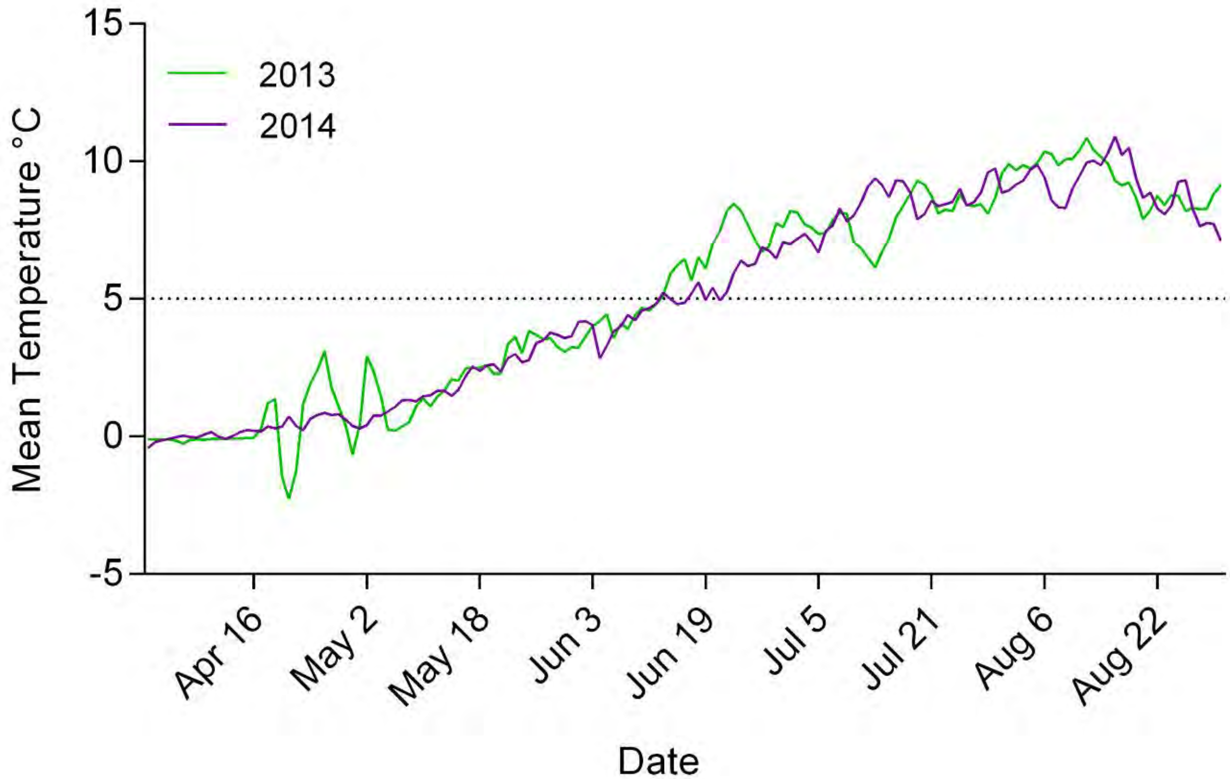

Figure 12. **Daily mean water temperature in Ole Creek in 2013 and 2014.**

The stream gauging stations were maintained during the first field visit on May 8-9, 2014. The stations were in good condition and appeared to be operating normally. Photos of the stations from the maintenance visit are included in Appendix 1. One anchor cable had broken during the winter and was replaced during the next field visit. The re-survey of the station elevations indicated that the stations had not moved (Table 5). The results of the re-survey were also similar to those obtained in 2013 (Golder 2014) providing further indication that the stations had not moved. The Hobo water temperature loggers were replaced during the August fish sampling session.

The manual discharge measurements in 2014 were completed on May 8, June 23, and August 19 in Six Mile Creek and on May 9, June 24, and August 24 in Ole Creek. Measurements were completed at a range of flow rates and rating curves were calculated for both creeks. The stage rating curves and associated tables are included in Appendix 2.

Table 5. Surveyed elevations for stream-gauging stations.

Component	2014 Re-survey		Original Survey (m)	Difference Between Surveys (m)
	Elevation (m)	Difference from Benchmark (m)		
Six Mile Creek Station (5018)				
Benchmark	-0.093	-	-	-
Upstream Nail	2.350	2.443	2.47	0.027
Top of T-post	2.297	2.390	2.42	0.030
Top of Stilling Pipe	1.804	1.897	1.93	0.033
Top of Staff Gauge	2.776	2.869	2.89	0.021
Ole Creek Station (4078)				
Benchmark	-0.401	-	-	-
Top of Rebar	0.913	1.314	1.317	0.003
Top of Stilling Pipe	0.696	1.097	1.096	-0.001
Top of Staff Gauge	1.639	2.040	2.049	0.009

5.2 Fish Surveys

5.2.1 Tributary Access Assessment and Fish Habitat

The early spring assessments were completed at low reservoir elevations (658.6-658.7 m) and low stream discharge. The reservoir was still mostly ice-covered and snow was present in the forested areas around the streams but the drawdown zone was snow and ice free. During the mid-June field visit, the reservoir was at a moderate level (666 m) and the streams flows were declining from recent peak freshet values. The proposed enhancement work had been completed at both Six Mile and Ole Creek sites immediately prior to the June visit. The highest flows had passed the week prior. In August, the streams were at very low discharge and the reservoir elevation had dropped slightly from its peak elevation (668.7 m) to 668.4 m. As noted above, precipitation had been well below average in the previous months. Based on the reservoir elevations there were no concerns for fish access to the tributaries in either June or August. Photographs from the photo reference points (Table 2) in 2014 are included in Appendix 3.

No significant physical barriers were observed within the drawdown zone during the site visits in 2014 with the exception of a woody debris clusters near the mouth of Factor Ross during the May 9 site visit. This barrier likely limited some fish access until it was inundated by the reservoir in mid to late May. No other barriers to upstream fish migration observed during sampling in 2014. Further details of the access assessments and drawdown zone habitat mapping are provided below for each stream. The habitat maps are included in Appendix 4.

5.2.1.1 Six Mile Creek

Habitat surveys of Six Mile Creek were completed on May 8, 2014 at close to low pool conditions for the reservoir. Habitat mapping was completed on a total of 852 m of stream channel in the drawdown zone from the photo reference point downstream to the confluence with the reservoir (Appendix 4, Map 1). No barriers to fish passage were observed in the drawdown zone or at the photo monitoring point (Appendix 3, Photos 5 and 6). The channel consisted of a long riffle for the first 372 m from the upstream limit of the drawdown zone with minimal holding water in the form of pools or large eddies. Gradients were generally consistent at 2% with a short section at 4% in the first 372 m. Substrates consisted of cobbles and gravels with intermittent boulders. The channel began to consistently braid at 0+372 m down to the confluence at 0+852 m. In the braided section, the stream had scoured shallow channels through the fine substrate of the reservoir with some sections having up to 5 braids. Where several braids were present, the channels were often narrow and shallow (<15 cm) with poor habitat. Substrates in the braided sections were dominated by gravels. In the lower 400 m, the gradients were variable from 1 to 6% with more complexity resulting from woody debris and stumps which created some pool habitat and cover. Braided channels from Lamonti Creek joined braided channels from Six Mile at approximately 0+700 m and 0+751 m. No fish were observed during the assessment.

Stream length in the drawdown zone was reduced to approximately 295 m on June 16, 2014 by rising reservoir levels. The tributary access enhancement work had been recently completed but had not affected the available channel at this flow level. This section consisted of a long riffle with little velocity relief but no physical barriers were observed in the drawdown zone or at the photo monitoring point (Appendix 3, Photos 7 and 8). Water levels in the stream were moderate to high.

The final field visit of the monitoring year was completed on August 15, 2014. During the final visit the stream length in the drawdown zone was less than 50 m as the reservoir was near its annual peak (Appendix 3, Photos 9 and 10). No physical barriers were observed. Water levels in this section were low with reduced velocities and several small eddies behind boulders providing holding water for fish migrating upstream. The confluence consisted of a wide shallow glide where approximately 12-15 adult Bull Trout were observed staging in preparation for the fall spawn (estimated size range: 40-70 cm). In addition, three suckers approximately 25-30 cm long were also observed. Enhancement work consisting of large boulders and willow brush layers was present along the left side of the stream. Most of the willows were desiccated.

5.2.1.2 Lamonti Creek

Habitat surveys of Lamonti Creek were completed on May 8, 2014. A total of 709 m of stream channel was mapped in the drawdown zone from the photo reference site downstream to the confluence of the longest braid with the reservoir (Appendix 4, Map 2). No barriers to fish passage were observed in the drawdown zone or at the photo monitoring point (Appendix 3, Photos 11 and 12). The stream in the drawdown zone was braided throughout with increasing separation and number channels (up to 5) with distance downstream. The majority of the braided channels were shallow (10-15 cm) and narrow 1-3 m wide with minimal cover. Gradients were generally consistent at 2% and the morphology was predominantly riffle with no velocity breaks (e.g., pools). At 0+337 m and 0+446 m braided channels continued west to connect with braided channels from Six Mile Creek while a single braid turned south at large bedrock ledge to connect directly to the reservoir at 0+709 m. Similar to Six Mile Creek, substrates became finer moving downstream (boulder/cobble to cobble/gravel). No fish were observed during the assessment.

Stream length in the drawdown zone was reduced to approximately 290 m on June 17, 2014 by rising reservoir levels. This section consisted of shallow braided riffles (10-20 cm) with little velocity relief but no physical barriers were observed in the drawdown zone or at the photo monitoring point (Appendix 3, Photos 13 and 14). Water levels in the stream were low to moderate.

The final field visit of the monitoring year was completed on August 17, 2014. Stream length in the drawdown zone was reduced to less than 50 m as the reservoir was near its annual peak (Appendix 3, Photos 15 and 16). No physical barriers were observed. Water levels in the stream were low with an abundance of pocket water that would allow for easy fish access. No fish were observed during this visit.

5.2.1.3 Ole Creek

Habitat surveys of Ole Creek were completed on May 9, 2014. A total of 404 m of stream channel was mapped in the drawdown zone from the photo reference site to the confluence with the reservoir (Appendix 4, Map 3). No barriers to fish passage were observed in the drawdown zone or at the photo monitoring point (Appendix 3, Photos 17 and 18). The stream was flowing in a single channel for the first 139 m at an average gradient of 3-4%. This section consisted of a swift riffle with cobble and boulder substrates and some large woody debris (LWD) providing cover and creating small pools. The LWD was the result of debris accumulation from the previous year’s full pool. Below 0+139 m the stream was heavily braided and eventually formed into two channels (between 0+254 m and 0+279 m) that persisted down to the confluence with the reservoir. The braided channels were scoured into fine sand substrates with erodible, unstable banks. The channels were deeply incised with a substrate of gravel and cobble but the water depths were shallow (10-15 cm). The braided channels had intermittent large woody debris and stumps which created small breaks in the riffle morphology but no deep pools were present. No fish were observed during the assessment.

Stream length in the drawdown zone was reduced to approximately 133 m by rising reservoir levels by June 18, 2014. The stream was also confined to a single channel as the tributary access enhancement works had been completed. The enhancement work confined the flows within an angular boulder channel that consisted of a long rifle with minimal velocity breaks (no pools or woody debris cover). Holding water was available along the stream margins where eddies were created behind large boulders and woody debris. No physical barriers were observed in the drawdown zone or at the photo monitoring point (Appendix 3, Photos 19 and 20). Water levels in the stream were moderate.

The final field visit of the monitoring year was completed on August 22, 2014. During the final visit the stream length in the drawdown zone was approximately 80 m. There was less reduction in stream length than observed at the Parsnip reach sites due to the steeper gradients. No physical barriers were observed in the drawdown zone or at the photo monitoring point (Appendix 3, Photos 21 and 22). Stream water levels were low to moderate resulting in reduced velocities and exposing several small eddies behind boulders amongst the riffle providing holding water for any fish migrating upstream. The confluence consisted of a wide deep run where approximately 12-15 adult bull trout were observed holding in preparation for the fall spawn (sizes estimated at 40-70 cm).

5.2.1.4 Factor Ross

Habitat surveys were completed on Factor Ross Creek on May 9, 2014. A total of 559 m of stream channel was mapped in the drawdown zone from the photo reference site to the confluence with reservoir (Appendix 4, Map 4). No physical barriers were observed at the photo monitoring point (Appendix 3, Photos 23 and 24). In the drawdown zone, two small cascades over woody debris were present at 0+348 m and 0+466 m (Map 4, insets 4 and 5). The most upstream cascade was located on a braid and no cascade was present on the other braid. The cascades were not considered complete barriers but would likely limit some upstream fish passage when exposed. The stream was relatively confined for the first 164 m before the channel braided. The upper section of the stream was primarily a long riffle with boulder and cobble substrates. A large pool was present at 0+160 m that provided some velocity relief. The braided section from 0+164 m to 0+378 m consisted of two to three shallow channels flowing among numerous stumps. The channels had scoured through the fine sand and silt to expose a cobble and gravel substrate. Woody debris in the form of stumps and logs was prevalent throughout the braided section and continued down to the confluence with reservoir at 0+559 m. The flow through the woody debris in this section has created habitat complexity, cover, and velocity breaks in the form of small pools, runs, and glides that were not observed at the other three streams. The stream was a single channel again from 0+378 m down to 0+559 m where it fanned out at the confluence with the reservoir. A single sculpin was observed near the confluence.

The stream length in the drawdown zone was reduced to approximately 165 m within a single channel on June 18, 2014 by rising reservoir levels. The exposed channel consisted of a straight riffle and terminated in a deep pool at the reservoir after a short steeper riffle. Holding water was available along the stream margins where eddies were created behind large boulders and woody debris. No physical barriers were observed in the drawdown zone or at the photo monitoring point (Appendix 3, Photos 25 and 26). Water levels in the stream were moderate.

The final field visit of the monitoring year was completed on August 21, 2014. The stream length in the drawdown zone was approximately 50 m. No physical barriers were observed in the drawdown zone or at the photo monitoring point (Appendix 3, Photos 27 and 28). Water levels in the stream were low to moderate resulting in reduced velocities and exposing several small eddies behind boulders. In addition, the backwatering effect of the reservoir had reduced water velocities compared to what was observed in June. This would allow easier access for fish into the upstream reaches. The confluence consisted of a wide deep run where an unknown number of adult bull trout were observed staging in preparation for the fall spawn.

5.2.2 Drawdown Zone Fish Sampling

Stream lengths sampled within the drawdown zone on June 16-18, 2014, were 295 m at Six Mile Creek, 290 m at Lamonti Creek, 165 m at Factor Ross Creek and 133 m at Ole Creek. This sampling effort resulted in total sampled areas of 1595 m^2 at Six Mile, 1575 m^2 at Lamonti, 810 m^2 at Factor Ross and 720 m^2 at Ole Creek of what was primarily categorized as riffle habitat with occasional pocket water. All streams had reasonable visibility as peak freshet had passed and water levels were declining.

The primary fish observations were all age classes of sculpins (both Prickly and Slimy) with Bull Trout being the most abundant salmonid and the only salmonid found in all streams. Rainbow Trout were captured in low numbers in all streams except for Factor Ross Creek where none were captured or observed. Both species of sculpin were encountered at all sites but there was a noticeable difference between the Parsnip and Finlay Reach sites. Slimy Sculpin was the dominant species at Six Mile and Lamonti Creeks (Parsnip) while Prickly Sculpin was the dominant species at Ole and Factor Ross Creeks (Finlay). No fish larger than 153 mm were encountered.

The total numbers of fish by species and catch per unit effort (CPUE) are provided for each site in Table 6. As sampling was conducted by single pass electrofishing with no enclosure, not all fish were captured. Fish that were not captured but could be identified are included in the observed category.

Thirty-three fish were caught or observed in the drawdown zone reach of Six Mile Creek (Table 6). Sampling in Six Mile Creek was restricted to the slower stream margins due to high water levels and velocities at the time of sampling. Sculpins were the most commonly captured (57.8%, 0.0119/m^2) followed by Bull Trout (30.3%, 0.0063/m^2). Only two Rainbow Trout were caught. All of the salmonids captured were small (<120 mm) and considered juveniles. A Longnose Dace and a Burbot were also captured in the drawdown zone reach of Six Mile Creek.

A total of 46 Bull Trout, Rainbow Trout, and sculpin were captured or observed in the Lamonti Creek drawdown zone reach (Table 6). Nearly 85% of the total fish captures were sculpin (0.0248/m^2) and most of these were Slimy Sculpin. Bull Trout were the second most abundant species but comprised only 10.8% of the total catch (0.0032/m^2) (Table 6). The single Rainbow Trout captured and the Bull Trout were categorized as juveniles (<85 mm FL).

A total of 20 Bull Trout, Rainbow Trout and sculpin were captured or observed in the Ole Creek drawdown zone (Table 6). Seventy percent of the total fish captures were sculpin (0.0333/m^2) with most of these being Prickly Sculpin (Table 6). Bull Trout were the second most abundant at 25% of the total catch (0.0069/m^2). The single Rainbow Trout and the Bull Trout were categorized as juveniles (≤153 mm FL). The sculpins were primarily captured in the lower portion of the drawdown zone reach, below a steep riffle, where some reservoir backwatering was occurring. The majority of the salmonids were captured above the steep riffle.

A total of 30 fish were captured or observed in the Factor Ross drawdown zone reach and consisted of only Bull Trout and sculpins (Table 6). Nearly 87% of the total fish captures were sculpins (0.0321/m^2) (Table 6) with most of these being Prickly Sculpin. Bull Trout made up the rest of the catch and were considered to be all juveniles (<125mm FL). All sculpins were captured downstream of a steep riffle section approximately half way along the reach.

5.2.1 Spawner Surveys

Spawner surveys were conducted from June 23-26, 2014 once water temperatures in Six Mile and Ole Creeks were consistently above 5°C, as recorded by the remote monitoring stations. The approximate stream lengths assessed during the surveys were 2.2 km for Six Mile Creek, 0.8 km for Patsuk Creek, 1.4 km for Lamonti Creek, 2.1 km for Ole Creek, and 1.7 km for Factor Ross Creek (Table 7). Horizontal visibility in Six Mile and Lamonti Creeks was 4.3 m and 3.0 m respectively (Table 7), allowing the snorkeler to observe the majority of the area within the assessed spawning habitat with relative confidence. In Ole Creek the visibility was 2.7 m while Factor Ross Creek was measured at 2.0 m (Table 7), which likely reduced the snorkelers' ability to locate fish in the assessed spawning habitat. In general, Six Mile/Patsuk and Lamonti Creeks had higher visibility during spawning assessments compared to Ole and Factor Ross Creek. Water temperatures measured in the field during spawner surveys ranged from 6°C to 6.7°C, which is adequate for Rainbow Trout spawning (Table 7). The spawning survey field data for the four systems is included in Appendix 5. Maps showing the locations of suitable spawning substrates are included in Appendix 6.

Table 6. **Number of fish and catch per unit effort (CPUE) by species during drawdown zone electrofishing in Six Mile, Lamonti, Ole, and Factor Ross Creeks in 2014.**

Site	Metric	Species				
		Longnose Dace	Rainbow Trout	Bull Trout	Burbot	Sculpin sp.
Six Mile	Captured	1	2	9	1	18
	Observed			1		1
	Total	1	2	10	1	19
	CPUE (#/sec)	0.0006	0.0011	0.0059	0.0006	0.0106
	CPUE (#/100m²)	0.0006	0.0013	0.0063	0.0006	0.0119
Lamonti	Captured		1	4		34
	Observed		1	1		5
	Total		2	5		39
	CPUE (#/sec)		0.0012	0.003		0.0232
	CPUE (#/100m²)		0.0013	0.0032		0.0248
Ole	Captured		1	5		10
	Observed					4
	Total		1	5		14
	CPUE (#/sec)		0.001	0.0048		0.0134
	CPUE (#/100m²)		0.0014	0.0069		0.0333
Factor Ross	Captured			3		21
	Observed			1		5
	Total			4		26
	CPUE (#/sec)			0.0031		0.0201
	CPUE (#/100m²)			0.0049		0.0321

Table 7. **Conditions during spring 2014 Rainbow Trout spawner surveys in Williston Reservoir study tributaries.**

Site	Date Surveyed	Approximate Stream Length Surveyed (km)	Water Temperature (°C)	Horizontal Visibility (m)
Six Mile	June 23, 2014	2.2	6	4.3
Lamonti	June 26, 2014	1.4	6	3.0
Ole	June 24, 2014	2.1	6.7	2.7
Factor Ross	June 25, 2014	1.7	6.7	2.0

Six Mile and Patsuk Creeks had a total of 111 m² and 212 m² of suitable spawning substrate over the assessed area, respectively (Table 8). No active redds were observed in either Six Mile or Patsuk Creeks. Two mature Rainbow Trout (approximately 350 mm FL) were observed within Six Mile Creek but not in a location with suitable spawning habitat. No fish were observed in Patsuk Creek.

Lamonti Creek had the highest number of Rainbow Trout observed and was the only stream where active redds were observed (Table 8). In total, eight mature Rainbow Trout (approximately 300-400 mm FL) were observed over the 1.4 km of stream surveyed. Five active redds were identified, three of which were observed with fish at the redd site. The area of suitable spawning habitat identified in the assessed portion of Lamonti Creek was 31.1 m². This total includes the 8.89 m² area of the redds identified during the survey (Table 8).

No active redds were observed in Ole Creek or Factor Ross Creek (Table 8). Two Rainbow Trout (approximately 350 mm) were observed in Factor Ross Creek in close proximity to an area identified with suitable spawning substrate. No Rainbow Trout were observed in Ole Creek during the survey (Table 8). In total, 34.76 m² and 32.13 m² of suitable spawning substrate was observed in Factor Ross Creek and Ole Creek, respectively (Table 8).

Table 8. Summary of results from the 2014 Rainbow Trout spawning surveys.

Site	Spawning Habitat Area (m^2)	No. of Redds	No. of Rainbow Trout	Comments
Six Mile	111	-	2	Two Mature Rainbow trout observed in area with no spawning habitat
Patsuk	212	-	-	
Lamonti	31.1	5	8	Rainbow Trout observations include 2 mature females and a spawning pair.
Ole	32.13	-	-	
Factor Ross	34.76	-	-	Two mature fish observed, assumed to be salmonids

5.2.2 Juvenile Fish Surveys

The same mark-resight method for estimating the abundance of juvenile fish was used in Year 4 as was used in Years 2 and 3, as recommended in the Year 3 report (Golder 2014). Results from the electrofishing (mark), night snorkel surveys (resight), and population estimation components are described below. Data from Year 2 (2012) and Year 3 (2013) of the monitoring program (Golder 2013, 2014) are included for comparison.

Prickly Sculpin (*Cottus asper*) and Slimy Sculpin (*C. cognatus*) are both known to occur in tributaries to Williston Reservoir. Sculpins captured in 2014 were identified to species in the field. However, it is not possible to reliably identify sculpin to species for fish that were observed but not captured both during electrofishing and snorkelling. As sculpins are not a target for enhancement and because observed individuals could not be identified to species, all sculpins were combined for data summary and analyses.

5.2.2.1 Electrofishing

Fish captures through electrofishing in Year 4 were higher than in either Year 2 or 3 but varied between the four streams. Maps showing the locations of the electrofishing and snorkelling sites for each stream are included in Appendix 6. A summary of the electrofishing sites and effort for all streams is included in Appendix 7. A total of 32 fish were marked in the Parsnip Reach sites with 12 in Six Mile Creek and 20 in Lamonti Creek (Table 9). In the Finlay Reach sites, a total of 48 fish were marked with 28 in Ole Creek and 20 in Factor Ross Creek (Table 10). Rainbow Trout was the only species that was captured and marked in all four streams (and). No Bull Trout were captured or marked in Lamonti Creek in 2014. As in previous years, Burbot were only found in Six Mile Creek. Mountain Whitefish were captured and marked in both Ole and Factor Ross Creek (Table 10). No Arctic Grayling were captured during electrofishing in Factor Ross Creek in 2014 (Table 10).

In 2014, fish species captured and observed in Six Mile Creek by electrofishing included Bull Trout, Rainbow Trout, Burbot, and sculpins (Prickly and Slimy) (Table 9). Six Mile Creek is the only stream in the project where Burbot have been observed. Sculpins were the most abundant fish captured during electrofishing comprising 63.8% of the total in Six Mile Creek (Table 9). Sculpins were also the most abundant fish captured during electrofishing in Lamonti Creek representing 60.8% of the total. Rainbow trout were the only other species captured in Lamonti Creek in 2014 (Table 9).

Fish species captured and observed during electrofishing in Ole and Factor Ross Creeks were similar to those observed in 2012 and 2013 with Rainbow Trout, Bull Trout, Mountain Whitefish and sculpins captured in both streams (Table 10). Kokanee and Arctic Grayling were not captured or observed during electrofishing in 2014 (Table 10). The relative abundance of Bull Trout was higher than Rainbow Trout in both Ole and Factor Ross Creeks (Table 10), which is the opposite of what was observed in the Parsnip Reach sites. The relative abundance of Bull Trout in Ole Creek and Mountain Whitefish in Factor Ross Creek based on the electrofishing surveys was notably higher than in previous years (Table 10).

Table 9. Catch-per-unit-effort (CPUE) during electrofishing in the Parsnip Reach sites (Six Mile and Lamonti Creeks) in 2012, 2013, and 2014.

Site	Year	Metric	Rainbow Trout	Bull Trout	Burbot	Sculpin sp.	Unknown
Six Mile	2012	Captured	2	4	2	6	
		Observed				6	
		Total	2	4	2	12	
		CPUE (#/sec)	0.0009	0.0019	0.0009	0.0056	
		CPUE (#/100m²)	-	-	-	-	
	2013	Captured	2	2		3	
		Observed	2			3	
		Total	4	2		6	
		CPUE (#/sec)	0.0019	0.001		0.0029	
		CPUE (#/100m²)	0.5546	0.2773		0.8319	
	2014	Captured	7	4	2	33	
		Observed	4	1		4	3
		Total	11	5	2	37	3
		CPUE (#/sec)	0.0042	0.0019	0.0008	0.0142	0.0011
		CPUE (#/100m²)	1.1282	0.5128	0.2051	3.7949	0.3077
Lamonti	2012	Captured	2	1		1	
		Observed	1			2	
		Total	3	1		3	
		CPUE (#/sec)	0.0027	0.0009		0.0027	
		CPUE (#/100m²)	0.85	0.28		0.85	
	2013	Captured	2	1		3	
		Observed	1			1	
		Total	3	1		4	
		CPUE (#/sec)	0.0014	0.0005		0.0018	
		CPUE (#/100m²)	0.5348	0.1783		0.713	
	2014	Captured	20			39	
		Observed	6			9	5
		Total	26			48	5
		CPUE (#/sec)	0.0137			0.0253	0.0026
		CPUE (#/100m²)	5.2632			9.7166	1.0121

Table 10. Catch-per-unit-effort (CPUE) during electrofishing in the Finlay Reach sites (Ole and Factor Ross Creeks) in 2012, 2013, and 2014.

Site	Year	Metric	Rainbow Trout	Kokanee	Bull Trout	Mountain Whitefish	Arctic Grayling	Sculpin sp.	Unknown
Ole	2012	Captured	1		13			2	
		Observed	1	1	3			2	
		Total	2	1	16			4	
		CPUE (#/sec)	0.0011	0.0006	0.0091			0.0023	
		CPUE (#/100m²)	0.52	0.26	4.2			1.05	
	2013	Captured			6	1			
		Observed			2	1			
		Total			8	2			
		CPUE (#/sec)			0.0025	0.0006			
		CPUE (#/100m²)			1.3658	0.3414			
	2014	Captured	2		32	2		5	
		Observed			11	4			29
		Total	2		43	6		5	29
		CPUE (#/sec)	0.0008		0.0171	0.0024		0.002	0.0116
		CPUE (#/100m²)	0.3373		7.2513	1.0118		0.8432	4.8904
Factor Ross	2012	Captured		2	3		1	3	
		Observed			1		2		
		Total		2	4		3	3	
		CPUE (#/sec)		0.0016	0.0033		0.0024	0.0024	
		CPUE (#/100m²)		0.37	0.74		0.56	0.56	
	2013	Captured			7	1		3	
		Observed			5				
		Total			12	1		3	
		CPUE (#/sec)			0.0057	0.0005		0.0014	
		CPUE (#/100m²)			3.44	0.29		0.86	
	2014	Captured	4		6	15		6	
		Observed			1	21			7
		Total	4		7	36		6	7
		CPUE (#/sec)	0.0028		0.0048	0.0249		0.0041	0.0048
		CPUE (#/100m²)	0.6211		1.0886	5.5988		0.9331	1.0886

5.2.2.2 Night Snorkel Surveys

Night snorkel surveys were completed at each of the electrofishing sites a minimum of 24 hours after the release of marked fish. While a quiet approach to each site and visual survey from the shore was used at each site, most fish observations were made while snorkelling. The exception to this was Lamonti Creek where most fish were observed during the initial visual survey from the shore. This was a result of the low water levels in Lamonti Creek at the time of the snorkel surveys. Higher numbers of fish and more species were observed during the snorkel surveys than while electrofishing.

The number of fish observed in the snorkel surveys for the Parsnip Reach sites was higher than in previous years but there was some variation in relative abundance (Table 11). In Six Mile Creek, all fish species captured and observed during electrofishing were observed in the snorkel surveys including Bull Trout, Rainbow Trout, Burbot, and sculpins (Table 11). Mountain Whitefish were also observed in Six Mile Creek during the snorkel surveys (Table 11). Consistent with Years 2 and 3, Rainbow Trout (45.6% of observations) were the most common fish observed in Six Mile Creek (Table 11). In Lamonti Creek, Rainbow Trout were the most commonly observed species (67.9% of observations) and were notably more abundant than in previous years (Table 11). Bull Trout were only observed during the snorkel surveys on Lamonti Creek in Year 4 and at lower abundances than in previous years.

In the Finlay reach sites, trends in the number of fish observed in the snorkel surveys differed between the two streams. The number of fish observed in Ole Creek increased over previous years while in Factor Ross Creek the number of observations was similar to 2012 and 2013 (Table 12). Bull Trout were the most common fish in the Ole Creek the snorkel surveys (84.3% of observations) and had a notable increase in relative abundance compared to the previous two years (Table 12). Mountain Whitefish continued to be the most common fish observed in Factor Ross Creek (Table 12). While no Arctic Grayling were captured during electrofishing in 2014, two were observed in Factor Ross Creek during the snorkel surveys (Table 12). Factor Ross is the only stream where Arctic Grayling have been observed during this monitoring program.

Table 11. Catch-per-unit-effort (CPUE = number of fish/100m^2) during snorkel surveys in the Parsnip Reach sites (Six Mile and Lamont Creeks) in 2012, 2013, and 2014.

Site	Year	Metric	Rainbow Trout	Bull Trout	Mountain Whitefish	Burbot	Sculpin sp.	Unknown
Six Mile	2012	Observed	20				1	
		CPUE	7.1				0.4	
	2013	Observed	29	5	11		5	
		CPUE	4.2	0.7	1.6		0.7	
	2014	Observed	57	30	11	1	25	1
		CPUE	5.8	3.1	1.1	0.1	2.6	0.1
Lamonti	2012	Observed	5	7				
		CPUE	2.5	3.4				
	2013	Observed	14	17			1	
		CPUE	2.5	3			0.2	
	2014	Observed	55	11			15	
		CPUE	11.1	2.2			3	

Table 12. Catch-per-unit-effort (CPUE = number of fish/100m^2) during snorkel surveys in the Finlay Reach sites (Ole and Factor Ross Creeks) in 2012, 2013, and 2014.

Site	Year	Metric	Rainbow Trout	Bull Trout	Mountain Whitefish	Arctic Grayling	Sculpin sp.	Unknown
Ole	2012	Observed	2	31	4			
		CPUE	0.5	8.1	1			
	2013	Observed	2	36	2		1	
		CPUE	0.4	6.7	0.4		0.2	
	2014	Observed	8	75	13			2
		CPUE	1.3	12.6	2.2			0.3
Factor Ross	2012	Observed	1	11	42	1	1	
		CPUE	0.2	2.7	10.4	0.2	0.2	
	2013	Observed	3	14	84	1	1	
		CPUE	0.9	4	24.1	0.3	0.3	
	2014	Observed	4	10	82	2	1	
		CPUE	0.6	1.6	12.8	0.3	0.2	

5.2.2.3 Abundance Estimates

In Year 4, fish were frequently identified in different sites from where they were originally marked and in some cases up to two sites away. Due to the large number of fish of similar size that had been marked, the exact fish could not always be recalled so actual movement distances could not be determined. However, in all cases it appeared the fish had moved downstream. No fish with tags from previous years were encountered. A summary of the number of fish marked and resighted in each stream used for calculating abundance is included in Table 13. Abundance was not calculated for species that were not marked (e.g., Arctic Grayling) and non-sportfish species (sculpins).

The Bayesian and Peterson estimates of abundance in Year 4 were generally similar and were much higher than those from the snorkel surveys (Table 14). The only exception was the Petersen estimate for Mountain Whitefish in Factor Ross Creek which was much higher than the Bayesian estimate (Table 14). The Peterson model could be not be applied to Bull Trout and Burbot in Six Mile Creek or Rainbow Trout and Mountain Whitefish in Ole Creek as no marked fish were resighted. No species had a 100% reobservation rate.

Although comparable to one another, data from the Bayesian population estimates varied for most species-stream groups from 2012-2014 (Table 15). In general, mean abundance estimates for all species were higher in 2014 than in previous years (Table 15). The only exception was a slight decrease in estimated Bull Trout abundance in Factor Ross Creek in 2014 (Table 15). However, the abundance estimate was similar to those from 2012 and 2013. As a higher number of fish were marked in 2014, the variance of the abundance estimates also generally decreased (Table 15). Variance was still high for species with low numbers of fish marked and recaptured. Capture efficiencies varied between 2012, 2013, and 2014 but were comparable in most cases (Table 16).

Notable changes in the abundance estimates were observed for Bull Trout in Six Mile Creek (4.0 fish/100 m² in 2013 to 12.7 fish/100 m² in 2014) and Rainbow Trout in Lamonti Creek (9.3 fish/100 m² in 2013 to 24.2 fish/100 m² in 2014 (Table 15). Abundance estimates in the Finlay Reach sites were generally comparable to previous years, where estimates were available for previous years. Abundance estimates were calculated for the first time in 2014 for Rainbow Trout in Ole and Factor Ross Creeks, Mountain Whitefish in Ole Creek, and Burbot in Six Mile Creek (Table 15). No abundance estimates could be calculated for Bull Trout in Lamonti Creek, Mountain Whitefish in Six Mile Creek, and Arctic Grayling in Factor Ross Creek due to a lack of marked fish.

Table 13. Mark-resight data used for fish abundance estimates for four Williston Reservoir tributaries in 2014. Data only includes tagged fish (first sample) and observations of those species while snorkeling (second sample).

Site	Species	Electrofishing (1st Sample) No. Marked	Snorkeling (2nd Sample)		
			Marked	Unmarked	Total
Six Mile	Rainbow Trout	7	4	53	57
	Bull Trout	3	0	30	30
	Burbot	2	0	1	1
Lamonti	Rainbow Trout	20	8	47	55
Ole	Rainbow Trout	2	0	8	8
	Bull Trout	24	10	65	75
	Mountain Whitefish	2	0	13	13
Factor Ross	Rainbow Trout	4	2	2	4
	Bull Trout	4	1	9	10
	Mountain Whitefish	12	3	79	82

Table 14. Bayesian population estimates compared to night snorkeling observations and Petersen mark-recapture estimates from mark-resight data in 2014.

Site	Species	Bayesian			Snorkel Survey		Peterson			
		Mean	SD	Mean/100 m²	No.	No./100 m	Mean	LCI	UCI	Mean/100 m²
Six Mile	Rainbow Trout	105.4	33.26	10.81	57	5.84	100	39	366	10.25
	Bull Trout	124.0	54.8	12.71	30	3.07	-	-	-	-
	Burbot	50.06	52.19	5.13	1	0.10	-	-	-	-
Lamonti	Rainbow Trout	119.9	32.08	24.2	55	11.1	138	76	265	27.9
Ole	Rainbow Trout	73.98	52.82	12.4	8	1.35	-	-	-	-
	Bull Trout	151.7	33.0	25.5	75	12.6	180	105	324	30.3
	Mountain Whitefish	86.64	54.83	14.6	13	2.19	-	-	-	-
Factor Ross	Rainbow Trout	10.62	14.32	1.65	4	0.62	8	5	27	1.24
	Bull Trout	57.44	42.84	8.93	10	1.55	40	7	1580	6.22
	Mountain Whitefish	201.5	46.78	31.3	82	12.7	328	112	1591	51.0

Table 15. Comparison of Bayesian populations estimates based on mark-resight data for four Williston Reservoir tributaries in 2012, 2013, and 2014.

Site	Species	2012			2013			2014		
		Mean	SD	Mean/ 100 m²	Mean	SD	Mean/ 100 m²	Mean	SD	Mean/ 100 m²
Six Mile	Rainbow Trout	26.7	13.78	10.1	-	-	-	105.4	33.26	10.81
	Bull Trout	-	-	-	25.84	29.9	4.0	124.0	54.8	12.71
	Burbot	-	-	-	-	-	-	50.06	52.19	5.13
Lamonti	Rainbow Trout	7.564	8.736	4.9	50.14	37.76	9.3	119.9	32.08	24.2
	Bull Trout	21.46	24.87	11.0	40.55	31.45	7.3	-	-	-
Ole	Rainbow Trout	-	-	-	-	-	-	73.98	52.82	12.4
	Bull Trout	112.6	42.71	32.5	91.99	50.97	18.1	151.7	33.0	25.5
	Mountain Whitefish	-	-	-	-	-	-	86.64	54.83	14.6
Factor Ross	Rainbow Trout	-	-	-	-	-	-	10.62	14.32	1.65
	Bull Trout	60.14	50.8	14.6	62.39	49.43	20.6	57.44	42.84	8.93
	Mountain Whitefish	-	-	-	119.1	35.24	34.5	201.5	46.78	31.3

Table 16. Comparison of estimated capture probabilities from Bayesian mark-resight model for four Williston Reservoir tributaries in 2012, 2013, and 2014.

Site	Species	Estimated Capture Probability					
		2012		2013		2014	
		Mean	SD	Mean	SD	Mean	SD
Six Mile	Rainbow Trout	0.73	0.19	-	-	0.54	0.14
	Bull Trout	-	-	0.34	0.21	0.28	0.13
	Burbot	-	-	-	-	0.09	0.12
Lamonti	Rainbow Trout	0.62	0.23	0.39	0.21	0.41	0.09
	Bull Trout	0.50	0.26	0.55	0.25	-	-
Ole	Rainbow Trout	-	-	-	-	0.18	0.14
	Bull Trout	0.30	0.10	0.50	0.23	0.44	0.08
	Mountain Whitefish	-	-	-	-	0.22	0.15
Factor Ross	Rainbow Trout	-	-	-	-	0.39	0.19
	Bull Trout	0.34	0.25	0.37	0.25	0.25	0.15
	Mountain Whitefish	-	-	0.74	0.17	0.40	0.09

5.2.3 Fry Surveys

Fry surveys were completed on all four creeks in conjunction with the night snorkel surveys. The amount of suitable fry habitat searched varied depending on the stream although the number of sites searched was similar in each stream (Table 17). Sizes of Rainbow Trout and Bull Trout fry observed in the four tributaries were <45 mm, and <55mm respectively. Rainbow Trout Fry were only observed in Six Mile Creek while Bull Trout fry were observed in all streams except for

Lamonti Creek in 2014 (Table 17). No fry were observed in Lamonti Creek during the 2014 surveys (Table 17). A summary of the fry survey results is included in Appendix 8.

Table 17. Summary of the fry surveys on Six Mile, Lamonti, Ole and Factor Ross Creeks in 2014.

Site	Number of Sites	Length Surveyed (m)	Species	Number Observed	CPUE (no./m)
Six Mile	15	160	Rainbow Trout	37	0.23
			Bull Trout	13	0.081
			Unknown	1	0.006
			Total	51	0.32
Lamonti	15	66	Rainbow Trout	0	0
			Bull Trout	0	0
			Unknown	0	0
			Total	0	0
Ole	13	37.25	Rainbow Trout	0	0
			Bull Trout	3	0.08
			Unknown	0	0
			Total	3	0.08
Factor Ross	14	65	Rainbow Trout	0	0
			Bull Trout	9	0.14
			Unknown	0	0
			Total	9	0.14

5.3 Vegetation Surveys

In Year 4 of the study, a total of ten habitat classes describing vegetation communities at the tributary enhancement and control sites were identified and mapped, including ten habitat classes at Six Mile Creek, seven classes at Lamonti Creek, six classes at Ole Creek and seven at Factor Ross Creek (Table 18). Habitat classes BS, GS, SD, SF, SW and SP were common to all sites, whereas WH, WS and WW were only found at Six Mile Creek (Table 18). A total of 136 polygons were identified and mapped across the study sites covering 56.07 ha (Table 19). The number of polygons for each habitat class ranged from one (classes SW, WW and SP) to 13 (class GS) (Table 19). The percentage of total area covered by habitat classes ranged from 0.59% (class SW) to 37.31% (class BS) across all sites. Detailed descriptions and photos of the habitat classes are provided in Appendix 10.

The most abundant habitat classes at Six Mile Creek (Figure 13) by number of polygons were GS (12 polygons), SD (10 polygons) and SW (10 polygons) (Table 19). All other classes had five or fewer polygons. By area, habitat classes SF and SP accounted for the largest area, covering 52.44% of the total area at Six Mile Creek. The next largest habitat class by area was class BS, accounting for 17.90% of the total area at this site. All other classes at this site had a cover of <8%.

At Lamonti Creek (Figure 14), the most abundant habitat classes by number of polygons were GS (nine polygons) and OV (five polygons) (Table 19). All other classes had three or fewer polygons. By area, habitat classes BS, SF, and SP accounted for the largest area, covering 63.43% of the total area at Lamonti Creek. The next largest habitat class by area was class GS, accounting for 10.09% of the total area at this site. All other classes at this site had a cover of <9%.

The most abundant habitat classes at Ole Creek (Figure 15) by number of polygons were GS (13 polygons and SD (six polygons) (Table 19). All other classes had three or fewer polygons. By area, habitat classes SF and SP accounted for the largest area, covering 71.89% of the total area at Ole Creek. The next largest habitat class by area was class GS, accounting for 12.05% of the total area at this site. All other classes at this site had a cover of <5%.

For Factor Ross Creek (Figure 16), the most abundant habitat classes by number of polygons were SP (eight polygons), SW (four polygons) and SD (four polygons) (Table 19). All other classes had two polygons. By area, habitat classes BS and SF accounted for the largest area, covering 71.89% of the total area at Factor Ross Creek. The next largest habitat class by area was class GS, accounting for 12.08% of the total area at this site. All other classes at this site had a cover of <5%.

Table 18. Habitat classification summary for enhancement and reference sites in Year 4.

Year 4		Site			
Habitat Class	**Habitat Class Description**	**Six Mile**	**Lamonti**	**Ole**	**Factor Ross**
BS	Basin Silt	√	√	√	√
GS	Gravel and Sand	√	√	√	√
OV	Organic Veneer	√	√		√
SD	Shoreline Driftwood	√	√	√	√
SF	Shoreline Forest	√	√	√	√
SW	Shoreline Willow	√	√	√	√
SP	Streams and Ponds	√	√	√	√
WH	Wetland Horsetail	√			
WS	Wetland Sedge	√			
WW	Wetland Willow	√			

Table 19. Number of polygons and area for habitat classes identified during photo interpretation for enhancement and reference sites in Year 4. Refer to Appendix 10 for detailed descriptions of the habitat classes.

			Year 4			
			Area (ha)			
Site	**Habitat Class**	**Habitat Class Description**	**Number of Polygons**	**Mean**	**Total**	**Percent of Total Area**
Six Mile	BS	Basin Silt	5	0.50	2.51	17.90
	GS	Gravel and Sand	12	0.05	0.55	3.96
	OV	Organic Veneer	5	0.16	0.80	5.75
	SD	Shoreline Driftwood	10	0.10	1.03	7.33
	SF	Shoreline Forest	4	0.75	3.00	21.40
	SW	Shoreline Willow	10	0.09	0.90	6.42
	SP	Streams and Ponds	5	0.87	4.35	31.04
	WH	Wetland Horsetail	4	0.06	0.23	1.62
	WS	Wetland Sedge	5	0.03	0.17	1.21
	WW	Wetland Willow	1	0.48	0.48	3.40
			61		**14.00**	**100.00**
Lamonti	BS	Basin Silt	2	0.97	1.93	21.71
	GS	Gravel and Sand	11	0.08	0.90	10.09
	OV	Organic Veneer	5	0.14	0.72	8.15
	SD	Shoreline Driftwood	3	0.33	0.98	11.01
	SF	Shoreline Forest	3	0.59	1.78	20.07
	SW	Shoreline Willow	2	0.34	0.69	7.71
	SP	Streams and Ponds	1	1.89	1.89	21.20
			25		**8.89**	**100.00**
Ole	BS	Basin Silt	3	0.33	0.98	11.76
	GS	Gravel and Sand	13	0.08	1.00	12.05
	SD	Shoreline Driftwood	6	0.08	0.50	6.06
	SF	Shoreline Forest	2	1.43	2.86	34.40
	SW	Shoreline Willow	1	0.05	0.05	0.59
	SP	Streams and Ponds	1	2.91	2.91	35.08
			26		**8.30**	**100.00**
Factor Ross	BS	Basin Silt	2	4.64	9.28	37.31
	GS	Gravel and Sand	2	1.50	3.01	12.08
	OV	Organic Veneer	2	0.37	0.75	3.00
	SD	Shoreline Driftwood	4	0.28	1.12	4.51
	SF	Shoreline Forest	2	4.30	8.60	34.58
	SW	Shoreline Willow	4	0.25	1.01	4.05
	SP	Streams and Ponds	8	0.14	1.11	4.47
			24	**11.48**	**24.88**	**100.00**

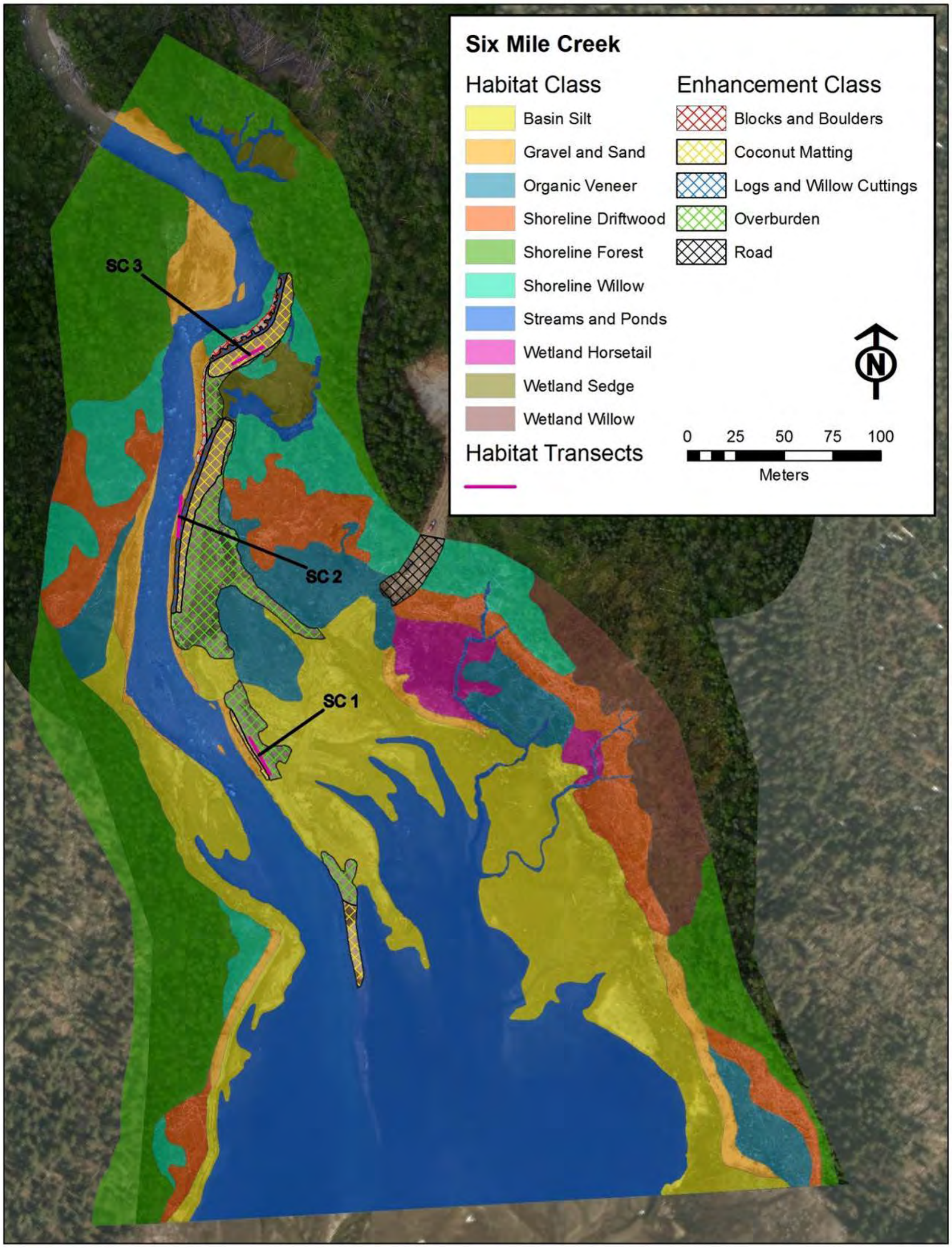

Figure 13. Habitat classes and transect locations at Six Mile Creek.

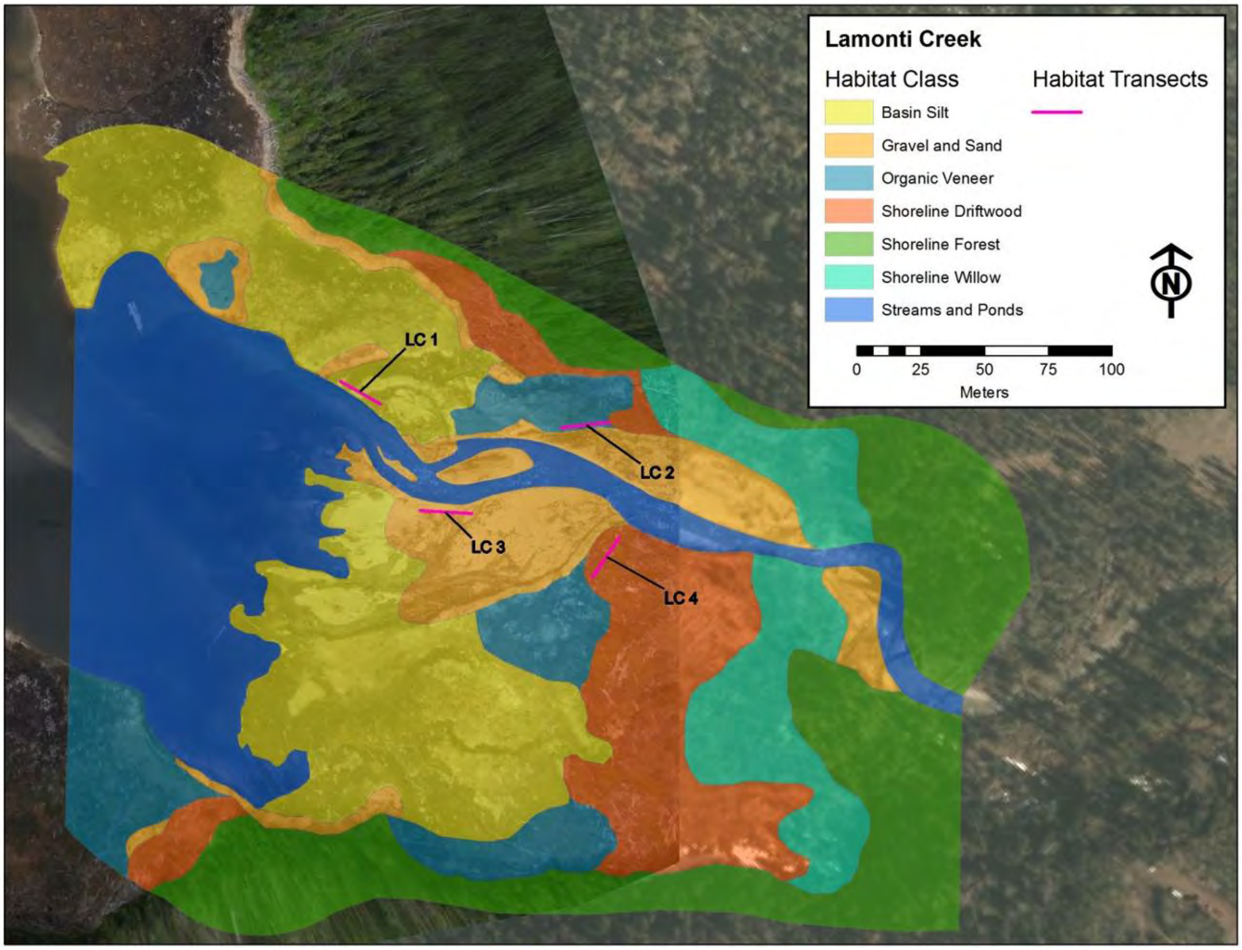

Figure 14. Habitat classes and transect locations at Lamonti Creek.

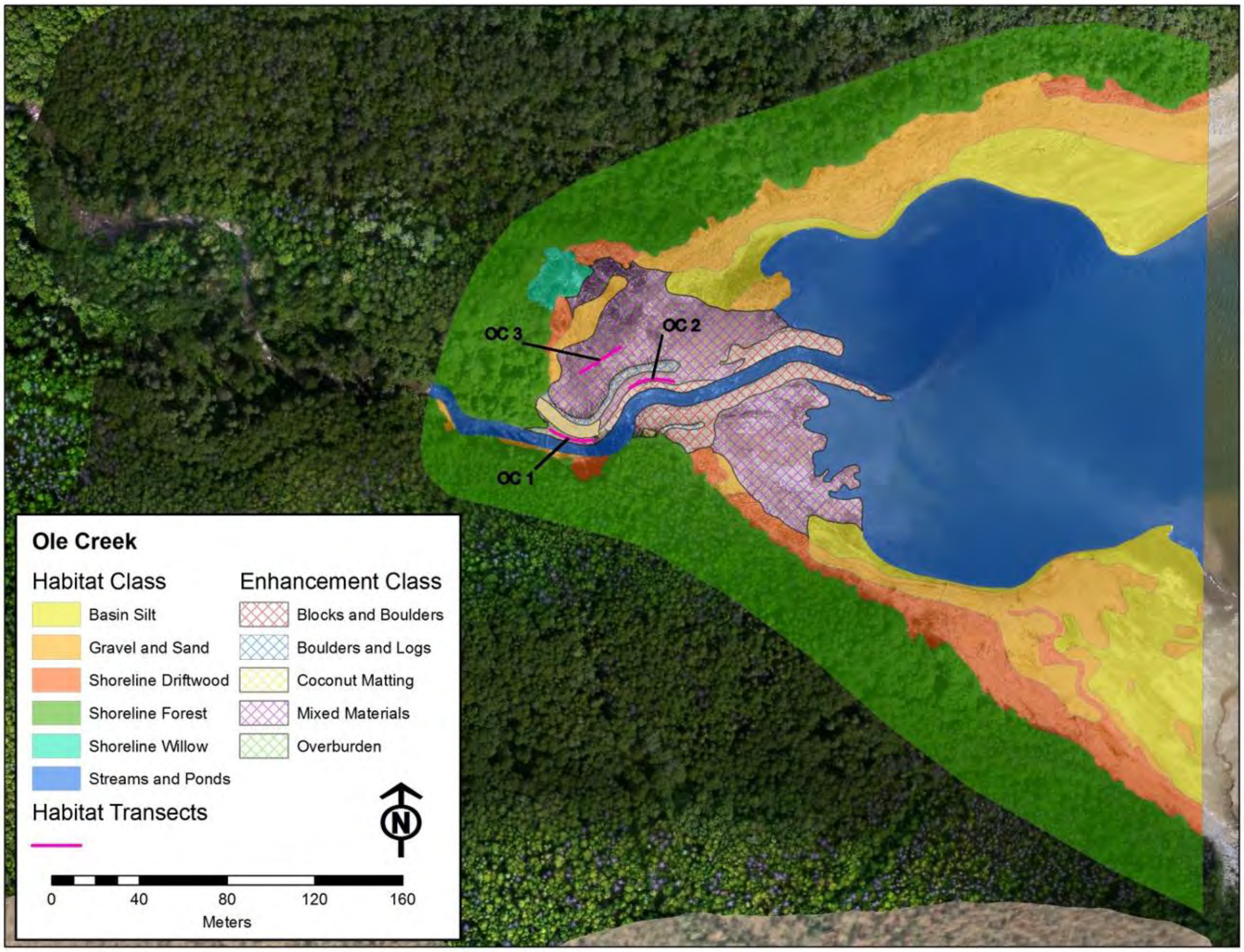

Figure 15. Habitat classes and transect locations at Ole Creek.

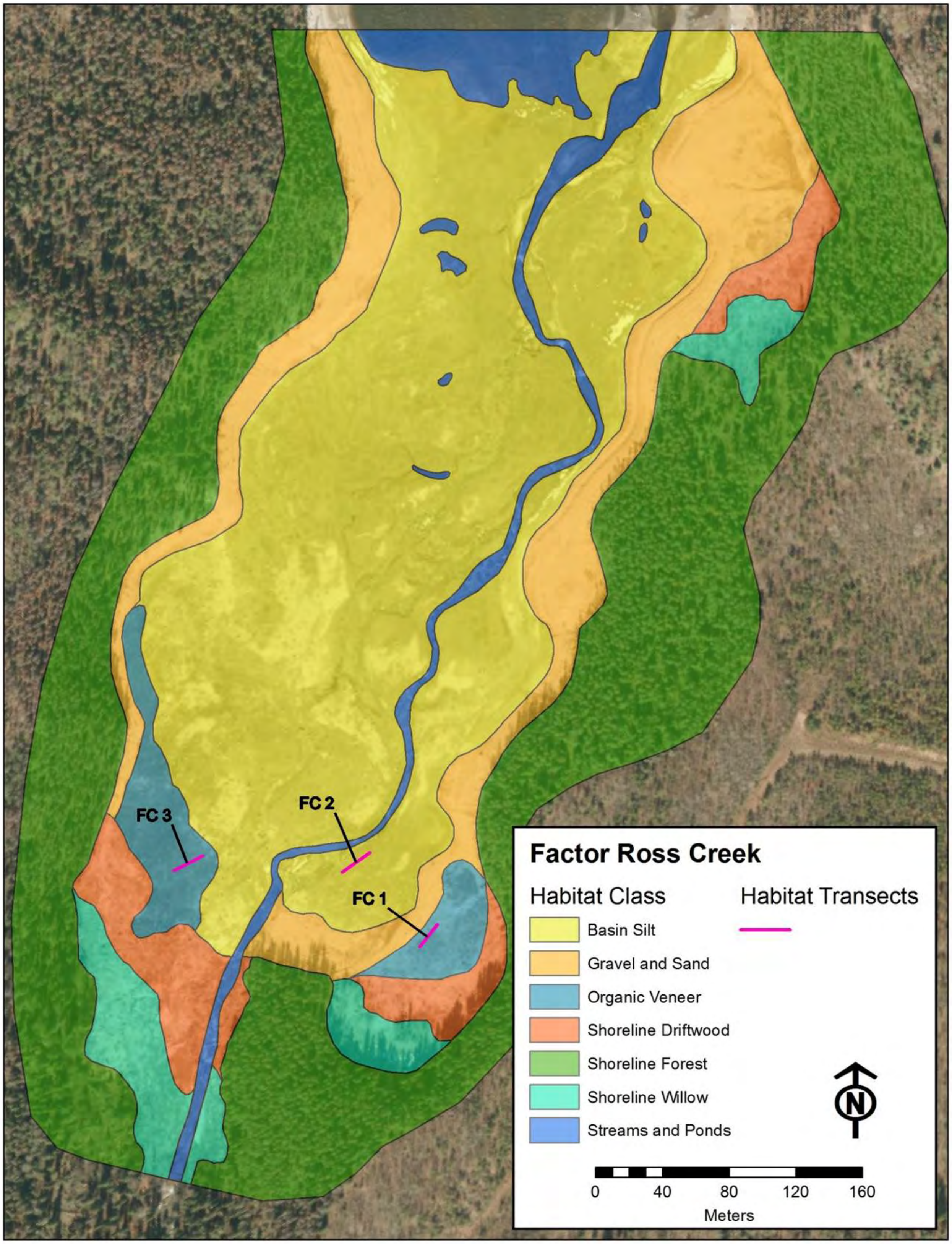

Figure 16. Habitat classes and transect locations at Factor Ross Creek.

A total of seven classes describing the enhancement works and initial reclamation at Six Mile Creek and Ole Creek were identified and mapped, including five classes at Six Mile Creek and five at Ole Creek. Enhancement class BB, CM and OV were common to all sites, whereas LW, RD and MM were only found at one of the two sites (Table 20). A total of 26 polygons were identified and mapped across the two sites covering 1.48 ha (Table 21). The number of polygons for each enhancement class ranged from one (classes OB and RD) to 4 (class CM) (Table 21). The percentage of total area covered by enhancement classes ranged from 2.52% (class CM) to 73.28% (class MM) across both sites. Detailed descriptions and photos of the enhancement classes are provided in Appendix 11.

The most abundant enhancement classes at Six Mile Creek (Figure 13) by number of polygons were CM (four polygons) and OB (four polygons) (Table 21). All other classes had two or fewer polygons. By area, enhancement classes CM and OV accounted for the largest area, covering 80.26% of the total area at Six Mile Creek. The next largest habitat class by area was class RD, accounting for 9.22% of the total area at this site. All other classes at this site had a cover of <7%.

At Ole Creek (Figure 15), the most abundant enhancement class by number of polygons was BB (three polygons) (Table 21). All other classes had two or fewer polygons. By area, enhancement classes BB and MM accounted for the largest area, covering 92.98% of the total area at Ole Creek. All other classes at this site had less than 4% cover.

Table 20. Enhancement classification summary for Six Mile and Ole Creek sites in Year 4.

Year 4		Site	
Habitat Class	**Habitat Class Description**	**Six Mile**	**Ole**
BB	Blocks and Boulders	√	√
BL	Boulders and Logs		√
CM	Coconut Matting	√	√
LW	Logs and Willow Cuttings	√	
MM	Mixed Materials		√
OB	Overburden	√	√
RD	Road	√	

Table 21. Number of polygons and area for enhancement classes identified during photo interpretation for Six Mile and Ole Creeks in Year 4. Refer to Appendix 11 for detailed descriptions of the enhancement classes.

			Year 4			
				Area (ha)		
Site	**Enhancement Class**	**Enhancement Class Description**	**Number of Polygons**	**Mean**	**Total**	**Percent of Total Area**
Six Mile	BB	Blocks and Boulders	2	0.01	0.02	3.87
	CM	Coconut Matting	4	0.04	0.14	23.63
	LW	Logs and Willow Cuttings	2	0.02	0.04	6.72
	OB	Overburden	4	0.08	0.34	56.63
	RD	Road	1	0.06	0.06	9.22
			13		**0.60**	**100.00**
Ole	BB	Blocks and Boulders	3	0.06	0.17	19.70
	BL	Boulders and Logs	2	0.02	0.03	3.51
	CM	Coconut Matting	2	0.01	0.02	2.52
	MM	Mixed Materials	2	0.32	0.64	73.28
	OB	Overburden	1	0.01	0.01	1.10
			10		**0.88**	**100.00**

Vegetation transects at the enhancement sites were located on enhancement structures or on areas disturbed by construction of enhancements and generally consisted of nutrient poor soils, with slight to moderate slopes; flooding at these locations is expected to be frequent to annual flooding (Table 22). No vegetation was observed on any of the transects (with the exception of the occasional annual ryegrass germinants at Ole Creek and planted live willow cuttings at both sites), denoted as sparse structural stage (1a; sparse – less than 10% vegetation cover). The surface substrate at these transects was mineral (overburden, sand, or gravel) with little to no organic content (Table 22). Photos of the vegetation transects at the enhancement sites are provided in Appendix 12.

Vegetation transects at the control sites were located on natural features (i.e., benches) and in close proximity to the main stream channel. Transects located on benches generally consisted of nutrient rich soils, with flat to slight slopes and flooding is expected to be frequent to annual (Table 22). Transects located in close proximity to the stream channel consisted of nutrient poor soils with a slight slope and flooding is expected to be annual (Table 22). The structural stage of vegetation on the benches was graminoid-dominated (2b) and sparse on areas near the main stream channel. The surface substrate on the benches appear to be soils of past forest cover, consisting of a decomposed organic layer overlaying mineral layers (Table 22); surface substrates along the main stream channels are mineral with little to no organic content (Table 22). Photos of the vegetation transects at the control sites are provided in Appendix 13.

Table 22. Site characteristics for vegetation transects sampled at enhancement and reference sites in Year 4.

Site	Transect	BGC Unit	Water Source[1]	Soil Moisture Regime[2]	Soil Nutrient Regime[3]	Successional Status[4]	Structural Stage[5]	Elevation (m)	Slope (%)	Aspect (°)	% Organic Matter[6]	% Rocks[6]	% Decayed Wood[6]	% Mineral Soil[6]	% Bedrock[6]	% Water[6]	Drainage[7]	Flood Regime[8]
Six Mile	SC 1	SBSmk2	P	2	B	NV	1a	666	2	158	0	45	0	55	0	0	r	A
	SC 2	SBSmk2	P	2	B	NV	1a	671	2	182	0	10	6	84	0	0	r	F
	SC 3	SBSmk2	P	n/a	n/a	NV	1a	677	1	172	100	0	0	0	0	0	n/a	R
Lamonti	LC 1	SBSmk2	F	5	A	DC	1a	663	1	210	0	7	1	87	0	5	r	A
	LC 2	SBSmk2	G	5	D	DC	2b	672	2	230	50	0	15	35	0	0	w	F
	LC 3	SBSmk2	F	1	A	NV	1a	670	1	294	0	65	1	34	0	0	f	A
	LC 4	SBSmk2	G	5	D	DC	2b	672	3	257	77	5	13	5	0	0	r	F
Ole	OC 1	SBSmk2	P	2	B	NV	1a	680	38	188	0	16	2	82	0	0	r	R
	OC 2	SBSmk2	P	1	A	NV	1a	677	2	068	0	25	0	75	0	0	x	A
	OC 3	SBSmk2	G	3	C	NV	1a	675	4	048	0	6	10	84	0	0	r	A
Factor Ross	FC 1	SBSmk2	P	5	D	DC	2b	676	1	014	35	12	3	50	0	0	r	A
	FC 2	SBSmk2	F	5	A	NV	1a	678	2	002	0	0	3	97	0	0	w	A
	FC 3	SBSmk2	P	5	D	DC	2b	677	1	012	35	0	3	62	0	0	w	A

[1] P=Precipitation, G=Groundwater, S=Snowmelt, F=Stream sub-irrigation and flooding, M=Mineral spring, T=Tidal, freshwater, E=Tidal, saltwater, Z=Permafrost
[2] 0=Very Xeric, 1 = Xeric, 2 = Subxeric, 3= Submesic, 4= Mesic, 5= Subhygric, 6=Hygric, 7=Subhygric, 8=Hydric
[3] A=Very poor, B=Poor, C=Medium, D=Rich E=Very rich, F=Saline
[4] NV=Non-vegetated, DC =Disclimax
[5] 2a= Forb dominated – includes non-graminoid herbs and ferns; 2b= Graminoid dominated – includes grasses, sedges, reeds, and rushes
[6] Values represent observations in 2014.
[7] v=very poorly drained, p=poorly drained =imperfectly drained, m=moderately well drained, w=well drained, r=rapidly drained, x = very rapidly drained
[8] A=annual flood, F=frequent flooding, O=occasional, R=rare flood

During Year 4 ground sampling for terrestrial vegetation, a total of 27 herb species were recorded across the 13 vegetation transects. Average percent herb cover by transect ranged from 0% to 35.33% (Table 23). No species of shrubs or moss were observed during ground sampling. A summary of the terrestrial plant species and percent cover for each transect is provided in Appendix 14.

Table 23. Vegetation cover for vegetation transects sampled at the tributary enhancement and control sites in Year 4.

Site	Transect	No. herb species	Average % Herb cover	No. moss/ lichen species	Average % Moss/Lichen Cover	No. shrub species	Average % shrub cover
Six Mile	SC 1	0	0	0	0	0	0
	SC 2	4	10.01	0	0	0	0
	SC 3	0	0	0	0	0	0
Lamonti	LC 1	6	5.15	0	0	0	0
	LC 2	8	3.77	0	0	0	0
	LC 3	0	0	0	0	0	0
	LC 4	11	35.33	0	0	0	0
Ole	OC 1	2	1.8	0	0	0	0
	OC 2	1	0.55	0	0	0	0
	OC 3	0	0	0	0	0	0
Factor Ross	FC 1	12	16.72	0	0	0	0
	FC 2	0	0	0	0	0	0
	FC 3	5	11.45	0	0	0	0

Values represent an average number of species and % cover based on plot surveys completed in 2014; the average for number of species are rounded up to whole numbers where necessary.

The majority of the terrestrial plant species observed at the study sites during Year 4 ground sampling were common to habitat classes located in the upper elevations of the drawdown zone (e.g., habitat class OV and SD). Areas in the lower elevations of the drawdown zone (e.g., habitat class SG, BS) were either sparsely vegetated or non-vegetated. Examples of the most common species observed along vegetation survey transects (observed at 3 or more transects) included grasses (Gramineae), sedges (*Carex* spp.), common horsetail (*Equisetum arvense*), water sedge (*Carex aquatilis*) and purslane speedwell (*Veronica peregrina* var. *xalapensis*). From general observations of vegetation at the sites, plant species observed to be common within the drawdown zone (but not necessarily observed along the survey transects) included bluejoint (*Calamagrostis canadensis*), swamp horsetail (*Equisetum fluviatile*), dwarf scouring-rush (*Equisetum scirpoides*), Norwegian cinquefoil (*Potentilla norvegica*), and tower mustard (*Turritis glauca*).

5.4 Amphibian Surveys

All amphibian species known to be indigenous to the local area were identified among the sites (Hengeveld 2000, iMapBC[1]). A single record of the boreal chorus frog (*Pseudacris maculata*) from the BC FrogWatch program has been noted approximately 100 km west of the Williston

[1] v2.0 including BC Frogwatch data layer and the BC MOE Wildlife Species Inventory data layer

Reservoir, adjacent to a tributary of the Omineca River. The nearest records for this species east of the reservoir are in Hudson's Hope (iMapBC). The boreal chorus frog has not been observed at any of the study locations since the start of the monitoring program and it is assumed that the study sites are outside of the natural distribution for this species.

A total of 58 terrestrial plots were established and searched in 2014 as follows: Six Mile Creek (17), Lamonti Creek (8), Ole Creek (16), and Factor Ross Creek (17). A total of 50 terrestrial transects were established and searched in 2014 as follows: Six Mile Creek (14), Lamonti Creek (6), Ole Creek (14), and Factor Ross Creek (15). A palustrine wetland at Six Mile was surveyed thoroughly, but eggs and larvae were not detected at the site until the final survey in August. A fluvial to palustrine wetland area with beaver activity was also surveyed extensively at Lamonti, but this area had largely dried up by the time of the August survey with only fluvial channels and no ponding. Multiple small open water depressions were surveyed at Factor Ross and Ole Creek, but no eggs, larvae, or tadpoles were detected at these locations.

All species detected in previous years were observed in 2014 in addition to new species observations (Table 24). All species were represented at Six Mile Creek with Factor Ross having the second highest level of recorded diversity (Table 24). Previous surveys recorded a total of 16 Columbia spotted frog (*Rana luteiventris*) tadpoles at Six Mile Creek and egg masses of long-toed salamanders (*Ambystoma macrodactylum*) in one of the mudflat ponds (Golder 2013, 2014). A wood frog (*Lithobates sylvaticus*) egg mass was also detected at Ole Creek in 2011 (Golder 2012). No egg masses or tadpoles were observed in 2014, but salamander larvae were detected in the large wetland at Six Mile Creek along with a larger number of decomposing egg jellies. No salamander adults were detected in the adjacent riparian, plot, or transect areas at Six Mile Creek.

Table 24. Comparison of amphibian species detections among sites and years (1 = detected, - = not detected).

Site	Species	2011	2012	2013	2014
Six Mile	Long-toed Salamander	1	-	-	1
	Columbia Spotted Frog	1	1	1	1
	Wood Frog	1	-	-	1
	Western Toad	1	-	-	1
Lamonti	Long-toed Salamander	-	-	-	-
	Columbia Spotted Frog	-	-	-	1
	Wood Frog	-	-	-	-
	Western Toad	1	1	-	1
Ole	Long-toed Salamander	-	-	-	1
	Columbia Spotted Frog	-	-	-	-
	Wood Frog	1	-	1	1
	Western Toad	1	1	1	1
Factor Ross	Long-toed Salamander	-	-	-	1
	Columbia Spotted Frog	-	-	-	-
	Wood Frog	-	1	1	1
	Western Toad	1	1	1	1

The catch-per-unit-effort (CPUE) for all amphibian species combined by year at each site are summarized in Table 25. While species diversity increased in 2014, the relative abundance (CPUE) values remained similar across all sites except for Ole Creek where CPUE declined (Table 25). However, refining the 2014 search area to the areas of greatest detections greatly increases the CPUE values (Table 25).

Table 25. Summary of the amphibian search effort and CPUE at four Williston Reservoir tributaries in 2011, 2012, 2013, and 2014.

Site	Year	Area (m^2)	Time (min)	Count	CPUE (#/min)
Six Mile	2011	7700	395	4	0.01
	2012	2800	150	5	0.03
	2013	7500	150	6	0.04
	2014	12678	597	18	0.03
	2014*	5355	142	21	0.15
Lamonti	2011	3200	210	1	0.01
	2012	2800	120	1	0.01
	2013	5600	120	1	0.01
	2014	3821	383.5	3	0.01
	2014*	800	45	3	0.07
Factor Ross	2011	3800	200	0	0
	2012	3800	200	2	0.2
	2013	1650	120	5	0.04
	2014	3835	536	23	0.04
	2014*	400	65	9	0.14
Ole	2011	1300	150	7	0.05
	2012	2800	120	2	0.02
	2013	2500	120	13	0.11
	2014	4174	456	4	0.01
	2014*	1774	136	4	0.3

*Including select habitats only.

Plots of snout-to-vent lengths (SVL) across years provided a proxy of age classes that were captured across the study sites (Figure 17). All Pearson's product-moment correlation tests between long-toed salamander Body-Mass-Index (BMI) and weights, and BMI and SVL, and SVL and weights were significant ($r > 0.89$, $p < 0.05$). Inspection of adult salamander skin patterns did not reveal any recaptures in the 2014 season. Limitations due to the camera used, lighting, and background proved ineffective for capturing frog or toad skin patterns in sufficient detail for determining if any individuals had been recaptured.

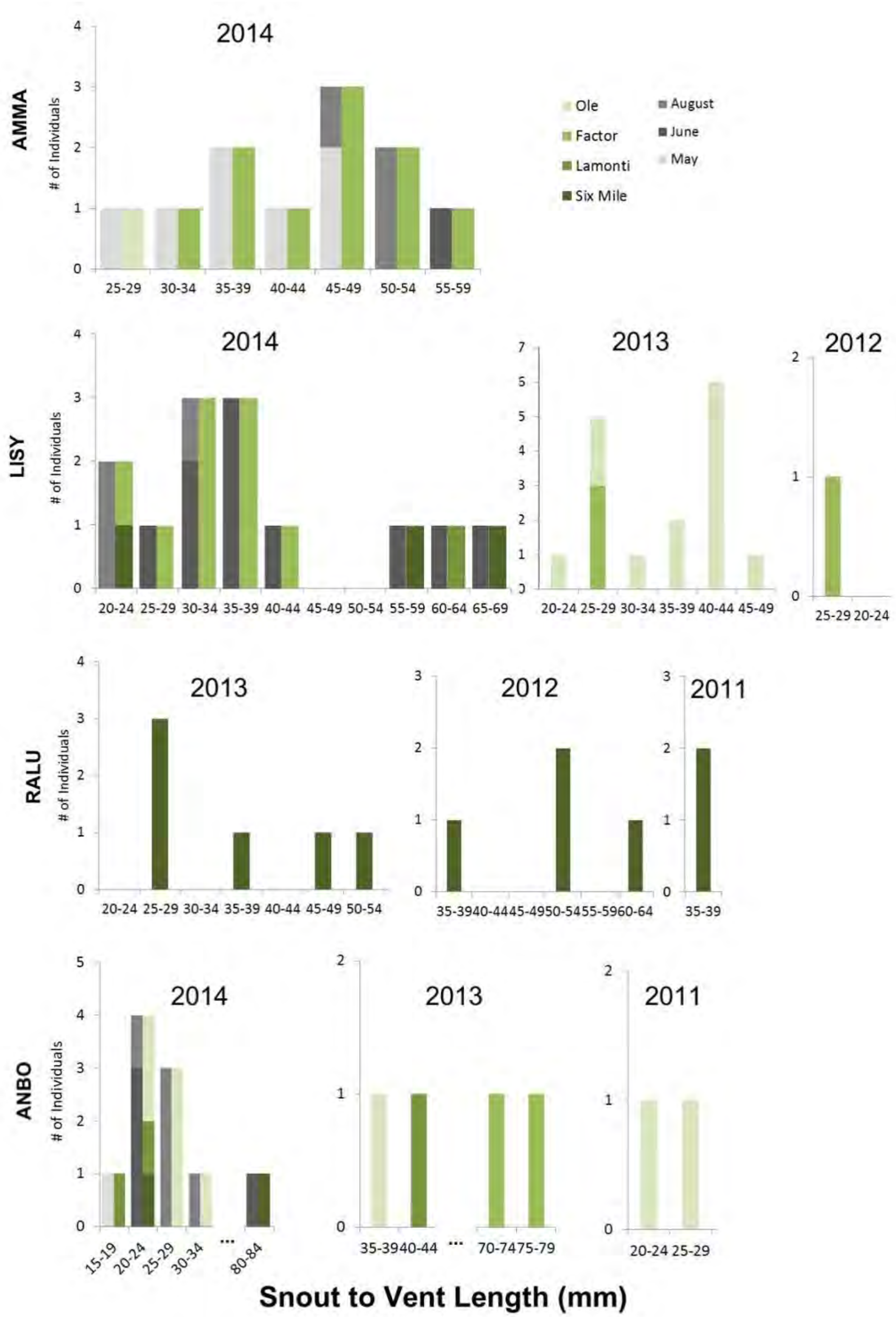

Figure 17. **Comparative histograms showing snout-to-vent length classes relative to the number of individuals captured at each site. Data for 2014 is further classified into time of survey. Species codes: AMMA = long-toed salamander, LISY = wood frog, RALU = Columbia spotted frog, ANBO = western toad.**

Distribution and detection maps for all four sites are included in Appendix 15. Two wetlands are located at Six Mile Creek. Four amphibian species were detected at the wetland immediately adjacent to plot 1.06 (Appendix 15, Map 9). Western toads (*Anaxyrus boreas*) were observed continuously at this location early in the season and appeared to be exhibiting courtship behaviour in May, but no eggs or tadpoles were observed during later surveys. The area of this wetland was measured as 1684 m^2 from the 2014 UAV photo and 1047 m^2 from the 2011 BC Hydro orthophoto. While western toads were clumped in distribution at the Six Mile Creek wetland (site 1.06) they were more dispersed along the stream margins and areas of debris cover in the floodplains at all the sites.

Older, aerial photo imagery (Bing Maps, unknown date, prior to Dec 2006) assumed to be taken at a reservoir level at or close to full pool shows Six Mile plot 1.06 flooded and continuous with the adjacent stream channel. The western edge of this wetland site has been impounded by an old beaver dam. A small flow exited the wetland through the dam and toward the stream from May through June. Columbia spotted frogs were observed at the marsh SA2 (Appendix 15, Map 9), which is connected to the wetland at 1.06 by a small, ephemeral stream channel. An ephemeral channel also connects SA2 with Six Mile Creek along the southern edge. An old beaver dam was observed at this site as well. The SA2 site measures 3380 m^2 from the 2014 UAV imagery, 1376 m^2 from the 2011 BC Hydro orthophoto, and 2329 m^2 from Bing Maps.

A smaller wetland site 2.P and a second fluvial to palustrine wetland system site 2.BP with lots of beaver activity were identified at Lamonti Creek (Appendix 15, Map 10). No apparent submerged aquatic vegetation was observed at site 2.P, which is dominated by large amounts of woody debris, shallow water, and minor fluvial activity. No amphibians were detected at this site. The larger site, 2.BP, had lots of fluvial activity, beaver dams, and shallow open water ponding. No apparent submerged aquatic vegetation was observed at site 2.BP. Western toads and Columbia spotted frogs were observed at this site, but no eggs or tadpoles were detected (Appendix 15, Map 10). Small open ponds were observed at both Factor Ross and Lamonti Creeks, but they were too small to be classified as wetlands.

A noticeable population of wood frogs was observed in the organic veneer and shoreline driftwood habitats (see vegetation mapping, Figure 16) along the floodplain at Factor Ross Creek (sites FA1, 1.01, 1.02). Rain showers the night before the June survey may have contributed to increased activity (Figure 17) as wood frogs were relatively easy to capture and were detected as they were flushed out during walks through the area. Several frogs that were spotted at Factor Ross (Appendix 15, Map 12) were not captured and could be reliably identified to species.

5.5 Songbird and Waterbird Surveys

The numbers of songbirds and waterbirds detected during the surveys in 2014 was relatively low with the highest number of species and detections at Six Mile Creek (Table 26). Within the 75 m radius survey circles, at total of 12 species were detected, including eight species at Six Mile Creek, three species at Lamonti Creek, one species at Factor Ross Creek, and zero species at Ole Creek. Thirteen additional species were detected beyond the 75 m circle during the point count, including seven at Six Mile Creek, six at Lamonti Creek, seven at Ole Creek, , and seven at Factor Ross Creek. Eight additional species were detected while on the sites outside of the official survey period. No species at risk were detected. However, one Olive-sided Flycatcher, a provincially blue listed species, was heard singing distant from Six Mile Creek.

Waterfowl detected at Six Mile included Common Merganser and a goldeneye species (either Barrow's or Common). A goldeneye species was the only waterfowl detected at Lamonti Creek. The only shorebird species detected at Six Mile and Lamonti Creeks was Spotted Sandpiper. At both sites, between one and three individuals were observed foraging along the shoreline on both survey days.

At Factor Ross Creek the only waterfowl detected was one Common Loon. Common Merganser was the only species detected at Ole Creek. Two Spotted Sandpipers were detected at Factor Ross Creek and one was detected at Ole Creek. An active nest containing four eggs was found at Factor Ross Creek, located in grass along the edge of the drawdown zone.

Table 26. Summary of all songbird, waterfowl, and shorebird detections at Six Mile, Lamonti, Ole, and Factor Ross Creeks in the 2014 surveys.

Group	Metric	Site				
		Six Mile 1	Six Mile 2	Lamonti	Ole	Factor Ross
Songbirds	No. of Species	12	7	4	9	8
	No. of Detections	17	9	6	12	11
Waterfowl	No. of Species	2	-	1	1	1
	No. of Detections	3	-	2	2	1
Shorebirds	No. of Species	1	-	1	1	1
	No. of Detections	8	-	4	1	2
Total	No. of Species	15	7	6	11	10
	No. of Detections	28	9	12	15	14

6 DISCUSSION

The results presented in this report are from the fourth year of a ten-year monitoring program. The focus of field activities in Year 4 was to continue baseline data collection at each site following the previously established methods and the collection of additional data on fish songbirds, waterbirds, and vegetation. The tributary access enhancement projects were completed at both Six Mile and Ole Creeks in late May and early June 2014, so the data collected from both of these sites is a combination of baseline data and initial post-construction observations. A summary of the progress towards addressing the management questions and hypotheses is provided in Table 27.

Table 27. The status of the GMSMON-17 management questions and hypotheses following completion of Year 4 of the monitoring program.

Management Question	Management Hypothesis (Null)	Year 4 (2014) Status
Does fish abundance and diversity in tributaries increase as a result of enhancement?	H_{01}: Fish abundance and diversity in tributaries does not increase as a result of tributary enhancement;	Testing of this hypothesis is not yet possible as both tributary enhancement projects were just completed in spring 2014. Year 5 will be the first year of post-construction monitoring.
Is the area and quality of fish habitat created by the tributary enhancement maintained over time?	H_{02}: Total rearing area for fish does not increase following enhancement to tributaries	Testing of this hypothesis is not yet possible as both tributary enhancement projects were just completed in spring 2014. Year 5 will be the first year of post-construction monitoring.
Does riparian vegetation along tributaries increase in abundance and diversity as a result of enhancement?	H_{03}: Riparian vegetation abundance and diversity along the tributaries does not increase following enhancement to tributaries;	Testing of this hypothesis is not yet possible as both tributary enhancement projects were just completed in spring 2014. Year 5 will be the first year of post-construction monitoring.
Does abundance and diversity of song birds (passerines) around tributaries change as a result of enhancement?	H_{06}: Song bird abundance and diversity near tributaries does not increase following tributary enhancement.	Testing of this hypothesis is not yet possible as both tributary enhancement projects were just completed in spring 2014. Year 5 will be the first year of post-construction monitoring.
Does amphibian abundance and diversity in tributaries change as a result of enhancement?	H_{04}: Amphibian abundance and diversity in and near tributaries does not change following tributary enhancement	Testing of this hypothesis is not yet possible as both tributary enhancement projects were just completed in spring 2014. Year 5 will be the first year of post-construction monitoring.
Does tributary enhancement change the area and quality of amphibian breeding habitat over time? If so, is the area and quality maintained over time?	H_{05}: Total amphibian breeding area does not change following enhancement	Testing of this hypothesis is not yet possible as both tributary enhancement projects were just completed in spring 2014. Year 5 will be the first year of post-construction monitoring.

6.1 Environmental Conditions

The general conditions observed at the Parsnip and Finlay Reach sites in Year 4 were similar to those observed in Year 3 and were close to average values. The regional snowpack for the winter of 2013-2014 was close to average for both the Pine Pass (Parsnip Reach sites) and Aiken Lake (Finlay Reach sites) stations. The similarity in regional snowpack in Years 3 and 4 also resulted in similar water levels in Six Mile and Ole Creeks in both Year 3 and 4. The notable difference between the two years were the lower water levels in both streams beginning in mid-July. The difference in water levels was greatest in Six Mile Creek with the recorded water level in late August of Year 4 only being 30-40% of the water level recorded in Year 3. In Ole Creek, the late August water levels were about 50-60% of those recorded in Year 3. Low water levels were observed in all four streams during the August juvenile fish sampling. The low water levels are a result of the well below average precipitation received in May, June, and July 2014. While total precipitation in August was just below average, the majority of this occurred in a single event on August 19 and made little or no difference in the recorded water levels in either stream.

Air temperatures recorded at both Six Mile and Ole Creeks in Year 4 and followed similar patterns with Ole Creek air temperatures slightly cooler than those observed at Six Mile Creek. The same pattern was true for water temperatures at both sites with cooler temperatures observed at Ole Creek. Less variation in the daily average temperature was also observed at Ole Creek. There was a noticeable difference in water temperatures between Year 3 and 4 in late June at both Six Mile and Ole Creeks with warmer temperatures and a faster increase in temperature in this period observed in Year 3 compared to Year 4. This period also coincides with the predicted and observed spawning time for Rainbow Trout. The difference in temperatures between years may have contributed to the apparent difference in fry emergence times between Years 3 and 4.

Rating curves and stage discharge tables were developed for both Six Mile and Ole Creeks based on the manual discharge measurements recorded across a variety of discharge levels in Year 4. Re-surveying the gauging stations and stream cross-sections will be required in future years to confirm that the staff gauges have not moved and that the stream cross-section profiles do not change.

6.2 Fish

6.2.1 Tributary Access and Fish Habitat

No physical barriers to upstream fish access were observed in any of the four project streams in the first three years of the monitoring program (2011-2013) (Golder 2012, 2013, 2014). In Year 4, no physical barriers to upstream fish passage were observed in any of the streams except for during the early May survey at Factor Ross Creek. Two cascades created by woody debris were observed in the lower portion of Factor Ross Creek (Appendix 4, Map 4). While the cascades may have limited some fish passage, they were not considered complete barriers to upstream migration by adult spawning Arctic Grayling or Rainbow Trout. The largest of the two blockages was near the confluence with the reservoir in the early May survey and would have been submerged by rising reservoir levels by the time spawning Rainbow Trout would likely be migrating upstream in late May and through June. During drawdown zone fish sampling in mid-June, both debris jams had been flooded by the reservoir and juvenile Bull Trout and sculpins were captured in areas upstream of both cascades (they were submerged by this time).

Of the four streams, Factor Ross Creek had the highest level of habitat complexity as a result of stream channel interaction with an abundance of stumps and LWD (Appendix 4, Map 4). The debris created small to large pools and eddies that provide cover and resting areas for migrating fish. Stumps were not as visible at the other streams and were considered to have been either washed away due to more consistent flows through the drawdown zone or buried by sediment deposits resulting in longer riffles. This pattern was particularly apparent at Ole Creek which had very few residual stumps.

While the highest level of habitat complexity was observed at Factor Ross Creek, the drawdown zone portion of all four streams was considered low quality habitat consisting of heavily braided shallow channels, long fast-flowing riffles, with little to no cover, pools, or resting areas despite the lack of physical or debris blockages. The lack of suitable habitat in addition to the cold temperatures experienced in the early spring in the drawdown zone may be a deterrent to fish migration upstream from the reservoir despite the presence of more suitable habitats upstream (Binder and Stevens 2004, Golder 2014). The identification of spawning Rainbow Trout in Six Mile, Lamonti, and Factor Ross Creeks as well as redds in Lamonti Creek is evidence that adfluvial fish are moving upstream by the late spring in those streams.

The peak reservoir level reached in Year 4 was approximately 0.5 m below average (Figure 1) and portions of the drawdown zone reaches were still exposed in all four streams during the late August survey. By this time, the streams were all reduced to single channels and the long-riffle sections were greatly reduced. Several adult Bull Trout with spawning colouration were observed staging at the stream mouths or within all the streams during the August electrofishing and snorkelling surveys. The streams were at low flows at this time of year, lower than observed in the spring but these large adults were still able to access upstream areas. As previously suggested (Cubberly and Hengeveld 2010, Golder 2014), tributary access for adfluvial fall spawners is not considered an issue. However, the enhancement works to improve access for spring spawners may also improve or maintain tributary access for adfluvial fall spawning species such as Bull Trout in years with low stream discharge and low reservoir levels.

The assessment of tributary access was extended in Year 4 to included fish habitat mapping for the reach of each stream located below the full pool level. Mapping was based on existing orthophotos of the drawdown zone and all stream channel mapping was completed in early May 2014 when the reservoir was close to low pool and prior to construction of the access enhancements. The habitat mapping will provide a record of annual changes in each stream channel to assist in determining the effectiveness and stability of the tributary access enhancements under low pool conditions. The established photo reference sites were reused in Year 4 but they appear to be located too far upstream to show any stream channel changes that would affect fish access or the effectiveness of the enhancement works. This is particularly true for the upstream views from each reference point where only minor enhancement work was completed on the two treatment streams (Six Mile and Ole Creeks).

While the enhancement works do extend up to the photo reference sites on Six Mile and Ole Creek, the stream channels at the upper limits of the drawdown zone for all four streams appear to be relatively stable and are unlikely to be the locations of large changes in stream morphology. The enhancement works also extend well downstream into the drawdown zone and out of the effective field of view for the photo reference sites, particularly for the summer photos when the vegetation is fully flushed. Therefore the collection of high resolution orthophotos and annual mapping of the drawdown zone portion of each stream will be more useful in determining the effectiveness of the tributary access enhancements and changes at the control sites. Logistical issues prevented the collection of high resolution orthophotos by UAV at low pool conditions in 2014. The collection of high resolution orthophotos at near low pool conditions is recommended in future years to identify potential barriers to upstream fish passage.

6.2.2 Drawdown Zone Fish Sampling

This was the first year fish sampling was completed in drawdown zone reach of each stream. This sampling was completed to provide a better understanding of fish use of the lower quality drawdown zone habitats during spring. The 2014 results showed that sculpins (Slimy and Prickly Sculpins) were primary fish present in the drawdown zone reaches of all four streams followed by lower numbers of juvenile Bull Trout and juvenile Rainbow Trout. No adult salmonids were captured. Sculpins were generally located in the lowest portions of streams in the drawdown zones, often close to the confluence with the reservoir. This was particularly the case at Ole and Factor Ross Creeks which featured steeper riffles than Six Mile and Lamonti Creeks. In the latter streams, sculpins were captured throughout.

Higher spring flows limited sampling to the stream margins as the middle of the streams were generally too deep or swift to safely electrofish, except for Lamonti Creek where the entire channel could be sampled. The stream margins generally contained slower velocities and eddies where smaller fish would be expected. It is possible that adults were present in the streams but were utilizing the deeper portions of the channel that was not sampled as this may have been their preferred habitat (Bjorn and Reiser 1991, Keeley and Slaney 1996). However, no adult salmonids were encountered in Lamonti Creek where the entire channel width was sampled.

Adult Rainbow Trout were observed upstream of the drawdown zone during the spawner surveys completed in the week following the drawdown electrofishing survey. This suggests that these fish either moved up immediately after the survey or had moved upstream prior to the sampling. As the drawdown zone sampling only occurred on a single day in each stream, it is possible that migrating fish could have been missed. However, the primary intent of these surveys is to provide an index of fish use of the drawdown zone reach of each stream and not for detection of fish migrating upstream to spawn. Additional sampling in future years will provide a better picture of fish use of the drawdown zone reaches of each stream and if there are any changes as a result of the access enhancement works. Single pass electrofishing can provide an index of fish abundance without the constraints associated with multiple-pass-removal methods (Kruse et al. 1998). While sampling earlier in the season when more of the drawdown zone portion of the stream is exposed would be preferable, sampling permit conditions restrict electrofishing when the water temperature is below 5°C and in streams containing Bull Trout between September 15 and June 15.

6.2.3 Spawner Surveys

The Rainbow Trout spring spawner surveys were completed once stream temperatures were consistently above 5°C in late June (temperatures were recorded at 6 to 6.7°C during the surveys). The surveys included all areas surveyed in previous years and were expanded further upstream for all streams. The portion of Patsuk Creek, a tributary of Six Mile Creek, downstream of the West Parsnip FSR was also included in the spawner survey. Discharge in Patsuk Creek was higher than from the upstream section of Six Mile Creek. In Year 4, Rainbow Trout spawning activity and redds were observed for the first time in this monitoring project. A total of five redds were observed in Lamonti Creek. Four pairs of adult Rainbow Trout were also observed in Lamonti Creek, with three of the pairs associated with redds. The observation of spawning activity confirms that the timing of the surveys in late June with the observed water temperatures was appropriate. In addition to the observations in Lamonti Creek, adult Rainbow Trout pairs were also observed in Six Mile and Factor Ross Creeks but no redds were observed.

A larger area of suitable spawning substrate were identified in each stream relative to the amounts reported in 2013. As a greater length was assessed in each stream this was to be expected. Unmeasured natural changes in channel morphology or visibility may also have contributed to the increase in are of spawning substrates (visibility was generally better in 2014 than in 2013). Annual changes in the area of spawning substrates will be verified through continuation of the spring spawner surveys.

The lack of redd observations during the previous years of the program and in most streams in Year 4 is not considered evidence of an absence of spawning as the surveys are completed over a short time frame during the spawning period (Golder 2014). However, spawning has been confirmed in previous years by the identification of Rainbow Trout fry and juveniles in all four streams during the August field surveys (Golder 2014). In 2014, Rainbow Trout fry were only observed in Six Mile Creek during the August field surveys.

During the August surveys, stream flows were very low as result of the dry summer in 2014. In Lamonti Creek, at least two of the redds identified in the June spawner surveys were found to be dry in August. While it is not possible to determine when the redds were exposed, the conditions observed in August would suggest complete failure of these two redds. Summer water levels in Six Mile Creek in 2014 were consistently lower than in 2013 and continued to drop from July 10 on.

During the spawner surveys, the majority of spawning habitat and fish were observed from the stream banks. The primary limiting factor in observing spawning fish and habitat is the higher water levels that occur in conjunction with the timing of the spawning surveys. Reduced fish activity during the day was also suggested as contributing to the low level of spawning activity observed (Golder 2014).The addition of snorkelling to the spawner surveys was beneficial in Six Mile and Factor Ross Creeks, the two larger streams in the monitoring program. In both of these streams, it was not possible to effectively observe all areas from the banks. The primary benefit of supplementing the spawning surveys with snorkelling is to identify staging fish in deeper, low-velocity habitats.

6.2.4 Juvenile and Small-Bodied Fish Survey

The mark-resight method used in Years 2 and 3 (Golder 2013, 2014) of the monitoring was continued in Year 4. Overall a higher number of fish were captured or observed in Year 4 allowing for a higher number of marked fish and population estimates for more species than in Years 2 and 3. Reasons for the higher number of fish captures and observations in the August surveys are likely a result of the low water levels and associated reduction in velocities and wetted widths. The reduced velocities and wetted widths likely increased the sampling efficiency and may have increased the relative density of fish in the streams.

The higher number of fish marked and resighted in Year 4 resulted in proportionately lower standard deviations for population estimates of the most abundant species compared to previous years (Table 15). However, the standard deviations were still quite large. The large variance will make it difficult to detect statistically significant population changes in the post-construction monitoring phase of the program. This is additionally problematic given the annual variation in population estimates and limited data resulting in missing estimates. As an example of variability, estimated Rainbow Trout densities in Lamonti Creek increased from 4.9 fish/100 m^2 in 2012 to 9.3 fish/100 m^2 in 2013 and 24.2 fish/100 m^2 in 2014 (Table 15). In contrast, there was little change in Six Mile Creek over the same period with an estimated density of 10.1

fish/100 m^2 in 2012 and 10.81 fish/100 m^2 in 2014 (Table 15). Additional data collection using the same methods will be required to determine if the observed differences are the result of natural variability, sampling variability, or a change in population.

In previous years, the juvenile fish populations were assumed to be closed due to lack of movement when resighting marked fish (Golder 2013, 2014). However, the large number of unmarked fish observed and number of marked fish not observed in the 2014 snorkel surveys suggests that fish are actively moving about the stream as they were likely residing in other habitats not sampled at the time of the specific surveys. In most streams there was ample rearing habitat in adjacent pocket water or other low-velocity areas that were not sampled where fish were likely present. Even though the fish were moving about the stream, it is assumed they are staying in the streams as documented movement was typically within 100 m of the original capture location so the closed population assumption is still valid. However, additional considerations for fish movement may need to be considered in the model. Movement is likely dictated by feeding and temperature but the sampling may have also have caused some fish to move as it was noted on at least two occasions where a fish moved downstream out of its capture pool after release.

A goal in subsequent years is to reduce the size of the confidence intervals in the Bayesian abundance estimator. The current methodology has low statistical power with reduces the confidence of inference in relation to a Before–After Control-Impact study design. Future estimates may need to consider a likelihood theoretic or mixed effects modelling approach that accounts for additional or multi-state factors (e.g., imperfect detection, body condition, quantifying habitat complexity, other study groups) that may increase the effect size (Lukacs et al. 2007, Price and Connors 2014) or better care may be also used in selecting priors (Link 2013). It is important to note that “a model that assumes equal catchability of individuals generally leads to an underestimation of the population” (Mantyniemi et al. 2005).

6.2.5 Fry Surveys

In Year 4, Rainbow Trout fry were only observed in Six Mile Creek during the August surveys. Bull Trout fry were also observed in all streams except for Lamonti Creek. The lack of Rainbow Trout in Lamonti Creek was surprising given the observations of spawning activity in late June. A combination of factors may have contributed to the lack of sightings but it is suspected that emergence had not yet occurred in the other streams due to cooler water temperatures. Based on the recorded temperatures from the Ole Creek gauging station (Figure 12), both Finlay Reach sites are considered to be cooler than Six Mile Creek. It was also noted that water temperatures in Lamonti Creek during the August survey were approximately 5°C cooler than in Six Mile Creek. Additionally, the Rainbow Trout fry observed in Six Mile Creek in Year 4 were smaller than those observed in Year 3 suggesting they had only recently emerged. Egg development and fry emergence is water temperature dependent (Murray 1980) so it is possible that emergence had not yet occurred in the other streams.

The observed temperature disparity in late August between Six Mile and Lamonti Creeks could not be confirmed over the length of the incubation period as continuous temperature monitoring has not been completed on Lamonti Creek. Following the incubation and spawning timing estimated by Golder (Golder 2013) based on Murray (1980), if Rainbow Trout spawned in Six Mile Creek around the same time as they did in Lamonti (June 26), emergence would have occurred in early August based on the temperatures measured at the gauging station. This corresponds with the first field observations of fry in Six Mile Creek on August 16. The fry appeared to have recently emerged (<week) based on their small size. A temperature disparity

between Six Mile and Lamonti Creeks throughout the incubation period could delay fry emergence in Lamonti by a few weeks depending on the temperatures. A temperature difference of 2°C (10°C to 8°C) could result in an incubation period that was 23 days longer (increase from 42 to 65 days) (Murray 1980). If an average 2°C disparity existed between Lamonti and Six Mile Creek, fry emergence may not have occurred until late August. Based on the observed spawning on June 26 this would result in emergence after the night-time fry surveys occurred on August 18 and 19.

As previously mentioned, it is suspected that emergence had not yet occurred in the Finlay Reach streams due to cooler temperatures. Ole and Factor Ross Creeks also appear to have relatively low Rainbow Trout populations which limits the number of fry that could potentially be present. In 2013, only one Rainbow Trout fry was observed in the Finlay Reach streams (Ole Creek) (Golder 2014).

Although fry survey sites were not randomly selected, they provide a representation of suitable fry habitat and relative fry abundance in the study tributaries. The data can be used to quantify how well suitable young-of-the-year habitats are seeded with fry, and compared to years following habitat enhancement. Continuation of the night-time fry surveys in conjunction with the mark-resight for juvenile fish will provide supporting information for the annual spawner surveys. Assessment of length-frequency distributions from the mark-recapture data will provide additional support to the spawning data by quantifying the abundance of parr (age-1+). Juvenile Rainbow Trout were observed in all four streams indicating spawning success in previous years despite the lack of fry observed in 2014.

In order to ensure that emergence has occurred, the fry surveys at Six Mile Creek and Lamonti Creek should be completed closer to the end of August. This strategy would also assist in obtaining information on redd failure during dry years if fry emergence was not observed by the end of August. This timing would also assist with the fry surveys in the Finlay Reach streams due to the cooler temperatures observed in those streams. However, Rainbow Trout appear to be less abundant in Ole and Factor Ross Creeks compared to Six Mile and Lamonti Creeks. Therefore fry observations may be of lesser value in determining spawning success in the two Finlay Reach sites. However, continuing the fry surveys in the post-enhancement period may yield an increase in fry numbers at Ole Creek if the objectives of the tributary access enhancements are realized (an increase in juveniles in subsequent years would also suggest this).

6.2.6 Fish Communities

Fish communities observed in the four tributary streams in Year 4 (the August surveys in particular) are similar to what has been previously documented throughout the pre-enhancement phase of this project. There was an overall trend to higher relative abundance compared to previous years but this was likely associated with higher catch efficiencies under low water conditions. In Six Mile and Lamonti Creeks, Bull Trout and Rainbow Trout are the most common species with a similar abundance of sculpins in both streams. Rainbow Trout were much more prevalent than Bull Trout in Lamonti Creek in 2014 compared to previous years and while Bull Trout were more abundant in Six Mile Creek in 2014, Rainbow Trout were still the most common species. Six Mile Creek is a larger stream and also contains Mountain Whitefish and Burbot which have not been observed to date in Lamonti Creek. Mountain Whitefish prefer deeper, fast flowing streams with larger substrates (McPhail 2007), habitats that are more typical of Six Mile Creek than Lamonti Creek.

Similar community structure was observed in Ole and Factor Ross Creeks in Year 4 when compared to previous years with the exception of Kokanee which have not been captured or observed in either stream since 2012. Bull Trout were the most common species in Ole Creek with considerably lower abundances of Mountain Whitefish and Rainbow Trout. In Factor Ross Creek, Mountain Whitefish were the dominant species, followed by smaller numbers of Bull Trout and Rainbow Trout. Sculpins were present in both streams but in low numbers above the drawdown zone relative to their abundance in the drawdown zone reaches of the streams. These results are not surprising given the steeper and faster flows, preferred by Bull Trout and Mountain Whitefish (McPhail 2007), found in the Finlay Reach streams versus the Parsnip Reach streams which have lower gradients and a higher proportion of low-velocity glides and pools.

Arctic Grayling were again only observed in Factor Ross Creek during the August snorkel surveys. Arctic Grayling were originally a target species of the tributary access enhancement project but low numbers of fish have only been documented in one of the study streams and no spawning activity has been observed. No population estimates have been calculated as a result. Historical data has shown presence of Arctic Grayling in other project streams including Six Mile Creek (BC MOE Habitat Wizard). However, the present distribution of Arctic Grayling has been reduced to a few of the major tributaries as a result of habitat loss and fragmentation following creation of the reservoir (Blackman 2002, Clarke et al. 2007). Based on the present distribution, it is unlikely that Artic Grayling will be observed in any of the other project streams.

Evidence of spawning for Rainbow Trout in Six Mile Creek (fry observation) and Lamonti (redd construction) in 2014 suggests that tributary access is not an issue during migration for this species under the Spring reservoir elevations observed to date in this study. This also assumes that any observed adult fish are adfluvial. Rainbow Trout in the two Finlay Reach streams appear to be generally less abundant than in the two Parsnip Reach streams and may be limited by availability of preferred habitats (Golder 2014). No distinct barriers to fish passage have been observed but it has been previously suggested that the higher gradient, continuous riffles in the drawdown zone of the Finlay Reach streams may act as a behavioural deterrent to fish passage (Golder 2014). Both Parsnip Reach streams have lower gradients in the drawdown zone than the Finlay Reach streams. A juvenile Rainbow Trout was observed in the drawdown zone portion of Ole Creek in Year 4.

6.3 Vegetation

Terrestrial vegetation mapping during Year 4 identified nine habitat classes and one non-vegetated (open water) habitat class at the four sites. With the exception of three wetland habitat classes identified at Six Mile Creek and one habitat class not present at Ole Creek, the vegetation communities documented at all sites were similar and their distribution in the drawdown zone followed a similar pattern. The general pattern, beginning at the forest edge and moving down the drawdown zone in bands generally parallel to the shoreline, begins with willows and grasses, followed by a moderate to high cover of coarse woody debris, transitioning into sparsely vegetated organic and coarse mineral soil surfaces and ending on non-vegetated silt flats that meet the reservoir at low pool.

Vegetation mapping also identified seven enhancement classes at Six Mile and Ole Creek sites. Enhancement structures at the two sites were for the most part similar and were concentrated along the edge of the main stream channels. During Year 4 ground sampling, no vegetation was observed on the enhancement structures, with the exception of the planted live willow cuttings and the occasional annual ryegrass germinants establishing on seeded areas. However, vegetation cover is expected to increase on enhancement structures in the years following construction.

With the exception of the undisturbed forest cover at shoreline, the habitat classes observed at the four sites have developed in response to the annual flooding regime from reservoir operations. As the timing of reservoir filling and the maximum elevation reached varies from year to year the species present in each of the habitat classes is expected to be variable, particularly in higher elevation habitat classes that may not be flooded every year. In a year where the reservoir level does not reach full pool, species less tolerant to flooding may colonize the drawdown zone during the following growing season (e.g., the GMSMON-15 Airport Lagoon site in 2011; CBA 2014). In comparison, following a year where full pool is reached, species that are less tolerant to flooding are typically absent.

All terrestrial species identified during Year 4 ground sampling are likely to be tolerant to flooding events. A majority of these species are adapted to wet soils that are often saturated for a portion of or the entire growing season (e.g., lady's thumb, common and swamp horsetail, bluejoint and water sedge). Many of these species have also been observed as regularly occurring in other areas of the Williston reservoir (e.g., GMSMON 15 Airport Lagoon and Beaver Pond sites).

6.4 Amphibians

More amphibian species were detected in Year 4 compared to previous years (Table 24). While the CPUE values were comparable, the refined systematic plot and transect methodology showed that amphibians are not randomly distributed and cluster into specific habitats (Appendix 15). Previous amphibian surveys used very general search strategies and did not identify clearly which habitats were searched (Golder 2012, 2013, 2014). Focusing the search effort on specific habitats dramatically increases the CPUE (Table 25) and makes it difficult to compare this index to previous years as level of effort varies greatly according to the type of habitat searched.

The comparative histograms on SVL's from different locations may provide a rough proxy for relative age class or cohort distributions, but SVL is too variable for age estimation in amphibians (Halliday and Verrell 1988, Russell et al. 1996). The results from this analysis indicate that detection has been variable across years through the range of sizes captured in one year and missed in another (e.g., Ole Creek wood frogs; Figure 17). While the sample size was insufficient to provide any sufficient determination for allometric body condition analysis (Wright and Zamudio 2002, Bancila et al. 2010), early results are promising and may prove effective in subsequent years as sample size increases.

The number of plots and transects that have been established are likely insufficient to achieve rigorous statistical power to account for imperfect detection. Small population size also reduces detection probabilities. Variation in weather, habitat type, species, and the level of experience of the surveyor are also important variables to consider in the analysis and interpretation of results. Imperfect detection can cause negative bias in any subsequent analyses of abundance, richness, or distribution (Tanadini and Schmidt 2011). While demographic statistics may be limited by detection and sample sizes, the distribution maps of observed amphibians in the study areas (Appendix 15) provide valuable spatial data that can be used to address the management questions including information on the location of different developmental stages.

Salamanders generally have smaller home ranges than frogs and toads (Wells 2007). Long-toed salamanders migrate in areas less than 100 m^2 in a season (Sheppard 1977). Western toads migrate up to 2.4 km (Semlitsch 2007), spotted frogs >1km (Pilliod et al. 2002), and wood frogs

<0.5 km (Baldwin et al. 2006). However, these estimates were obtained from telemetry studies that can underestimate the movement patterns (Trenham and Shaffer 2005). The plot design used in this study may share the advantage of Trenham and Shaffer's (2005) approach in providing an improved estimate on migration distances as it will register occurrence in the landscape. Moving the plot center into immediately adjacent undisturbed habitat on follow-up surveys may help to ensure that recapture rate is not as greatly impacted by disturbance induced emigration. The alteration of coarse woody debris types during searches modifies the environmental state and could potential increase emigration rates. Coarse woody debris features in plots were classified, typed (e.g., Stevenson et al. 2006), and counted to provide a descriptor of the habitat quality. This data can be used in future analyses of detection and abundance estimates as the sample sizes increase.

Alternative sampling approaches such as setting trap arrays (e.g., Trenham and Shaffer 2005) may offer an advantage in terms of reduced disturbance, but require a much higher effort to maintain and monitor the traps than the plot method used in this study. Likewise, transect survey areas are less intrusive, but detection rates seem to be diminished as very few amphibians were encountered. Nocturnal searches may improve on capture rates as many amphibians are more active at night (Buderman and Liebgold 2012).

Several locations of key importance to amphibians were identified at the study sites. The amphibian populations at the study sites appear to be relatively small and primarily rely on ephemeral breeding locations. The inference of small population size is based on past experience of capture and encounter rates and relative biomass of tadpoles or eggs observed at other locations. As amphibians generally exhibit high levels of biomass per unit of area relative to other vertebrate species (Semlitsch et al. 2014) any given habitat will have relatively high importance for the sustainability of amphibians at the location due to small population sizes. This also highlights the importance of the surrounding landscape to understand connectivity and sources of immigrants to the study sites.

A single observation of a long-toed salamander adult was made at Ole Creek in 2014 in an area containing shoreline driftwood of similar habitat quality to the organic veneer noted at Factor Ross Creek where salamanders were also captured. Driftwood in these areas are in an advanced stage of decay with organic matter accumulating at the base, which creates a moist substrate at the bottom that is also inhabited by an invertebrate food supply. The Ole Creek (site 1.01; Appendix 15) is located immediately adjacent to the enhancement works. Coconut matting was added or driftwood debris was removed from the adjacent areas where plots 1.02 and 1.03 had been established and searched prior to construction of the enhancement works.

Salamanders within these foreshore areas at Ole and Factor Ross Creek may also be isolated from the upland sites as no detections were made in the immediate upland plots. Salamanders that were detected in the upland areas at Factor Ross Creek (Appendix 15) may provide recruitment via dispersal by travelling through the stream. Alternatively, the populations within the foreshore area may receive recruitment from the reservoir itself. Ponding may occur in the foreshore area at these locations during high reservoir levels to provide breeding habitat for salamander or frogs. Individuals captured in 2014 may be remnants from breeding that occurred at the location in previous years, but not necessarily in the immediate preceding year as no small juveniles were detected. Long-toed salamanders can live from six years in the wild (Russell et al. 1996), which would leave a recruitment window for sit and wait residents.

The marsh site 1.06 at Six Mile Creek is an important breeding pond for salamanders and life history activities of the other amphibian species inhabiting the area. Although tadpoles or eggs of other species have not been reported at this site, this may depend on the water level. The aerial photo imagery from different years shows a wide range in water level. Flooding at this site may be reduced due to the stream enhancement works. The earth berm added to the north-end of this site could also contribute to the longer-term stability of the site.

The lead amphibian researcher for this project (M. Thompson) was on-site as an environmental monitor during construction of the enhancement works at Six Mile Creek. Direction was provided on the design and engineered field fit of the earth berm as it encroached into riparian areas adjacent to site 1.06. The construction crew were directed to leave riparian features around the wetland including avoidance of open water to the extent feasible, placement of large pieces of CWD, and leaving mounds of excavated dirt in locations that could provide cover in the riparian site. A small outflow from the wetland into Six Mile Creek that was altered by construction was re-created under the direction of the environmental monitor. However, construction of the tributary access enhancements may affect water level fluctuations, depth, temperature, and habitat availability at this site.

Long-toed salamander eggs were identified by Golder (2012) in one of the ponded areas along the drawdown zone on May 11, 2011. This site is 193 m away from site 1.06 and may be part of a continuous metapopulation. The entire foreshore area was thoroughly searched in Year 4 on numerous occasions by the environmental monitor during construction and no eggs were identified. Salamander larvae were not observed at the 1.06 site until August 13, 2014. The larvae were well developed and numerous decaying egg masses were highly visible. This is consistent with observations and dates of egg masses from other locations across the province for this species (Thompson 2003).

While Columbia spotted frogs were easily detected at the upper wetland site at Six Mile Creek, the numbers still appear to be relatively small. Golder (2014) reported only 9 spotted frog tadpoles for Six Mile Creek in 2013, but did not indicate if they were observed at the SA2 site. Egg mass and tadpole surveys were originally proposed as part of the study design using methods of Grant et al. (2005) and Gray et al. (2013). However, the relatively small encounter rates makes this type of analysis difficult. Wood frog eggs were previously detected at Ole Creek (May 16, 2011; Golder 2012) in a small ponded area along the road that was searched extensively in 2014. The hydrodynamics of these study locations will be important for future study of amphibian breeding at these sites.

Quality photographs are critical for PIMs (Yoshizaki et al. 2009), particularly when dealing with species that have mottled or low contrast in the skin patterns. Methods are being adapted for the photographic technique in this project to provide a stronger contrasting background and an improved lighting/diffuser box to assist with capturing skin patterns in frogs and toads. The strong contrast in the yellow dorsal stripe of a long-toed salamander makes this an ideal tool for mark-recapture study of this species.

The proposed effort for measuring environmental parameters at the amphibian breeding locations (including temperature, pH, top depth of eggs, bottom deepest depth of eggs, slope, aspect and general notes on egg substrate attachment sites) was not applied in Year 4 since the general pattern of breeding was not established. However, the high resolution images obtained by UAV do provide detailed information on habitat complexity. Individual pieces of woody debris can be identified in the UAV orthophotos (e.g., the pieces strategically placed at Six Mile Creek site 1.06), so that this information can be quantified in future study years. Future UAV flights at different times of the season can provide greater insight into the hydrodynamics of breeding sites that can be coupled with more intensive investigations in subsequent years of analysis.

The key management questions relating to the amphibian inventory are about changes in abundance, diversity, and habitat over time in relation to the enhancement works. Continued sampling of amphibians at a landscape scale can be used to detect changes in amphibian abundance over time. Attributing a change in abundance to a particular cause such as disturbance or the enhancement works requires consistent monitoring of the same parameters over time. While a robust before-after comparison will be challenging, the average fraction of years that a species is present in an area can be positively correlated to local population size (Werner et al. 2007) and this data was gathered throughout the duration of this project. Furthermore, body condition indices that can be extracted from the adopted PIM methodology, such as fluctuating asymmetry in colour pattern or body condition, can be used as a marker of disturbance through comparison to undisturbed reference populations (e.g., Wright and Zamudio 2002). More details and a more robust test of the hypotheses will be made possible by continued study of habitat use, age classes, body condition, and the spatial ecology of amphibians in relation to the enhancement works and habitat characteristics using the systematic landscape-scale search design that was initiated in Year 4.

6.5 Songbirds and Waterbirds

The low numbers of species detected within the survey circles is likely due to the lack of habitat (vegetation) for songbirds at the survey points, which were located along the streams near the enhancement works within the drawdown zone. Additional species were present beyond 75 m where there is more vegetation available. Surveys prior to construction in 2011 (Golder 2012) detected a total of 70 species at these sites, but those surveys included many more points at each site covering a wider variety of habitat. As the enhancement works, including planted vegetation, were recently completed, avian use of these areas may increase in upcoming years.

Abundance and diversity of waterfowl and shorebirds was low at all the sites surveyed and no unusual species were detected. Waterfowl and shorebird surveys were not previously conducted at these sites, so it is unknown whether any changes in abundance and diversity of species has occurred.

7 CONCLUSIONS

The additional baseline data and initial post-construction observations collected in Year 4 of the GMSMON-17 project are generally consistent with data collected in the previous years of the project. Data collected at the two control sites (Lamonti and Factor Ross Creeks) in Year 4 adds to the existing baseline data at these two sites. At the two tributary enhancement sites (Six Mile and Ole Creeks) the tributary access enhancement projects were constructed in late May – early June during part of the field data collection period for Year 4. Therefore, the data collected from these two sites is a combination of both baseline and initial post-construction observations. Construction activities may have had some influence on the data collected for all indicator groups (fish, vegetation, amphibians, and birds) and this will need to be considered in future analyses to assess the effectiveness of the projects.

The key management questions relating to fish within the monitoring program focus on changes in fish abundance and diversity as well habitat quantity and quality as a result of the tributary access enhancements. As the management questions are targeted at post-enhancement results and the enhancement work was only completed in June 2014 no conclusions can be reached yet with respect to the success of the projects. It assumed that completion of the enhancement works in June would have limited influence on the Year 4 results as it is too soon for the projects to have any effects on fish populations. The higher number of fish captures in 2014 is most likely associated with the low water conditions encountered during the August surveys. The larger number of captures resulted in improved abundance estimates for some species, although the variance of the estimates was still large. A longer time series for the post-enhancement data than the pre-enhancement data set will assist in future data analyses as similar estimates rather than the CPUE from different sampling methods can be compared and used to refine the power of inference.

The area and quality of fish habitat as a result of the enhancement works can now be monitored through the combination of high resolution orthophotos (obtained by UAV), habitat mapping, and photo referencing tasks. The habitat data is highly important to the study questions. Continuing the early season UAV data acquisition will prove invaluable for quantifying changes in habitat complexity and stream channel characteristics. Assessing the tributary channels through the drawdown zone will provide information on annual changes in accessibility and channel stability for both the enhancement and control streams. The habitat monitoring will be supported by habitat usage information by fish through the drawdown zone sampling program and spawner surveys in the spring.

The baseline vegetation data collected in Year 4 provides a better characterization of the vegetation types at the four study sites in comparison to vegetation data collected in previous years. The completed tributary enhancements are likely to increase vegetation establishment along the stream channels within the drawdown zone over time. However, the abundance and diversity of vegetation in these areas is still expected to be primarily influenced by annual reservoir elevations. Changes in vegetation communities as a result of the tributary enhancements is most likely to be observed on the enhancement structures themselves due to the revegetation and the increased elevation. Changes in vegetation communities are also expected on areas adjacent to the structures where the ground has been disturbed as a result of construction activities.

The key management questions relating to the amphibian inventory are about changes in abundance, diversity, and habitat over time in relation to the enhancement works. However, it will be challenging to provide a robust test of changes in the abundance and diversity of amphibians through a before-after comparison due to differences in survey methods. The refined amphibian methods established in 2014 will assist in monitoring changes in the relative abundance and diversity in terms of habitat use, age classes, body condition, and spatial ecology over the duration of the project. More details on amphibian spatial ecology in relation to the enhancement works are revealed when coupled with the systematic landscape-scale search design that was initiated in Year 4.

The enhancement works at Ole Creek directly impacted one location where long-toed salamanders were identified (site 1.01; Appendix 15). The impact may be negative as some of the debris that provided cover around this location was removed. The debris at this location was likely a longer-term habitat feature as there was development an organic layer between the log and substrate. The removal of the debris and placement of the coconut matting at Ole Creek site 1.02 may also impede the available habitat for migration and foraging out of and around site 1.01.

The enhancement works at Six Mile Creek directly impacted an important wetland (site 1.06, Appendix 15). However, the impact may be positive as the stability of the wetland may be better maintained over time and improved cover along the riparian area may increase the available breeding area. The earth berm south of the wetland and diversion of flows may also create new stable wetland areas. However, the access roads to the site might also be an important effect to consider in relation to the upland dynamics. Upland migratory behaviour of the adult and sub-adult stages can be more important for sustaining the population than wetlands (Trenham and Shaffer 2005).

The number of birds and diversity observed in both of these surveys was relatively low. As previously noted by Golder (2012), the tributary access enhancements were not expected to have an impact on habitat for songbirds. However, the enhancements at Six Mile Creek did result in the modification of some riparian habitat and potentially creation of new riparian habitat on the two upper berms. This area was incorporated into the Year 4 surveys to allow for monitoring of changes associated with the enhancements. Additionally, little information exists on songbird and waterbird use of the drawdown zone and adjacent areas in Williston Reservoir. The information collected in these surveys will assist in the planning and assessment of future projects around the Williston Reservoir.

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Appendix 1. Photos of the Six Mile and Ole Creek stream gauging stations in May 2014.

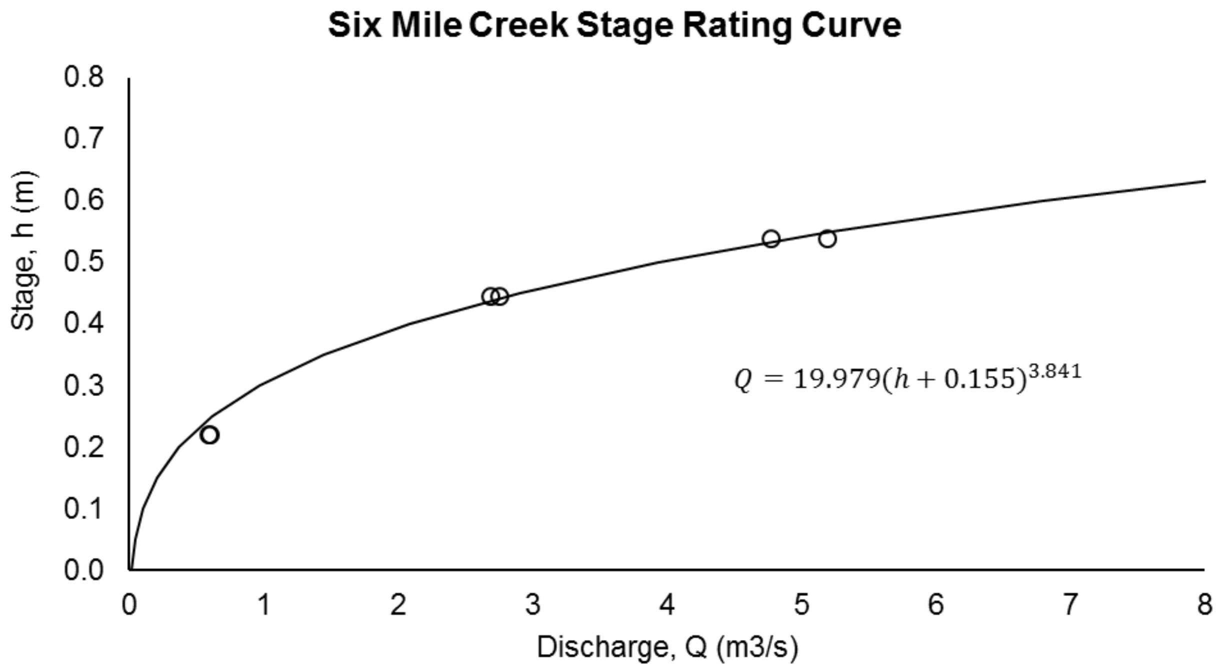
Photo 1. Gauging station on Six Mile Creek with temperature probe installed.

Photo 2. Gauging station on Six Mile Creek

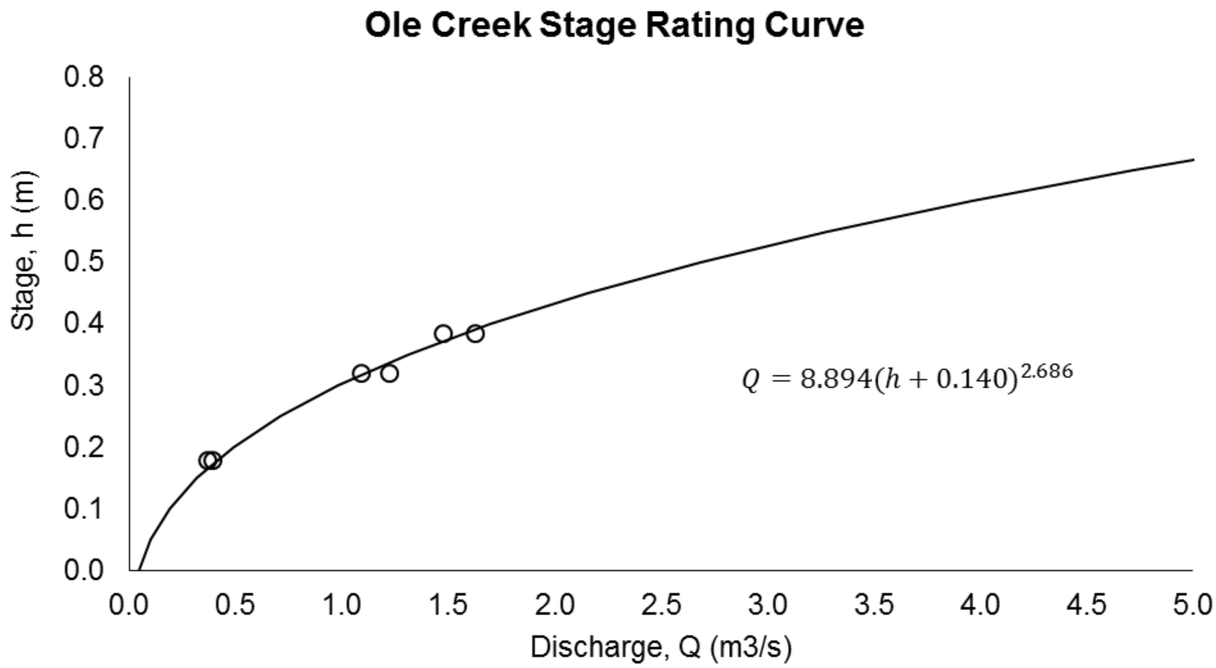
Photo 3. Gauging station on Ole Creek.

Photo 4. Gauging Station on Ole Creek.

Appendix 2. Rating curves and stage-discharge tables for Six Mile and Ole Creeks.



Stage Reading, h (m)	Discharge, Q (m^3/s)	Stage Reading, h (m)	Discharge, Q (m^3/s)
0.00	0.02	1.05	40.90
0.05	0.05	1.10	47.81
0.10	0.10	1.15	55.55
0.15	0.21	1.20	64.18
0.20	0.37	1.25	73.77
0.25	0.62	1.30	84.37
0.30	0.97	1.35	96.07
0.35	1.45	1.40	108.92
0.40	2.08	1.45	123.00
0.45	2.90	1.50	138.38
0.50	3.93	1.55	155.14
0.55	5.22	1.60	173.36
0.60	6.79	1.65	193.12
0.65	8.68	1.70	214.49
0.70	10.95	1.75	237.56
0.75	13.62	1.80	262.42
0.80	16.74	1.85	289.16
0.85	20.37	1.90	317.85
0.90	24.54	1.95	348.60
0.95	29.32	2.00	381.50
1.00	34.75		



Stage Reading, h (m)	Discharge, Q (m^3/s)	Stage Reading, h (m)	Discharge, Q (m^3/s)
0.00	0.05	1.05	14.19
0.05	0.10	1.10	15.85
0.10	0.19	1.15	17.63
0.15	0.32	1.20	19.52
0.20	0.49	1.25	21.54
0.25	0.71	1.30	23.69
0.30	0.98	1.35	25.96
0.35	1.31	1.40	28.37
0.40	1.70	1.45	30.91
0.45	2.16	1.50	33.59
0.50	2.68	1.55	36.41
0.55	3.28	1.60	39.38
0.60	3.96	1.65	42.50
0.65	4.72	1.70	45.76
0.70	5.57	1.75	49.18
0.75	6.50	1.80	52.75
0.80	7.53	1.85	56.48
0.85	8.66	1.90	60.38
0.90	9.88	1.95	64.43
0.95	11.21	2.00	68.66
1.00	12.65		

Appendix 3. 2014 photos from the photo monitoring points on Six Mile, Lamonti, Ole, and Factor Ross Creeks.

Photo 5. Six Mile Creek on May 8, 2014 from reference location (azimuth = 165°).

Photo 6. Six Mile Creek on May 8, 2014 from reference location (azimuth = 60°).

Photo 7. Six Mile Creek on June 23, 2014 from reference location (azimuth = 165°).

Photo 8. Six Mile Creek on June 23, 2014 from reference location (azimuth = 60°).

Photo 9. Six Mile Creek on August 15, 2014 from reference location (azimuth = 165°).

Photo 10. Six Mile Creek on August 15, 2014 from reference location (azimuth = 60°).

Photo 11. Lamonti Creek on May 8, 2014 from reference location (azimuth = 200°).

Photo 12. Lamonti Creek on May 8, 2014 from reference location (azimuth = 290°).

Photo 13. Lamonti Creek on June 26, 2014 from reference location (azimuth = 200°).

Photo 14. Lamonti Creek on June 26, 2014 from reference location (azimuth = 290°).

Photo 15. Lamonti Creek on August 17, 2014 from reference location (azimuth = 200°).

Photo 16. Lamonti Creek on August 17, 2014 from reference location (azimuth = 290°).

Photo 17. Ole Creek on May 9, 2014 from reference location (azimuth = 10°).

Photo 18. Ole Creek on May 9, 2014 from reference location (azimuth = 80°).

Photo 19. Ole Creek on June 24, 2014 from reference location (azimuth = 10°).

Photo 20. Ole Creek on June 24, 2014 from reference location (azimuth = 80°).

Photo 21. Ole Creek on August 22, 2014 from reference location (azimuth = 10°).

Photo 22. Ole Creek on August 22, 2014 from reference location (azimuth = 80°).

Photo 23. Factor Ross Creek on May 9, 2014 from reference site.location (azimuth = 340°).

Photo 24. Factor Ross Creek on May 9, 2014 from reference site.location (azimuth = 280°).

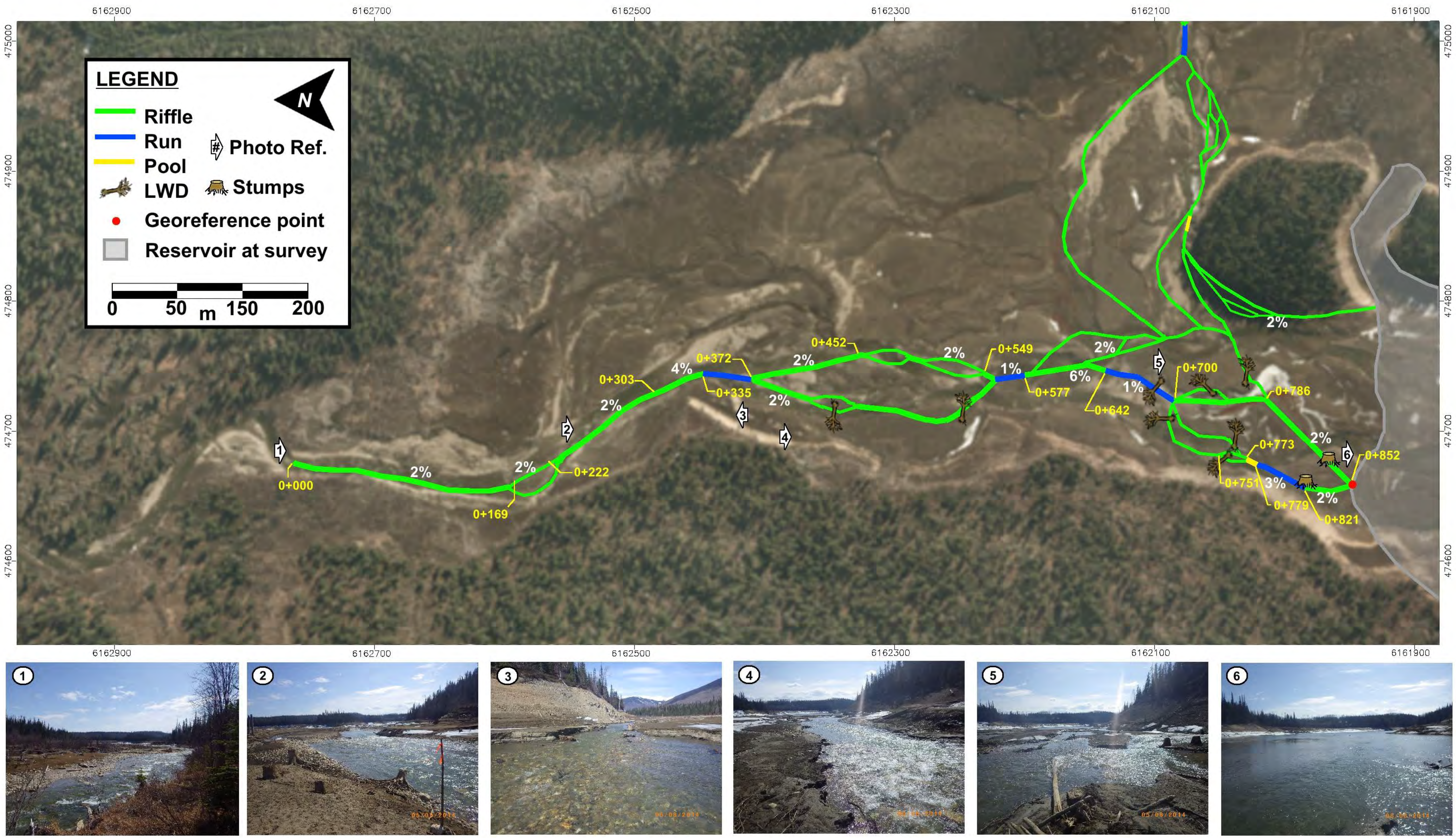
Photo 25. Factor Ross Creek on June 25, 2014 from reference site.location (azimuth = 340°).

Photo 26. Factor Ross Creek on June 25, 2014 from reference site.location (azimuth = 280°).

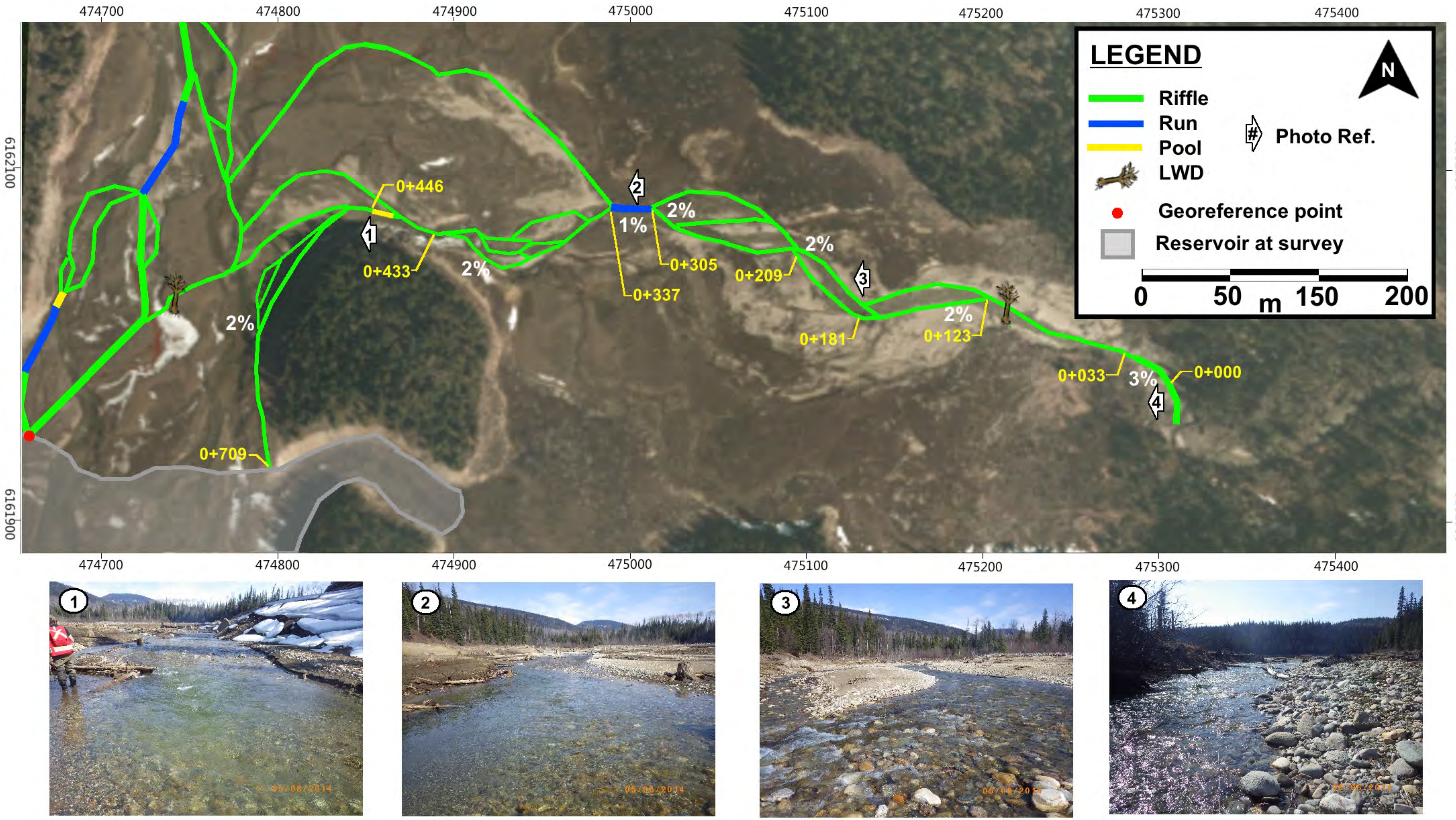
Photo 27. Factor Ross Creek on August 21, 2014 from reference site.location (azimuth = 340°).

Photo 28. Factor Ross Creek on August 21, 2014 from reference site.location (azimuth = 280°).

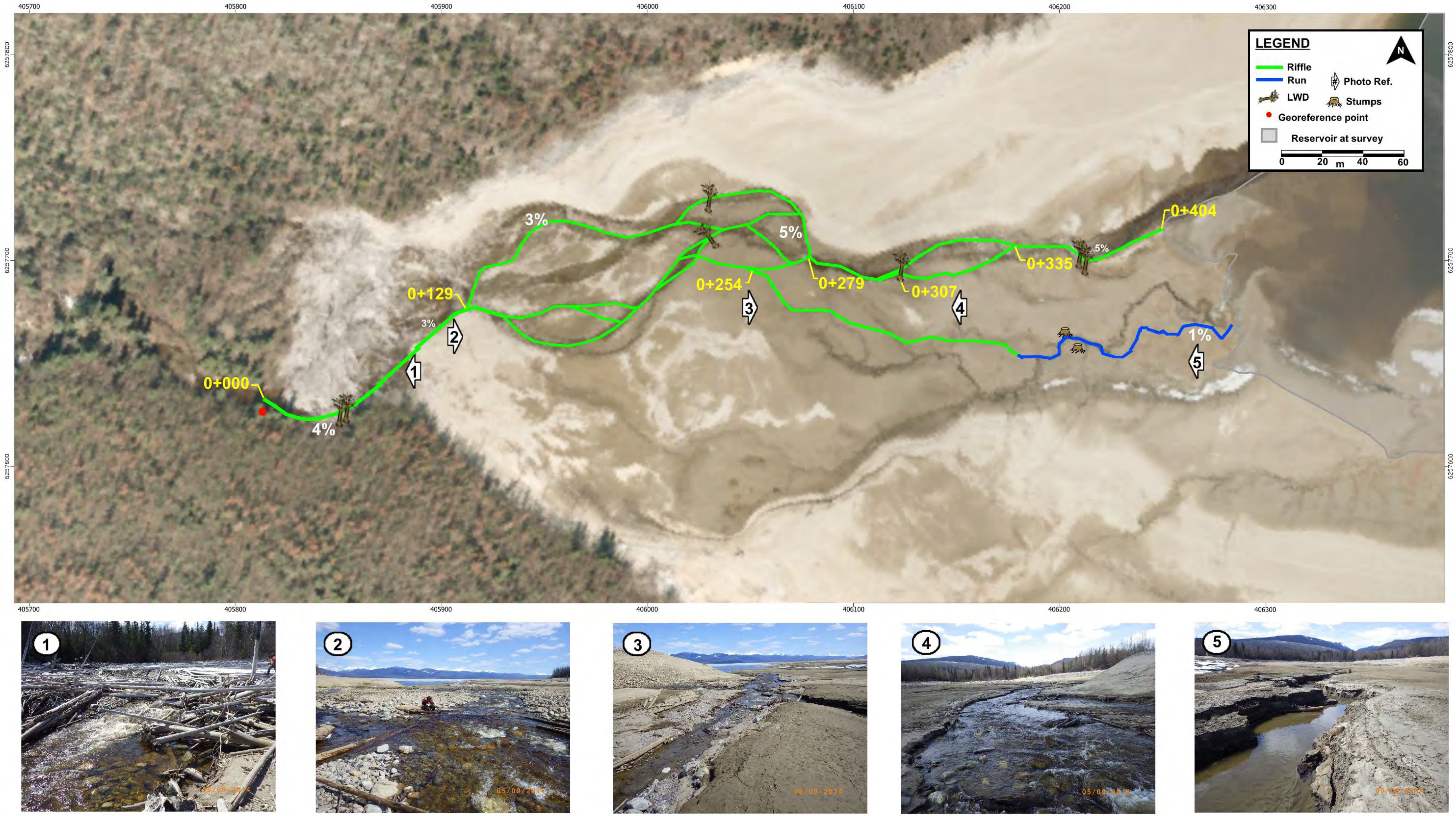
Appendix 4. Drawdown zone stream habitat maps for Six Mile, Lamonti, Ole, and Factor Ross Creeks.



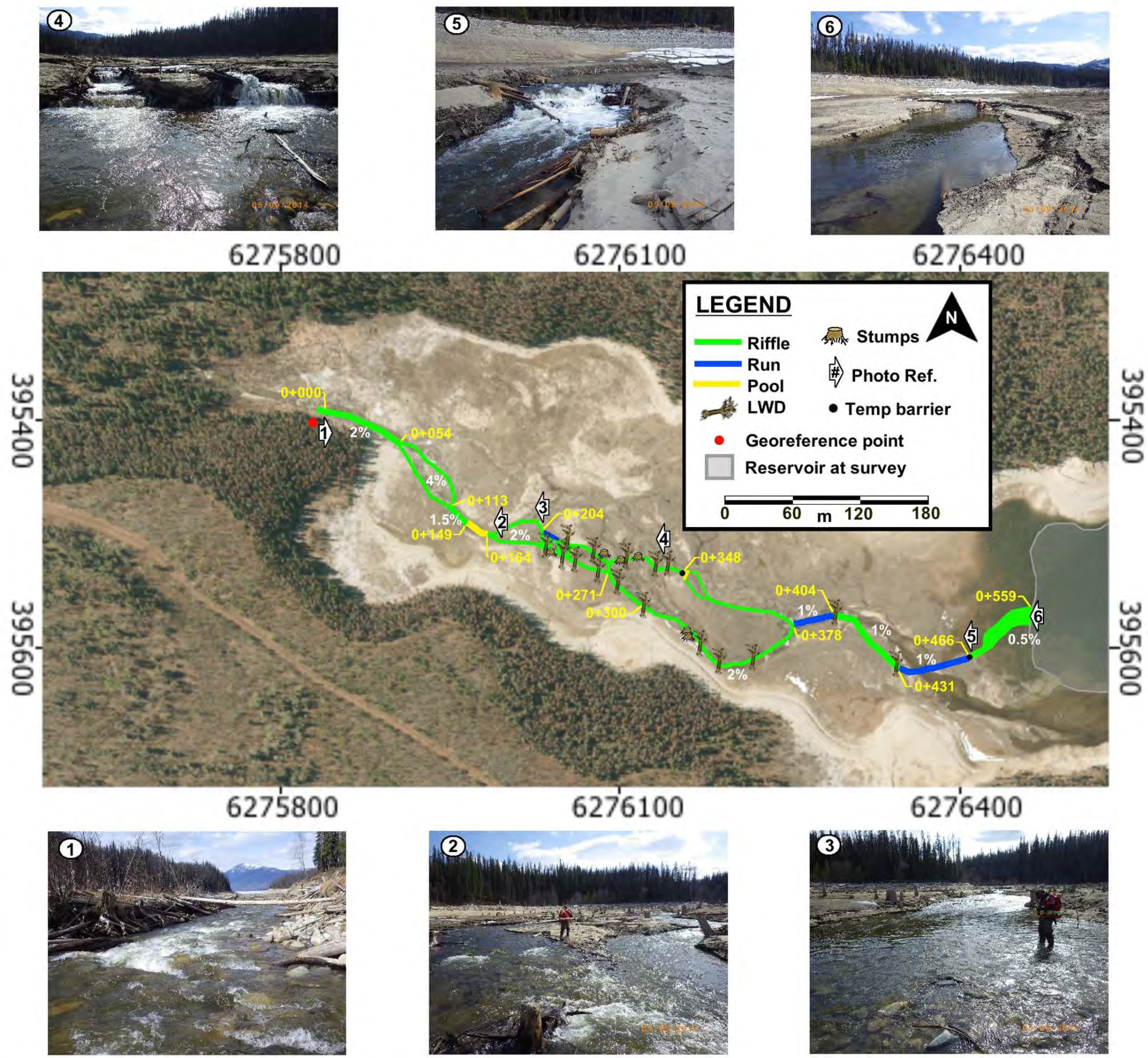
Map 1. Drawdown zone stream habitat map for Six Mile Creek in May 2014. Photos taken on May 8, 2014 at a reservoir elevation of 658.6 m and stream level of 0.308 m (discharge = 1.04 m^3/s).



Map 2. Drawdown zone stream habitat map for Lamonti Creek in May 2014. Photos taken on May 8, 2014 at a reservoir elevation of 658.6 m.



Map 3. Drawdown zone stream habitat map for Ole Creek in May 2014. Photos taken on May 9, 2014 at a reservoir elevation of 658.7 m and stream level of 0.209 m (discharge = 0.43 m^3/s).



Map 4. Drawdown zone stream habitat map for Factor Ross Creek in May 2014. Photos taken on May 9, 2014 at a reservoir elevation of 658.7 m

Appendix 5. Spawning survey results from June 23-26, 2014 from the four Williston Reservoir tributaries.

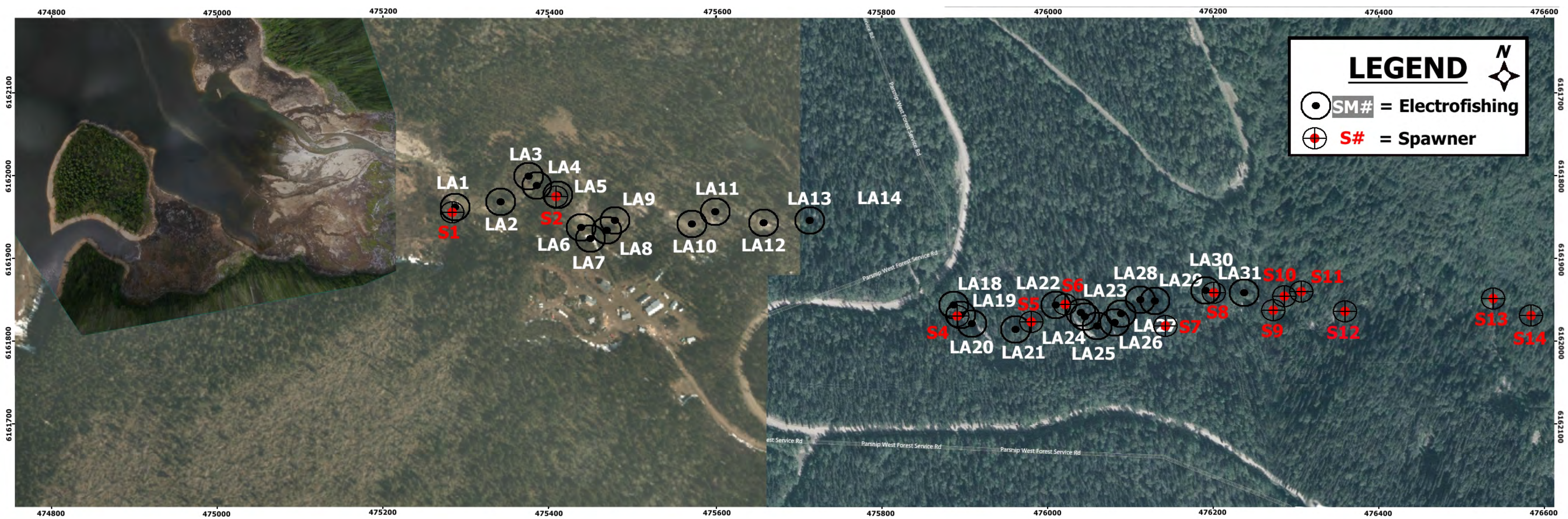
Site	UTM Coordinates			Fish Observed	Dimensions		Area (m^2)	Comment
	Zone	Easting	Northing		X	Y		
Six Mile	10U	474670	6163460	No	1	2	2	LDB on bend
	10U	474655	6163485	No	3	2	6	LDB side channel after log jam
	10U	474638	6163512	No	1.5	3	4.5	LDB side channel, tail out of pool.
	10U	474604	6163521	No	2	1	2	Mid-stream after sandbar
	10U	474557	6163656	No	2	4	8	Mid-stream left channel and LDB
	10 U	474498	6163645	2 Rainbow Trout				2 mature rainbow trout observed, no spawning habitat noted at location
	10U	474493	6163756	No	1	3	3	RDB
	10 U	474509	6163760	No	3	1	3	Spawning gravels under log
	10U	474509	6163760	No	1	6	6	More gravels on other side of the creek.
	10U	474464	6163889	No	1	2.5	2.5	LDB, small log jam
	10 U	474441	6163971	No	2	5	10	Located mid-channel with large woody debris below.
	10 U	474414	6164116	6 Whitefish				Six whitefish observed in larger pool; limited suitable spawning habitat at the tail out of the pool
	10U	474432	6163975	No	1	1	1	LDB
	10 U	474430	6163996	No	8	5	40	Shallow but good substrates on left bank
	10U	474488	6164174	No	2	3	6	Midstream to LDB
	10 U	474467	6164213	No	2	5	10	Tail out with good vegetative cover
	10 U	474421	6164256	No	1	7	7	Substrates in braided channel
Six Mile Total							**111**	
Patsuk	10 U	474580	6163984	No	5	20	100	Above log jam in wide section of channel
	10 U	474932	6164249	No	2	8	16	Above large log jam that has significant soft barriers and braids into multiple channels
	10U	474974	6164283	No	32	3	96	Above beaver dam tail out from long deep run, LWD throughout
Patsuk Total							**212**	
Lamonti	10 U	475330	6161949	No	2	1.5	3	Pool with spawning gravel
	10 U	475451	6161979	No	4	2	8	Tail out of pool with spawning gravel
	10 U	475872	6161853	No	1.12	1.28	1.61	Redd observed. Dimensions reflect those of redd.

Site	UTM Coordinates			Fish Observed	Dimensions		Area (m^2)	Comment
	Zone	Easting	Northing		X	Y		
	10 U	475918	6161807	No	1.15	1.6	1.84	Redd observed. Dimensions reflect those of redd.
	10 U	476009	6161795	Fish observed	1.46	1.56	2.28	Active redd and fish observed. Dimensions reflect the size of redd.
	10 U	476056	6161816	No	0.75	2	1.50	Below small log jam, mid-channel
	10 U	476180	6161790	No	0.75	2.25	1.68	LDB with small amount of LWD and overhanging vegetation
	10 U	476238	6161809	2 Rainbow Trout	.75	3.25	2.44	Redd and spawning pair of RB observed. Dimensions reflect size of redd.
	10 U	476311	6161800	No	0.75	1.25	0.94	Under overhanging vegetation
	10 U	476321	6161810	Fish observed				Mix of gravels & fines, fish observed. Area not recorded
	10 U	476343	6161814	1 Rainbow Trout	1.0	1.05	1.05	Active redd and 1 RB observed spawning. Dimensions reflect the size of redd.
	10 U	476391	6161794	1 RB, 1 juvenile salmonid	0.5	0.75	0.38	Tail out of run near undercut bank. Mature female RB observed.
	10 U	476572	6161807	1 Rainbow Trout	1	3	3	Spawning gravels mid-channel. Mature female RB observed.
	10 U	476609	6161790	No	0.75	1.5	1.13	Spawning substrate mid-channel behind large woody debris
	10 U	476688	6161604	No	0.75	3	2.25	Near tail out of run under large woody debris
Lamonti Total							**31.1**	
Ole	10 V	405761	6257655	3 Bull Trout	3	2	6	3 BT observed in area, not on spawning gravel.
	10 V	405676	6257711	No	1	3	3	LDB of main braid
	10 V	405309	6257861	No	2	5	10	No spawning habitat in the wetted perimeter but a gravel island exists nearby.
	10V	405201	6257815	No	1	2	2	
	10V	405176	6257785	No	3	2	6	Pool at downstream end of canyon
	10V	404626	6257630	No	0.5	1.5	0.75	LDB
	10 V	404299	6257701	No	4	1.5	6.00	Small braid
	10 V	404293	6257690	No	0.5	0.5	0.25	Spawning substrate below large soft barrier
	10 V	404263	6257689	No	1	3	3.00	Near undercut bank
	10 V	404249	6257734	No	0.75	1.5	1.13	Along braid, below soft barrier
Ole Total							**32.13**	

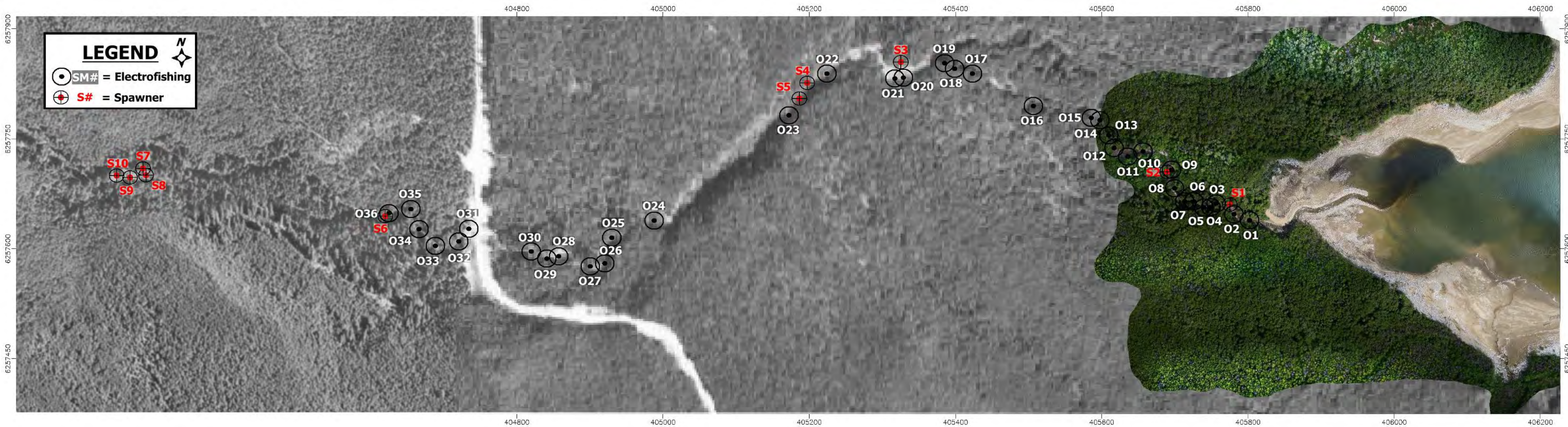
Site	UTM Coordinates			Fish Observed	Dimensions		Area (m²)	Comment
	Zone	Easting	Northing		X	Y		
Factor Ross	10 V	395383	6275626	No	0.5	2	1	RDB along straight section of creek; bank undercut
	10 V	395383	6275626	No	0.75	2.5	1.88	LDB same location as above, spawning gravels on opposite side of creek under alder
	10 V	395349	6275504	No	0.75	3	2.25	On inside corner; good depth
	10 V	395324	6275480	No	1	1.5	1.5	On bottom end of island just above log jam
	10V	395243	6275315	No	1	6	6	
	10V	395215	6275256	No	1	1.5	1.5	Near LWB on RDB
	10V	395141	6275160	No	2.5	1.5	3.75	RDB
	10 V	395133	6274907	No	0.75	2.5	1.88	Along the edge of a log jam.
	10 V	395172	6274897	2 fish observed.	3	5	15	Spawning substrates mid-channel with soft barrier below. 2 mature fish observed; likely salmonids based on swim burst speeds.
Factor Ross Total							**34.76**	

Appendix 6. Rainbow Trout spawning survey and juvenile fish survey location maps for Six Mile, Lamonti, Ole, and Factor Ross Creeks.

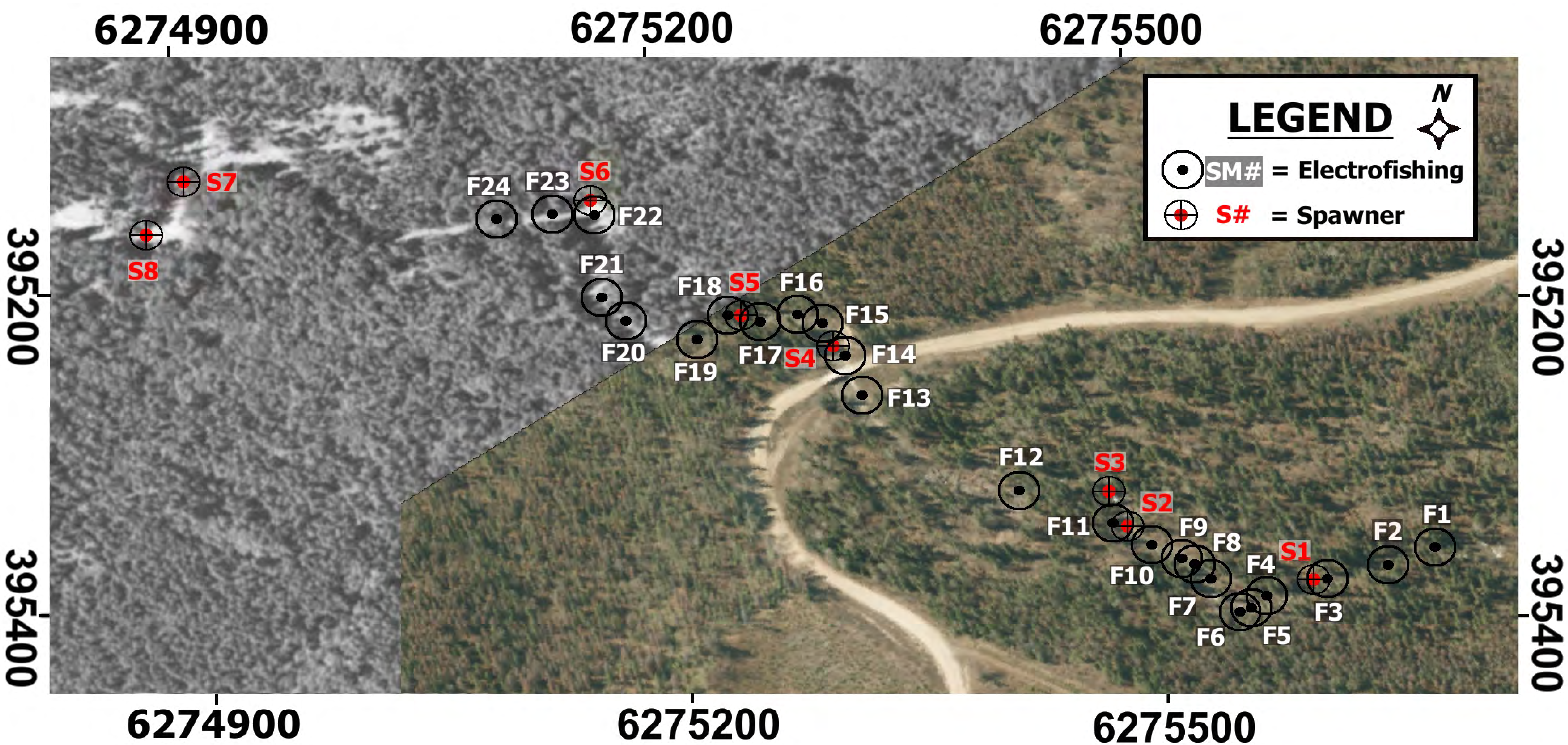
Map 5. Rainbow Trout spawning survey and juvenile fish survey location maps for Six Mile Creek in 2014.



Map 6. Rainbow Trout spawning survey and juvenile fish survey location maps for Lamonti Creek in 2014.



Map 7. Rainbow Trout spawning survey and juvenile fish survey location maps for Ole Creek in 2014.



Map 8. Rainbow Trout spawning survey and juvenile fish survey location maps for Factor Ross Creek in 2014.

Appendix 7. Locations of sample sites for electrofishing and night snorkel surveys for juvenile fish abundance in Six Mile, Lamonti, Ole, and Factor Ross Creeks in 2014.

Site	Site Name	Zone	Easting	Northing	Area (m²)	EF Effort (Sec.)	Habitat Complexity	Description
Six Mile	SM1	10 U	474621	6162883	25	65	Low	RDB
	SM2	10 U	474591	6162929	21	70	Low	RDB
	SM3	10 U	474630	6163013	41	78	Low	LDB
	SM4	10 U	474644	6163042	23	58	Low	LDB
	SM5	10 U	474589	6163117	30	108	Medium	LDB
	SM6	10 U	474540	6163304	45	77	Low	LDB
	SM7	10 U	474489	6163376	15	39	Low	RDB
	SM8	10 U	474564	6163420	25	84	Medium	LDB
	SM9	10 U	474578	6163409	58	157	Medium	LDB
	SM10	10 U	474671	6163476	25	67	Medium	LDB
	SM11	10 U	474663	6163494	15	44	Low	LDB
	SM12	10 U	474641	6163511	27	70	Low	LDB – Left side channel
	SM13	10 U	474632	6163505	45	165	High	RDB – Right side channel
	SM14	10 U	474600	6163520	18	63	Low	RDB
	SM15	10 U	474612	6163549	42	175	Medium	LDB – Right side channel
	SM16	10 U	474559	6163659	43	92	Low	LDB – Left side channel
	SM17	10 U	474535	6163639	90	118	Medium	RDB – Right side channel
	SM18	10 U	474495	6163647	33	33	Low	RDB
	SM19	10 U	474487	6163675	40	83	Low	RDB
	SM20	10 U	474496	6163717	32	76	Medium	LDB
	SM21	10 U	474496	6163750	25	75	Medium	RDB
	SM22	10 U	474476	6163830	18	53	Medium	RDB
	SM23	10 U	474458	6163893	43	129	Medium	RDB
	SM24	10 U	474464	6163925	14	194	High	Under log jam
	SM25	10 U	474448	6163945	12	46	Medium	Whole width
	SM26	10 U	474408	6163981	40	68	Low	RDB
	SM27	10 U	474403	6164045	10	34	Low	Middle of creek
	SM28	10 U	474412	6164096	40	50	Low	RDB
	SM29	10 U	474415	6164125	22	89	Low	Whole pools
	SM30	10 U	474425	6164137	14	28	Low	Centre of creek
	SM31	10 U	474475	6164175	14	30	Medium	Whole pool
	SM32	10 U	474490	6164182	30	93	Medium	2 pools over width of creek
	Total				**975**	**2611**		
Lamonti	LAM1	10 U	475329	6161950	40	91	Low	Whole creek
	LAM2	10 U	475389	6161978	25	73	High	Whole creek
	LAM3	10 U	475414	6161991	24	59	Medium	LDB
	LAM4	10 U	475430	6161984	9	39	High	Whole creek
	LAM5	10 U	475453	6161977	18	79	Low	RDB at lower whole creek u/s

Site	Site Name	Zone	Easting	Northing	Area (m²)	EF Effort (Sec.)	Habitat Complexity	Description
	LAM6	10 U	475482	6161931	10	62	Medium	RDB
	LAM7	10 U	475493	6161906	10	49	Medium	New Site, old site dry
	LAM8	10 U	475514	6161916	14	44	Medium	LDB
	LAM9	10 U	475539	6161935	24	97	High	RDB
	LAM10	10 U	475626	6161939	12	71	Medium	RDB
	LAM11	10 U	475646	6161942	8	48	Medium	LDB
	LAM12	10 U	475716	6161926	9	79	Medium	LDB
	LAM13	10 U	475761	6161928	30	103	High	LDB Under LWD
	LAM14	10 U	475840	6161917	11	64	Medium	Whole creek (2 pools)
	LAM15	10 U	475872	6161855	12	30	Low	Whole creek
	LAM16	10 U	475872	6161828	15	64	Low	Whole channel under bridge
	LAM17	10 U	475890	6161826	20	58	Low	Whole creek
	LAM18	10 U	475916	6161817	7.5	28	Medium	RDB
	LAM19	10 U	475932	6161810	6.5	37	Low	RDB
	LAM20	10 U	475950	6161801	10	38	High	LDB and small pool
	LAM21	10 U	475997	6161789	12	54	Low	Whole creek
	LAM22	10 U	476052	6161824	20	81	Medium	Whole creek
	LAM23	10 U	476082	6161800	10	53	Medium	Right channel
	LAM24	10 U	476085	6161797	10	41	Medium	LDB
	LAM25	10 U	476094	6161785	5	24	Low	Mid channel and log
	LAM26	10 U	476106	6161784	60	130	Low	RDB
	LAM27	10 U	476122	6161807	12	38	Low	RDB
	LAM28	10 U	476140	6161809	22	112	Medium	Whole channel
	LAM29	10 U	476159	6161800	12	45	Low	LDB
	LAM30	10 U	476234	6161816	4	62	Low	RDB
	LAM31	10 U	476276	6161817	12	44	Low	Whole creek
	Total				**494**	**1897**		
Ole	OLE1	10V	405785	6257636	16	40	Medium	LDB
	OLE2	10V	405768	6257649	36	70	Medium	RDB and whole creek at north end
	OLE3	10V	405742	6257666	8	56	High	Whole creek
	OLE4	10V	405733	6257660	11	50	High	RDB and South RDB pool
	OLE5	10V	405725	6257658	12	24	Low	2 pools; one at RDB of right side channel; one at RDB at LDB channel
	OLE6	10V	405713	6257669	10	37	Medium	LDB of left side channel and north pool
	OLE7	10V	405702	6257671	18	49	High	LDB of left side channel and north pool
	OLE8	10V	405690	6257689	7	44	Medium	Whole pool left side channel
	OLE9	10V	405683	6257713	16	94	Low	Right side channel
	OLE11	10V	405618	6257728	5	24	Low	Middle of channel
	OLE12	10V	405608	6257746	4	24	Low	LDB

Site	Site Name	Zone	Easting	Northing	Area (m²)	EF Effort (Sec.)	Habitat Complexity	Description
	OLE13	10V	405597	6257762	18	111	Medium	LDB 2 pools
	OLE14	10V	405581	6257780	23	71	High	Whole creek
	OLE15	10V	405570	6257789	40	126	High	Whole creek and upper pool
	OLE16	10V	405491	6257798	10	79	Medium	RDB and upper pool
	OLE17	10V	405410	6257848	11	46	Medium	Whole creek
	OLE18	10V	405388	6257852	22	106	Medium	Whole creek
	OLE19	10V	405382	6257861	12	37	Medium	Whole Creek
	OLE20	10V	405310	6257843	10	51	Medium	RDB and upper pool
	OLE21	10V	405302	6257847	26	36	Medium	LDB of left channel
	OLE22	10V	405226	6257835	12	40	Low	
	OLE23	10V	405176	6257769	60	111	Low	Whole creek at d/s end of channel
	OLE24	10V	404965	6257639	55	127	Low	Immediately above canyon
	OLE25	10V	404938	6257611	9	74	Low	RDB
	OLE26	10V	404913	6257589	21	166	Low	Large deep pool
	OLE27	10V	404890	6257589	14	105	Low	Left channel
	OLE28	10V	404839	6257581	11	72	Low	RDB of left channel; whole right channel
	OLE29	10V	404829	6257584	8	56	Medium	Whole channel
	OLE30	10V	404810	6257597	20	124	High	Whole channel
	OLE31	10V	404725	6257610	8	51	Medium	Whole channel
	OLE32	10V	404726	6257603	9	54	Low	RDB and side pool
	OLE33	10V	404699	6257585	24	110	Medium	RDB
	OLE34	10V	404657	6257618	6	51	Low	RDB
	OLE35	10V	404647	6257638	11	124	Low	Most of channel on LDB and u/s RDB
	OLE36	10V	404637	6257643	10	68	low	RDB
	Total				**593**	**2508**		
Factor Ross	FR1	10V	395364	6275690	11	51	Medium	Mid-stream boulder
	FR2	10V	395368	6275659	11	41	Low	Mid-stream boulder
	FR3	10V	395384	6275622	25	78	Low	LDB and RDB
	FR4	10V	395384	6275594	13	75	Low	Right bank extending to boulders mid channel
	FR5	10V	395396	6275585	22	53	Low	RDB
	FR6	10V	395397	6275583	60	137	Low	RDB
	FR7	10V	395379	6275552	26	58	Low	LDB
	FR8	10V	395371	6275548	23	52	Medium	2 x LDB + RDB
	FR9	10V	395365	6275539	14	38	Low	LDB
	FR10	10V	395355	6275513	40	66	Low	LDB
	FR11	10V	395346	6275500	35	73	Low	RDB, small pools
	FR12	10V	395330	6275437	60	113	Medium	RDB log jam
	FR13	10V	395268	6275336	44	69	Low	RDB – 2 side eddies

Site	Site Name	Zone	Easting	Northing	Area (m²)	EF Effort (Sec.)	Habitat Complexity	Description
	FR14	10V	395245	6275319	22	112	Low	RDB
	FR15	10V	395224	6275316	12	99	Low	RDB
	FR16	10 V	395216	6275294	15	31	Low	Middle of channel in eddy
	FR17	10 V	395218	6275272	30	34	Medium	Whole channel
	FR18	10 V	395217	6275253	14	35	Medium	RDB
	FR19	10 V	395230	6275233	45	38	Medium	RDB
	FR20	10 V	395223	6275177	35	54	High	Whole channel
	FR21	10 V	395210	6275171	14	30	Low	RDB
	FR22	10 V	395160	6275163	32	39	High	Whole channel
	FR23	10 V	395156	6275141	10	46	Medium	RDB
	FR24	10 V	395155	6275106	30	24	Medium	RDB and LDB (not middle)
	Total				**643**	**1446**		

Appendix 8. Summary of the night-time fry surveys at four tributaries of Williston Reservoir in 2014. Site refers to the number of the adjacent snorkeling site.

Site	Date	Site Name	Site Length (m)	Species: Rainbow Trout	Species: Bull Trout	Species: Unknown	Species: Total	Comments
Six Mile	16-Aug-14	SM10	8	1	7	0	8	Rainbow Trout ~20mm, Bull Trout ~40mm
	17-Aug-14	SM16	15	0	3	1	4	1 fry observed while snorkeling unable to ID. Bull Trout ~50mm
		SM17	28	2	0	0	2	Rainbow Trout ~20mm
		SM18	5	0	2	0	2	Bull Trout ~25mm
		SM19	12	3	0	0	3	Rainbow Trout ~25mm
		SM21	5	0	1	0	1	Bull Trout ~40mm
		SM22	12	3	0	0	3	Rainbow Trout ~20mm
		SM23	15	7	0	0	7	Rainbow Trout ~25mm
		SM24	9	14	0	0	14	Rainbow Trout ~25mm
		SM25	6	1	0	0	1	Rainbow Trout ~20mm
		SM26	16	0	0	0	0	No fry observed
		SM27	7	1	0	0	1	Rainbow Trout ~20mm
		SM28	9	2	0	0	2	Rainbow Trout ~20mm
		SM29	8	3	0	0	3	Rainbow Trout ~20mm
		SM30	5	0	0	0	0	No fry observed
		Total	**160**	**37**	**13**	**1**	**51**	
	CPUE (#/m)			**0.23**	**0.081**	**0.006**	**0.32**	
Lamonti	18-Aug-14	LA1	8	0	0	0	0	No fry observed
		LA2	4	0	0	0	0	No fry observed
		LA5	6	0	0	0	0	No fry observed
		LA6	8	0	0	0	0	No fry observed
		LA8	3	0	0	0	0	No fry observed
		LA9	10	0	0	0	0	No fry observed
		LA10	6	0	0	0	0	No fry observed
		LA11	8	0	0	0	0	No fry observed
		LA13	3	0	0	0	0	No fry observed
	19-Aug-14	LA15	4	0	0	0	0	No fry observed
		LA16	1	0	0	0	0	No fry observed
		LA17	2	0	0	0	0	No fry observed
		LA18	1.5	0	0	0	0	No fry observed
		LA23	0.5	0	0	0	0	No fry observed
		LA28	1	0	0	0	0	No fry observed

Site	Date	Site Name	Site Length (m)	Species				Comments
				Rainbow Trout	Bull Trout	Unknown	Total	
		Total	**66**	**0**	**0**	**0**	**0**	
		CPUE (#/m)		**0**	**0**	**0**	**0**	
Ole	23-Aug-14	OLE1	3	0	0	0	0	No fry observed
		OLE2	5.5	0	0	0	0	No fry observed
		OLE6	2.25	0	1	0	1	1 Bull Trout fry observed
		OLE8	3	0	1	0	1	1 Bull Trout fry observed
		OLE11	6	0	1	0	1	1 Bull Trout fry observed
		OLE15	0.5	0	0	0	0	No fry observed
		OLE16	2.5	0	0	0	0	No fry observed
		OLE18	0.5	0	0	0	0	No fry observed
		OLE19	2	0	0	0	0	No fry observed
		OLE20	1	0	0	0	0	No fry observed
		OLE21	7	0	0	0	0	No fry observed
	24-Aug-14	OLE29	2	0	0	0	0	No fry observed
		OLE32	2	0	0	0	0	No fry observed
		Total	**37.25**	**0**	**3**	**0**	**3**	
		CPUE (#/m)		**0**	**0.08**	**0**	**0.08**	
Factor Ross	21-Aug-14	FR13	7	0	0	0	0	No fry observed
		FR14	9	0	0	0	0	No fry observed
		FR15	10	0	0	0	0	No fry observed
		FR17	10	0	0	0	0	No fry observed
		FR18	5	0	0	0	0	No fry observed
		FR19	4	0	3	0	3	3 Bull Trout fry
		FR20	5	0	1	0	1	1 Bull Trout fry
		FR22	4	0	3	0	3	3 Bull Trout fry
	22-Aug-14	FR3	1	0	0	0	0	No fry observed
		FR4	2	0	1	0	1	Bull Trout ~55mm
		FR5	2	0	0	0	0	No fry observed
		FR8	2	0	0	0	0	No fry observed
		FR10	2	0	0	0	0	No fry observed
		FR11	2	0	1	0	1	Bull Trout ~35mm
		Total	**65**	**0**	**9**	**0**	**9**	
		CPUE (#/m)		**0**	**0.14**	**0**	**0.14**	

Appendix 9. Locations of vegetation belt-transects.

Site	Transect[1]	UTM Zone	Easting	Northing
Six Mile	SC1-1	10U	474716	6162533
	SC1-2	10U	474705	6162552
	SC2-1	10U	474668	6162655
	SC2-2	10U	474670	6162676
	SC3-1	10U	474697	6162745
	SC3-2	10U	474712	6162753
Lamonti	LC1-1	10U	475082	6162074
	LC1-2	10U	475098	6162065
	LC2-1	10U	475169	6162056
	LC2-2	10U	475187	6162058
	LC3-1	10U	475113	6162023
	LC3-2	10U	475133	6162022
	LC4-1	10U	475181	6161997
	LC4-2	10U	475192	6162013
Ole	OC1-1	10V	405833	6257636
	OC1-2	10V	405831	6257638
	OC2-1	10V	405887	6257660
	OC2-2	10V	405867	6257657
	OC3-1	10V	405863	6257675
	OC3-2	10V	405844	6257664
Factor Ross	FC1-1	10V	395521	6275897
	FC1-2	10V	395511	6275884
	FC2-1	10V	395481	6275940
	FC2-2	10V	395464	6275928
	FC3-1	10V	395380	6275938
	FC3-2	10V	395363	6275929

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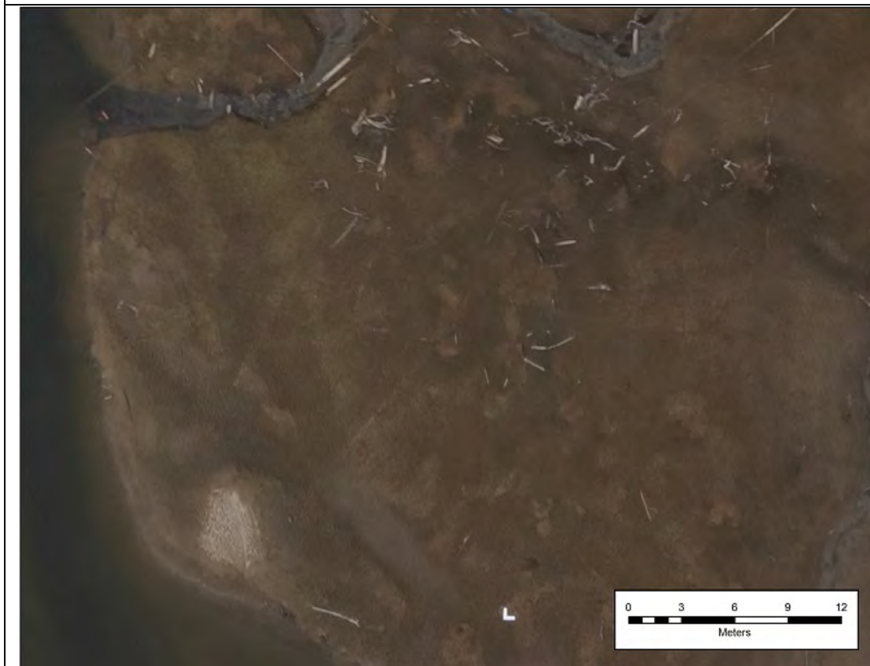
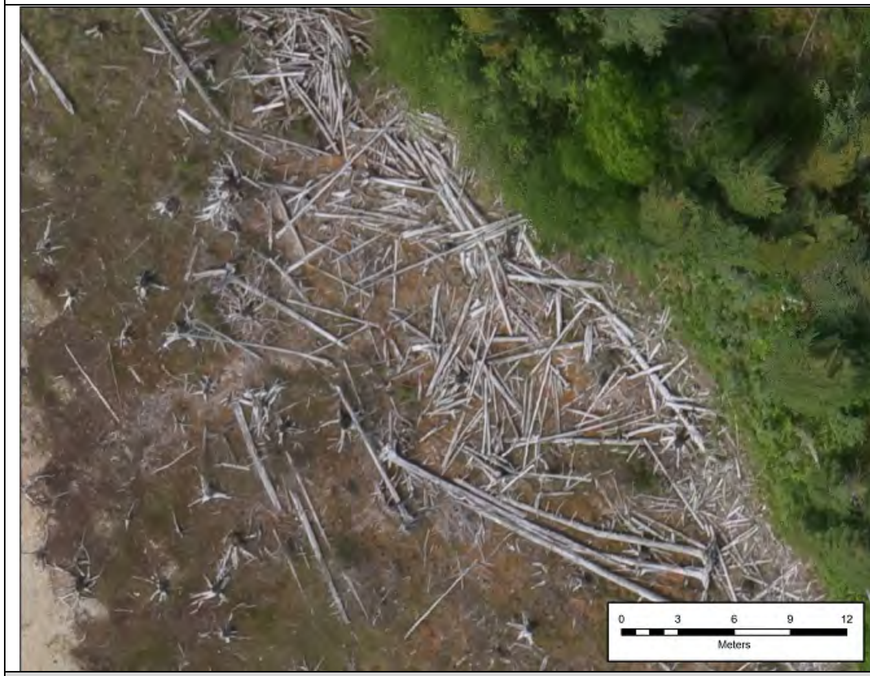
Appendix 10. Habitat class descriptions in the draw-down zone at enhancement and control sites.

BASIN SILT (BS)	
Representative Photographs	
Aerial View	**Ground View**
	
Description	
Basin Silt (BS): Lacustrine surface material with a plain surface expression and low to minimal coarse woody debris cover. Vegetation cover within the basin areas is mainly absent; however, occassional herbaceous germinants (e.g., lady's thumb) may be observed in the early spring, prior to flooding. Soils are mainly silt and sand textured. Groundwater is the main water source and reservoir flooding is expected to occur annually.	

Gravel and Sand	
Representative Photographs	
Aerial View	**Ground View**
	
Description	
Gravel and Sand (GS): Fluvial and glaciofluvial surface materials with undulating or gently sloping surface expressions and low coarse woody debris cover. Vegetation cover is sparse to absent, with the exeption of occasional patches localized to surface depressions within intermittent water channels and coarse woody debris structures. Soils are coarse textured, consisting of gravel and sand. Precipitation and stream sub-irrigation are the main water sources and reservoir flooding is expected to occur annually.	

<table>
<tr><th colspan="2">Organic Veneer (OV)</th></tr>
<tr><td colspan="2">Representative Photographs</td></tr>
<tr><th>Aerial View</th><th>Ground View</th></tr>
<tr><td>
</td><td></td></tr>
<tr><th colspan="2">Description</th></tr>
<tr><td colspan="2">Organic Veneer (OV): Organic surface material with a gently sloped surface expression and low coarse woody debris cover. Vegetation cover is sparse to low; species commonly observed include bluejoint, sedges (e.g., water sedge) and purslane speedwell. Soils appear to be remnant of past forest cover, with an organic horzion overlaying silt and clay mineral horizons. Groundwater is the main water source and reservoir flooding is expected to occur annually.</td></tr>
</table>

<table>
<tr><th colspan="2">Shoreline Driftwood (SD)</th></tr>
<tr><th colspan="2">Representative Photographs</th></tr>
<tr><th>Aerial View</th><th>Ground View</th></tr>
<tr><td></td><td></td></tr>
<tr><th colspan="2">Description</th></tr>
<tr><td colspan="2">Shoreline Driftwood (SD): Organic and glacialfluvial surface materials (depending on location and slope within the drawdown zone) on gently sloped surface expression with moderate to high coarse woody debris cover. Vegetation cover is low to moderate on organic surface materials and sparse to absent on glaciofluvial surfaces (i.e., gravel and sand). Species commonly observed include bluejoint, common horsetail (in wet depressions), marsh yellow cress (Rorippa palustris), tower mustard and Norwegian cinquefoil. Soils are either remnant of past forest cover (gentle slopes) or gravel and sand substrates (moderate slopes) occuring in the upper drawdown zone. Precipitation and groundwater are the main water sources and reservoir flooding is expected to occur annually to frequently.</td></tr>
</table>

Shoreline Forest (SF):	
Representative Photographs	
Aerial View	**Ground View**
	

Description

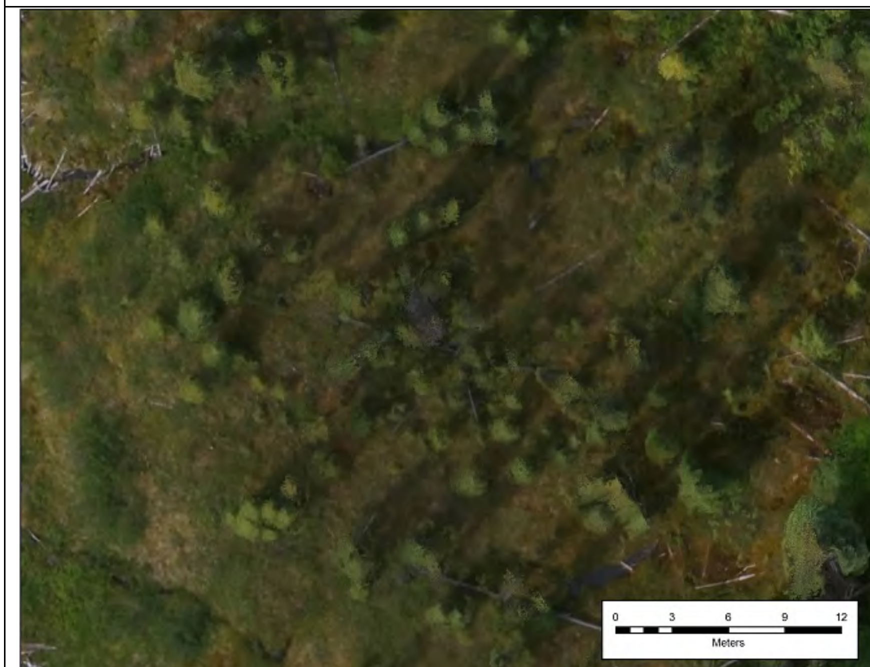
Shoreline Forest (SF): Undisturbed forest cover above the upper limits of the drawdown zone. Forest cover at the study sites is representative of the Williston variant for the moist cool subzone of the Sub-boreal Spruce Biogeoclimatic zone (SBSmk2). At Six Mile, Lamonti and Factor Ross Creek study sites, the tree cover along the shoreline is primarily coniferous; dominant tree species include lodgepole pine (*Pinus contorta* var. *latifolia*), subalpine fir (*Abies lasiocarpa*) and hybrid white spruce (*Picea glauca x engelmannii*), with Black Spruce (*Picea mariana*) occurring on wet sites. At Ole Creek, tree cover along the shoreline is primarily deciduous and diverse (shown in representative photographs above); species include trembling aspen (*Populus tremuloides*), black cottonwood (*Populus balsamifera* ssp. *trichocarpa*), paper birch (*Betula papryifera*), hybrid spruce, subalpine fir and lodgepole pine; large willow (*Salix* spp.) and Sitka alder (*Alnus viridis* ssp. *sinuata*) also occur within the tree canopy. Groundwater and precipitation are the main water sources and reservoir flooding is not expected to occur.

Shoreline Willow (SW)	
Representative Photographs	
Aerial View	**Ground View**
	
Description	
Shoreline Willow (SW): Organic surface materials on plain to gently sloping surface expressions with low to moderate coarse woody debris cover. Vegetation cover is moderate to high and consists of willow domianted shrub cover and a grass dominated (i.e., bluejoint) herbaceous cover. Reservoir flooding is expected to be frequent to rare.	

Streams and Ponds (SP)	
Representative Photographs	
Aerial View	**Ground View**
	
Description	
Streams and Ponds (SP): Areas of perennial water cover, including creeks, small streams, ponds and the reservoir.	

<table>
<tr><th colspan="2">Wetland Horsetail (WH)</th></tr>
<tr><th colspan="2">Representative Photographs</th></tr>
<tr><th>Aerial View</th><th>Ground View</th></tr>
<tr><td></td><td></td></tr>
<tr><th colspan="2">Description</th></tr>
<tr><td colspan="2">Wetland Horsetail (WH): Gently sloping areas within the upper drawdown zone that experience seepage from uphill perennial water sources, as well as along the edges of small streams. Vegetation cover is moderate to high and is dominated by bryophytes and swamp horsetail. Other herbaceous species observed includes yellow monkey flower (Mimulus gluttatus) and bluejoint. Groundwater is the main water source and reservoir flooding is expected to occur annually.</td></tr>
</table>

<table>
<tr><th colspan="2">Wetland Sedge (WS)</th></tr>
<tr><td colspan="2">Representative Photographs</td></tr>
<tr><td>Aerial View</td><td>Ground View</td></tr>
<tr><td>
</td><td></td></tr>
<tr><th colspan="2">Description</th></tr>
<tr><td colspan="2">Wetland Sedge (WS): Organic surface materials with a plain surface expression and low to sparse coarse woody debris cover. Vegetation cover is high and dominated by graminoids (e.g., grasses, sedges and rushes). Species observed include sedges, bluejoint, swamp horsetail, common horsetail, dwarf scouring-rush, marsh yellow cress and willows. Groundwater is the main water source and reservoir flooding is expected to be frequent to not occuring.</td></tr>
</table>

<table>
<tr><th colspan="2">Wetland Willow (WW)</th></tr>
<tr><th colspan="2">Representative Photographs</th></tr>
<tr><th>Aerial View</th><th>Ground View</th></tr>
<tr><td>
</td><td></td></tr>
<tr><th colspan="2">Description</th></tr>
<tr><td colspan="2">Wetland Willow (WW): Organic surface materials on a plain surface expression with sparse to absent coarse woody debris cover. Vegetation cover is high and dominated by bryophytes (e.g., sphagnum mosses) and willows. Black spruce may also be present. Groundwater is the main water source and reservoir flooding is expected to be frequent to rare.</td></tr>
</table>

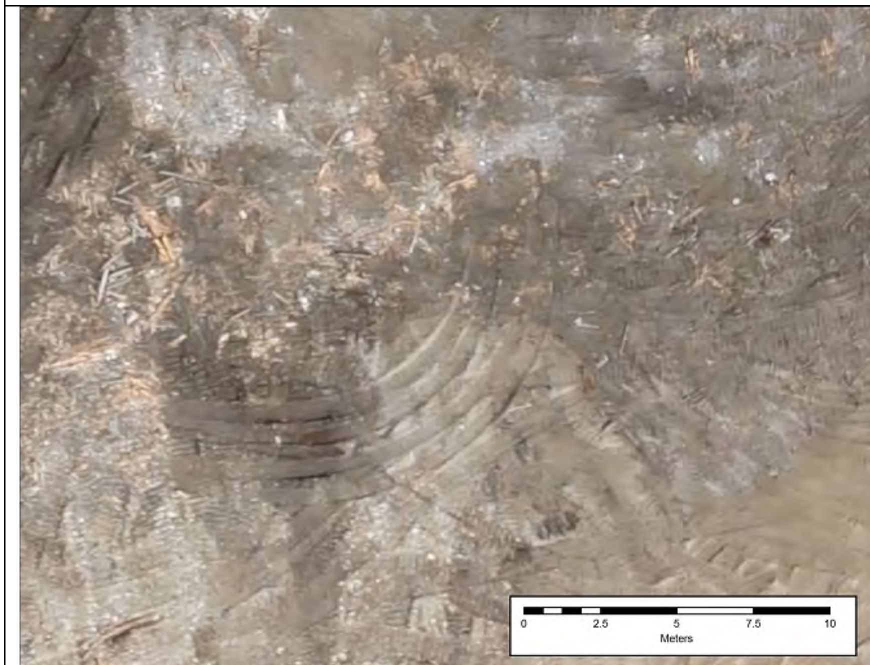
Appendix 11. Enhancement class descriptions in the draw-down zone at enhancement and reference sites.

<table>
<tr><th colspan="2">Blocks and Boulders (BB)</th></tr>
<tr><td colspan="2">Representative Photographs</td></tr>
<tr><th>Aerial View</th><th>Ground View</th></tr>
<tr><td>
</td><td></td></tr>
<tr><th colspan="2">Description</th></tr>
<tr><td colspan="2">Blocks and Boulders (BB): Structures constructed using glaciofluvial materials creating gentle to moderately sloped surface expressions. Vegetation and coarse woody debris cover is absent. Surface materials are coarse textured and include blocks, boulders, cobble, gravel and sand. Precipitation is the main water source and reservoir flooding is expected to occur annually.</td></tr>
</table>

Blocks and Logs (BL)	
Representative Photographs	
Aerial View	**Ground View**
	
Description	
Blocks and Logs (BL): Structures constructed using glaciofluvial materials and large logs, creating gentle to moderately sloped surface expressions and standing wood structures. Surface materials are coarse textured and include blocks, boulders, cobble, gravel and sand. Precipitation is the main water source and reservoir flooding is expected to occur annually.	

Coconut Matting (CM)	
Representative Photographs	
Aerial View	**Ground View**
	
Description	
Coconut Matting (CM): An artificial organic matting material placed along the surface of constructed berms with a gently sloped surface expression. Vegetation cover (with the exception of some fall ryegrass germinants) and coarse woody debris cover is absent. Precipitation is the main water source and reservoir flooding is expected to be annual to rare (depending on the location of the matting within the drawdown zone).	

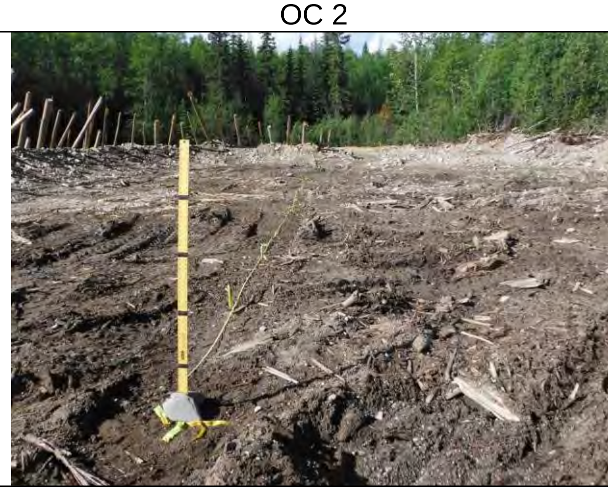
<table>
<tr><th colspan="2">Logs and Willow Cuttings (LW)</th></tr>
<tr><td colspan="2">Representative Photographs</td></tr>
<tr><td>Aerial View</td><td>Ground View</td></tr>
<tr><td>
</td><td></td></tr>
<tr><td colspan="2">Description</td></tr>
<tr><td colspan="2">Logs and Willow Cuttings (LW): Large logs with intact rooting bases and live willow stem cuttings implanted into the side wall of constructed berms with a gentle to moderately sloped surface expression. Precipitation is the main water source and reservoir flooding is expected to be annual to rare (depending on the location of the matting within the drawdown zone).</td></tr>
</table>

<table>
<tr><th colspan="2">Mixed Materials (MM)</th></tr>
<tr><td colspan="2">Representative Photographs</td></tr>
<tr><th>Aerial View</th><th>Ground View</th></tr>
<tr><td>
</td><td></td></tr>
<tr><th colspan="2">Description</th></tr>
<tr><td colspan="2">Mixed Materials (MM): Areas surrounding enhancement structures where the surface materials that were present prior to construction have been disturbed and/or mixed with other materials (e.g., overburden, silts and coarse woody debris). The surface expression is gently sloping. Vegetation is absent and course woody debris cover is low to absent. Precipitation and groundwater are the main water sources and reservoir flooding is expected to occur annually.</td></tr>
</table>

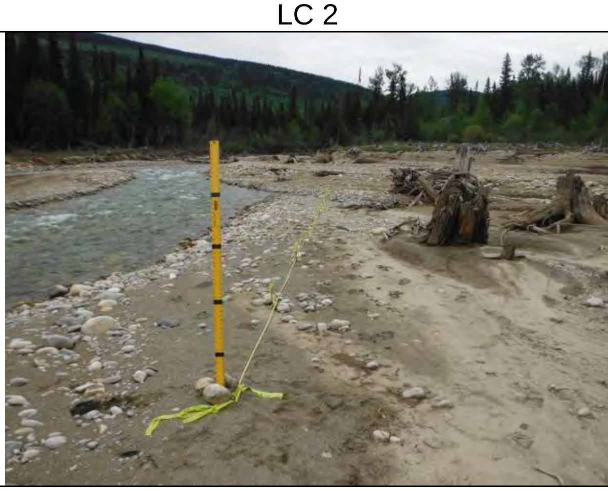
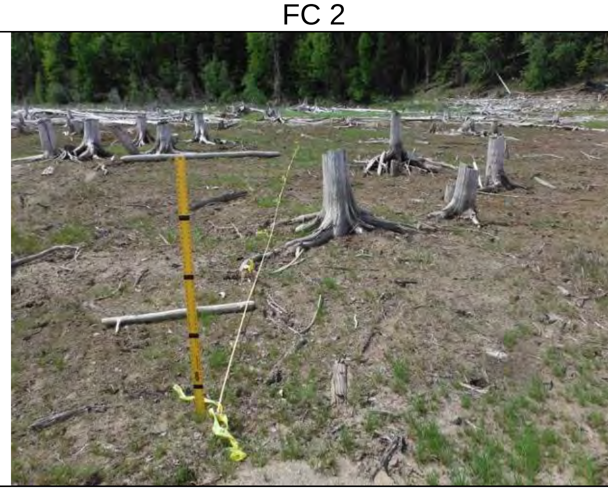
Overburden (OB):	
Representative Photographs	
Aerial View	**Ground View**
	
Description	
Overburden (OB): Mineral soils sourced from areas outside the drawdown zone and used as surface materials in the construction of roadways and berms. These soils have been spread over coconut matting on the berms. The surface expression is gently sloped. Vegetation and coarse woody debris cover is absent. Precipitation is the main water source and reservoir flooding is expected to occur annually.	

Road (RD)	
Representative Photographs	
Aerial View	**Ground View**
	
Description	
Road (RD): Compacted mineral soils on gently to moderate surface expressions. Vegetation and coarse woody debris cover is absent. Reservoir flooding is not expected to rare.	

Appendix 12. Photographs illustrating vegetation transects at enhancement sites.

<table>
<tr><th colspan="2">Representative Photographs</th></tr>
<tr><td></td><td></td></tr>
<tr><td>SC 1</td><td>OC 1</td></tr>
<tr><td></td><td></td></tr>
<tr><td>SC 2</td><td>OC 2</td></tr>
<tr><td></td><td></td></tr>
<tr><td>SC 3</td><td>OC 3</td></tr>
</table>

Appendix 13. Photographs illustrating vegetation transects at control sites.

Representative Photographs	
	
LC 1	FC 1
	
LC 2	FC 2
	
LC 3	FC 3

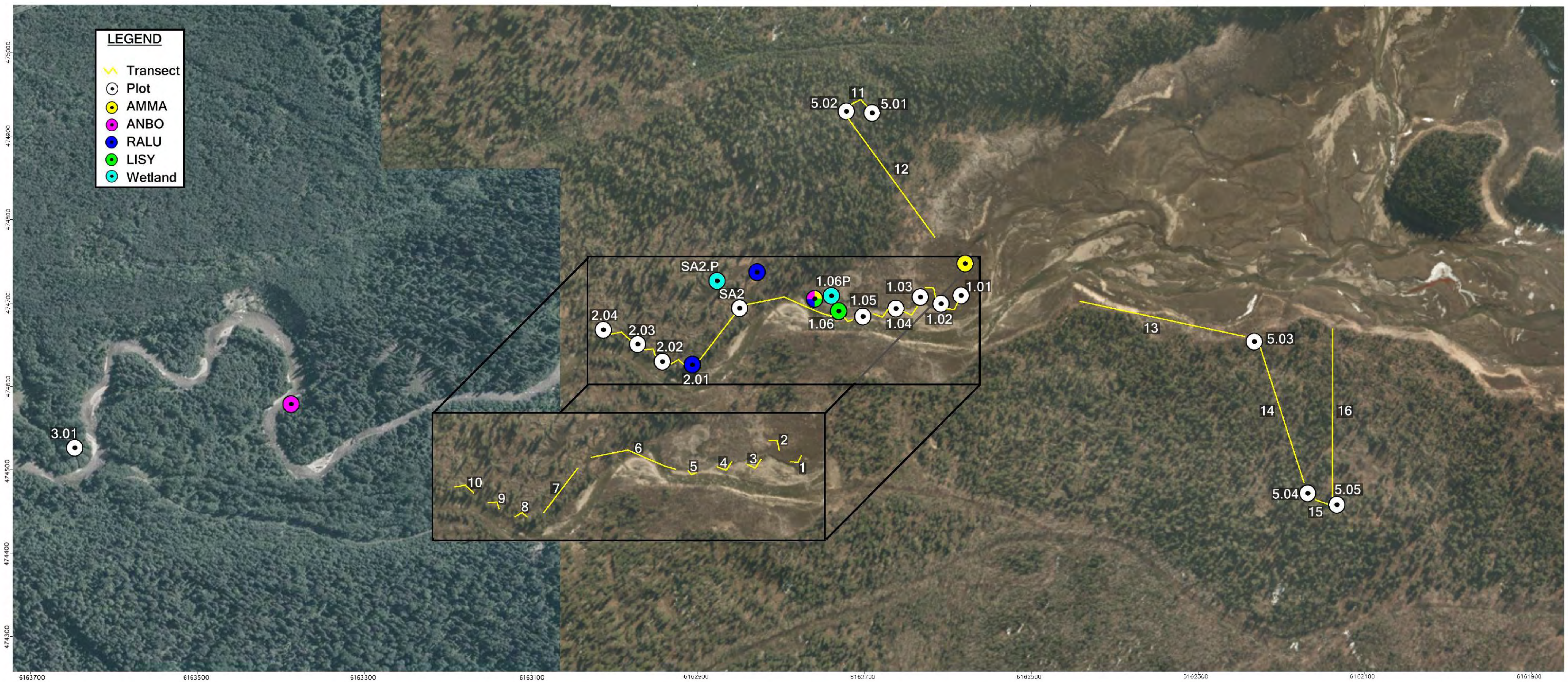
LC 4

Appendix 14. Summary of percent cover by plant species averaged across 10 quadrats in a 20 m belt-transect for vegetation transects sampled in Year 4 at enhancement and reference sites.

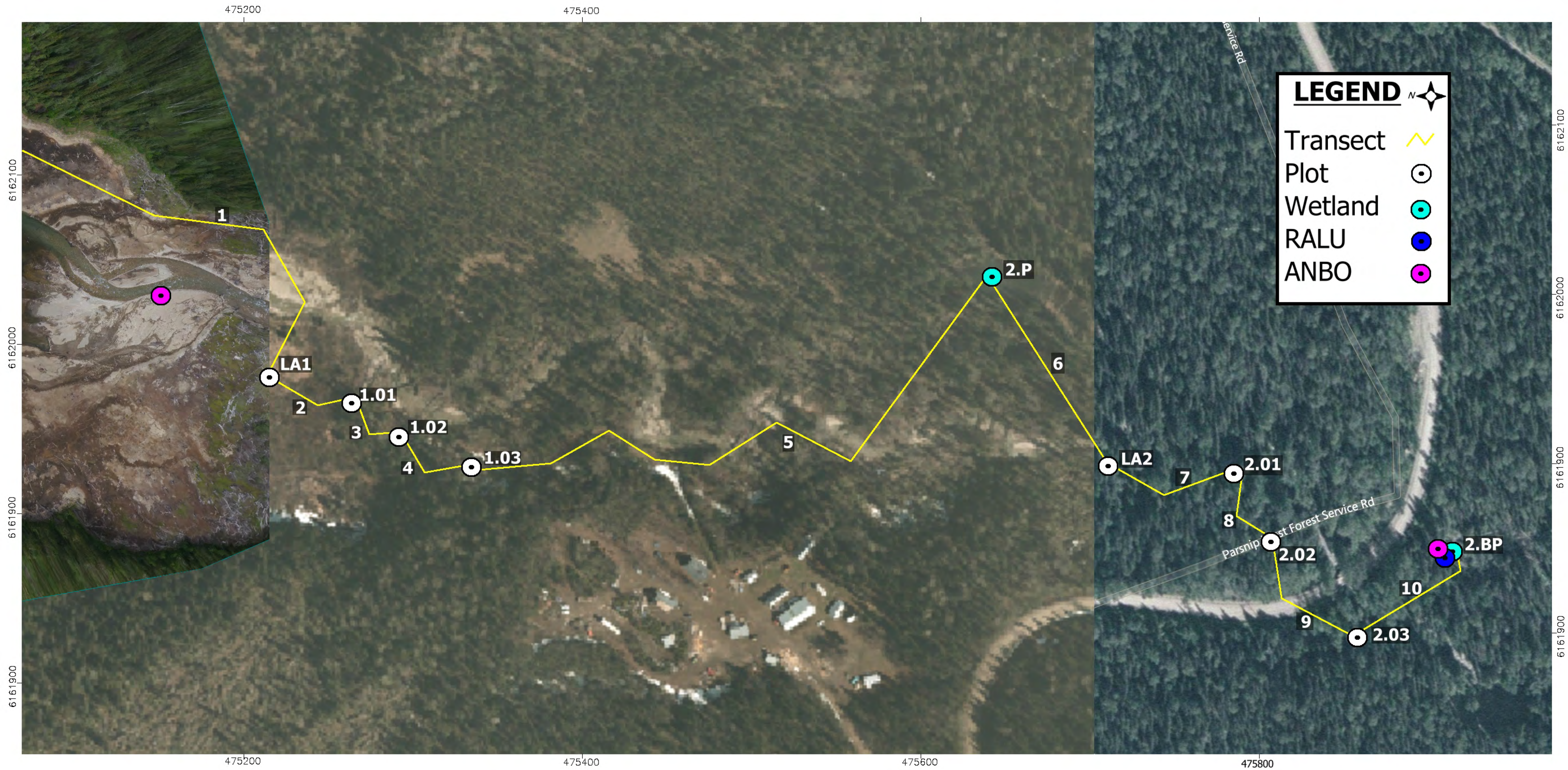
Group	Species	Transect													Total
		SC 1	SC 2	SC 3	LC 1	LC 2	LC3	LC4	OC 1	OC2	OC 3	FC 1	FC 2	FC 3	
Herbs/Forbs/ Graminoids	annual ryegrass	0	0	0	0	0	0	0	1.8	0	0	0	0	0	**1.8**
	bluejoint	0	0	0	0	0	0	3.2	0	0	0	0	0	0	**3.2**
	clover spp.	0	0	0	0	0	0	0	0	0	0	0.4	0	0	**0.4**
	common horsetail	0.3	0	0	0	0.1	0	0.5	0	0	0	5.7	0	1	**7.6**
	dangling suncress	0	0	0	0	0	0	0	0	0	0	0.03	0	0	**0**
	dwarf scouring-rush	8.6	0	0	0	0.7	0	0	0	0	0	0	0	0	**9.3**
	grass family	0.2	0	0	0	0.3	0	7.4	0	0.6	0	7.1	0	0	**15.6**
	Kamchatka rockcress	0	0	0	0	0	0	0.02	0	0	0	0	0	0	**0**
	Kellogg's sedge	1	0	0	0	0	0	0	0	0	0	0	0	0	**1**
	lady's thumb	0	0	0	5	0	0	0	0	0	0	0	0	0	**5**
	lamb's-quarters	0	0	0	0	0	0	0	0	0	0	0	0	0.2	**0.2**
	little meadow foxtail	0	0	0	0	0	0	0	0	0	0	0.1	0	10	**10.1**
	marsh yellow cress	0	0	0	0	0	0	0.1	0	0	0	0.1	0	0	**0.2**
	Merten's rush	0	0	0	0	0	0	0.02	0	0	0	0	0	0	**0**
	Norwegian cinquefoil	0	0	0	0	0	0	7.7	0	0	0	1.6	0	0	**9.3**
	purslane speedwell	0	0	0	0.01	1.1	0	0	0	0	0	0	0	0.3	**1.4**
	sedge spp.	0	0	0	0.01	0.7	0	15.1	0	0	0	0.9	0	0.1	**16.8**
	smooth hawksbeard	0	0	0	0	0	0	0.2	0	0	0	0.1	0	0	**0.3**
	tower mustard	0	0	0	0	0	0	0.9	0	0	0	0	0	0	**0.9**
	umbellate starwort	0	0	0	0	0	0	0	0	0	0	0.1	0	0	**0.1**
	water sedge	0	0	0	0	1	0	0.2	0	0	0	0.7	0	0	**1.9**
	UNKN41	0	0	0	0.01	0	0	0	0	0	0	0	0	0	**0**

Group	Species	Transect													Total
		SC 1	SC 2	SC 3	LC 1	LC 2	LC3	LC4	OC 1	OC2	OC 3	FC 1	FC 2	FC 3	
	UNKN43	0	0	0	0.1	0	0	0	0	0	0	0	0	0	**0.1**
	UNKN56	0	0	0	0.1	0.03	0	0	0	0	0	0	0	0	**0.1**
	UNKN58	0	0	0	0	0.1	0	0	0	0	0	0	0	0	**0.1**
	UNKN69	0	0	0	0	0	0	0	0	0	0	0.01	0	0	**0**
	UNKN72	0	0	0	0	0	0	0	0.01	0	0	0	0	0	**0**
		10.1	**0.0**	**0.0**	**5.2**	**4.0**	**0.0**	**35.3**	**1.8**	**0.6**	**0.0**	**16.8**	**0.0**	**11.6**	

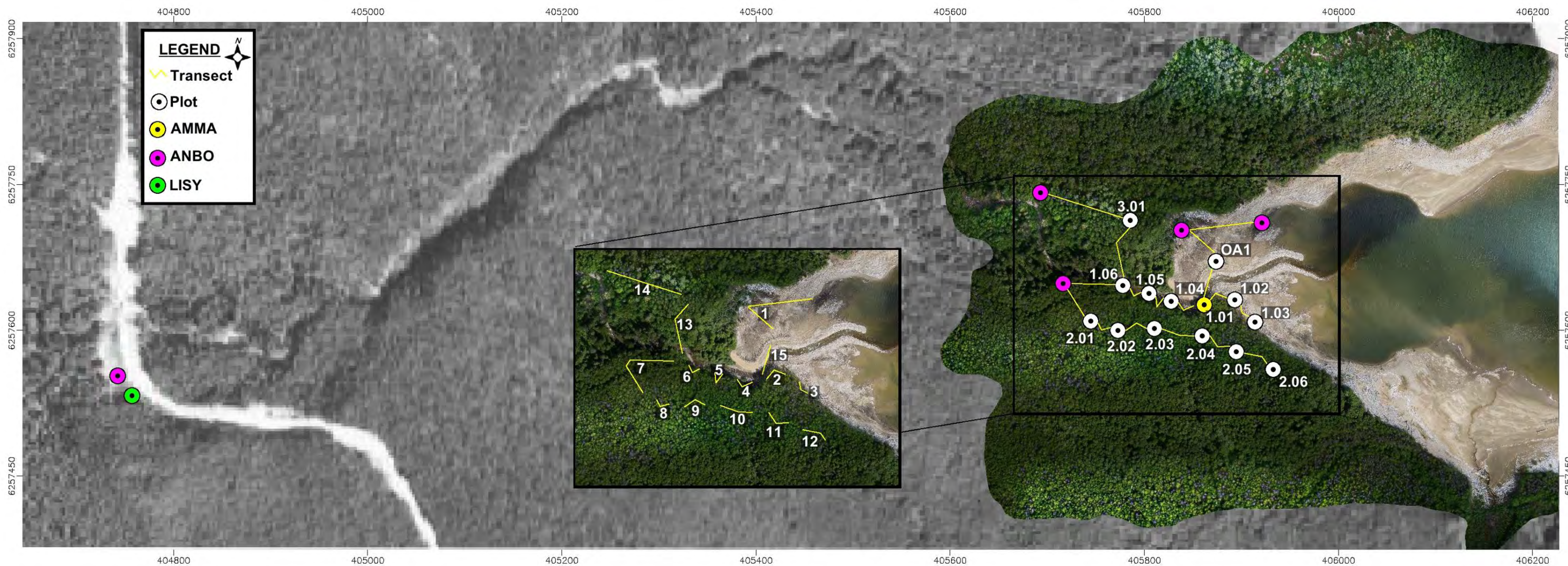
Appendix 15. Amphibian survey plots and transects with locations of amphibian detections in 2014.



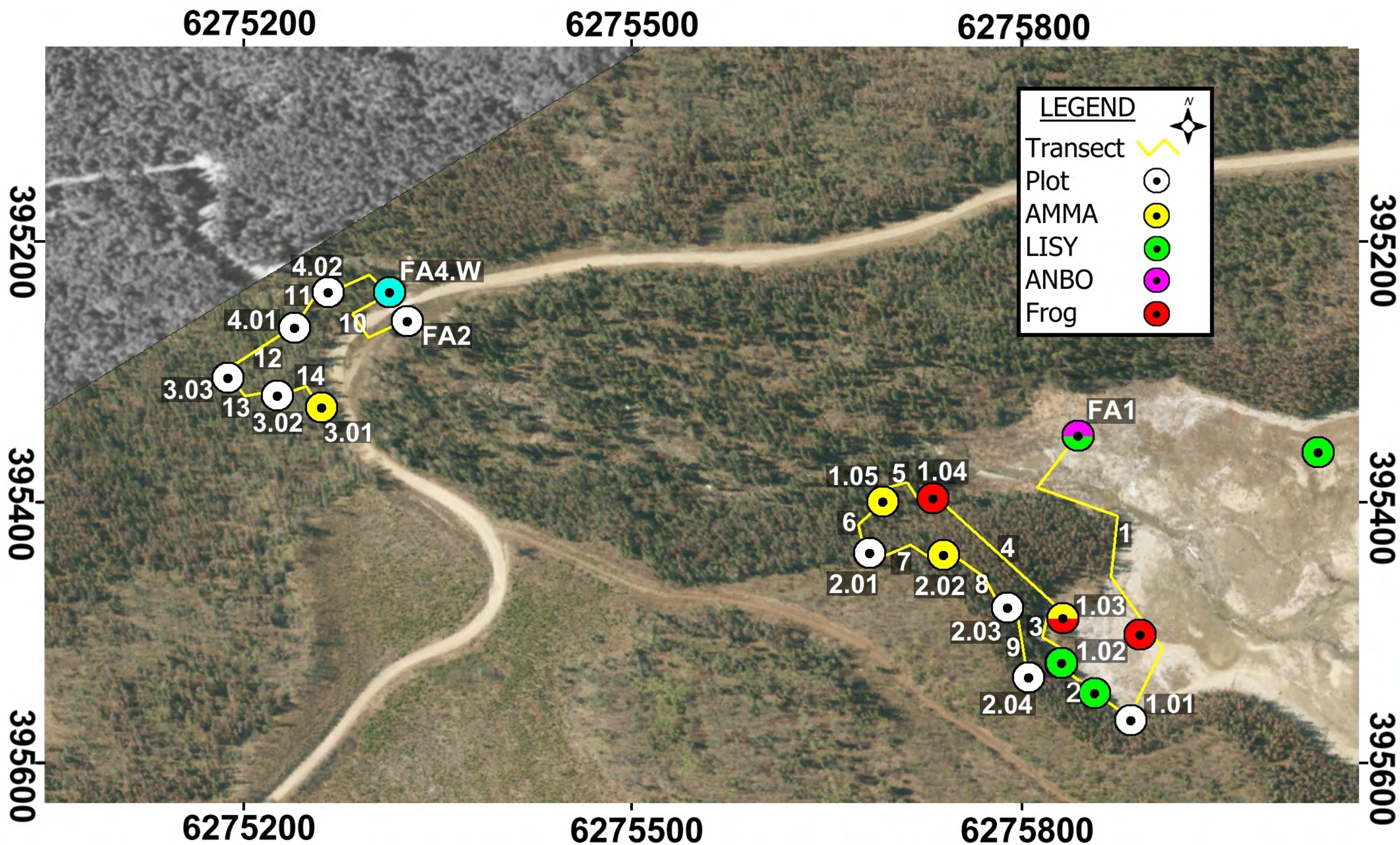
Map 9. Six Mile Creek amphibian survey locations and detections.



Map 10. **Lamonti Creek amphibian survey locations and detections.**



Map 11. **Ole Creek amphibian survey locations and detections.**



Map 12. **Factor Ross Creek amphibian survey locations and detections.**