Atlantic Gold

Appendix J.2

Fish and Fish Habitat Baseline Report – January 2021
Completed for the Updated 2021 Beaver Dam Mine EIS

Baseline Fish and Fish Habitat
2019-2020 Technical Report

Name of Project:

Beaver Dam Project
Location: Marinette, Nova Scotia
Prepared for: Atlantic Mining NS Corp.

Report Prepared by:

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Executive Summary

Atlantic Mining NS Corp. (AMNS) is proposing to construct, operate, decommission and reclaim the Beaver Dam Project (the Project), which is an open pit gold mine in Marinette, Nova Scotia. The Project includes the transportation of ore to the Touquoy Mine Site for processing. The Project Area (PA) incorporates three separate components: the Beaver Dam Mine Site, the Haul Road, and the Touquoy Mine Site.

This Baseline Fish and Fish Habitat 2020 Technical Report was prepared as baseline information to support the Project Environmental Impact Assessment. Fish and fish habitat surveys have been completed with the key objectives of facilitating avoidance of fish habitat where practicable, understanding the potential project interactions with fish and fish habitat, and to support fish and fish habitat regulatory applications. This is achieved by completing a review of background desktop resources in combination with field studies to identify potential environmental constraints and sensitivities within a defined Study Area. The Project location is shown on Figure 1, and the fish and fish habitat Study Area is shown on Figure 2. This report outlines the methods and results of field evaluations completed within the Beaver Dam Mine Site since the submission of the Revised Environmental Impact Statement (Atlantic Gold, 2019).

The 2019-2020 field program involved four main tasks within the Study Area, including seasonal trapping across multiple flow regimes within selected watercourses, eDNA sampling, three rounds of fish sampling (i.e., electrofishing and trapping) within selected watercourses and waterbodies, and detailed fish habitat characterization and quantification of watercourses predicted to be directly and indirectly affected by Project development. Water quality measurements were recorded *in-situ* during fish and fish habitat surveys.

Throughout the Study Area, recorded summer temperatures ranged from 8.3°C in to 27°C, with most temperatures surpassing temperatures suitable for salmonids by late summer. Only three sampling sites exhibited pH levels within Canadian Council of Ministers of the Environment (CCME) recommended range for freshwater aquatic life, while 28% percent of measurements recorded in-situ during fishing efforts and habitat assessment exhibited pH levels so low as to expect to cause harm to salmonid species (<5.0; CCREM, 1987; Farmer, 2000). The vast majority of dissolved oxygen (DO) levels recorded across aquatic features within the Study Area were below the minimum CCME recommended concentration of DO for early life stages of cold-water fishes, while 44% were below levels suitable for any life stage of cold or warm-water fishes (CCME, 1999). Low DO levels are typically associated with small, sluggish systems where DO would likely be consumed more quickly. Overall, low pH levels, elevated temperatures, and low DO concentrations limit fish habitat quality within select systems.

During the 2019-2020 field program, a total 11 species and 1732 individual fish were captured within the Study Area. This included 4 individual Atlantic salmon parr captured within the Killag River – no other Atlantic salmon were captured within the Study Area.

Detailed fish habitat surveys within selected watercourses were conducted using standard methodologies to gather key measurements such as reach length (m), reach wetted and bankfull width (m), reach slope (%), stream substrate composition (% composition), water depths (m), water velocities (m/s), cover (%), and riparian habitat per habitat unit. The data was used to determine the overall habitat area within each reach as well as the habitat suitability based on measured stream substrate, water depths, and water

velocities (habitat parameters) for each fish species identified within the Study Area. Detailed fish habitat assessments revealed suitable habitat for spawning, young of the year, juvenile, and adult life stages for various species throughout the Study Area.

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List of Acronyms

ACCDC	Atlantic Canadian Conservation Data Centre
CCME	Canadian Council of Ministers of the Environment
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
DFO	Fisheries and Oceans Canada
DO	Dissolved oxygen
HADD	Harmful Alteration, Disruption, or Destruction
KM	Kilometer
M	Meters
CM	Centimeter
MEL	McCallum Environmental Ltd.
NSDAF	Nova Scotia Department of Aquaculture and Fisheries
NSE	Nova Scotia Environment
NSESA	Nova Scotia Endangered Species Act
NSTDB	Nova Scotia Topographic Database
NSSA	Nova Scotia Salmon Association
SARA	Species at Risk Act
S-Rank	Status rank
TDS	Total Dissolved Solids
WC	Watercourse
WL	Wetland
WRSA	Waste Rock Storage Area
WRSH	West River Sheet Harbour

List of Scientific Names

American eel	*Anguilla rostrata*
Atlantic salmon	*Salmo salar*
banded killifish	*Fundulus diaphanus*
brook trout	*Salvelinus fontinalis*
brown bullhead	*Ameiurus nebulosus*
creek chub	*Semotilus atromaculatus*
golden shiner	*Notemigonus crysoleucas*
lake chub	*Couesius plumbeus*
ninespine stickleback	*Pungitius pungitius*
northern redbelly dace	*Chrosomus eos*
white sucker	*Catostomus commersonii*
yellow perch	*Perca flavescens*

1.0 INTRODUCTION

Atlantic Mining NS Corp. (AMNS), formerly Atlantic Gold, is proposing to construct, operate, decommission, and reclaim the Beaver Dam Project (the Project), which is open pit gold mine in Marinette, Nova Scotia. The Project includes the transportation of ore to the Touquoy Mine Site for processing. The Project Area (PA) incorporates three separate components: the Beaver Dam Mine Site, the Haul Road, and the Touquoy Mine Site (Figure 1, Appendix A).

McCallum Environmental Ltd (MEL) was retained to complete fish and fish habitat surveys within and in the vicinity of the PA to support the combined federal Environmental Impact Statement (EIS) with the Impact Assessment Agency of Canada (IAAC) and provincial Environmental Assessment Registration Document (EARD) with Nova Scotia Environment (NSE). Fish and fish habitat surveys have been completed with the key objectives of facilitating avoidance of fish habitat where practicable, understanding the potential project interactions with fish and fish habitat, and to support fish and fish habitat regulatory applications. This is achieved by completing a review of background desktop resources in combination with field studies to identify potential environmental constraints and sensitivities. This report outlines the methods and results of field evaluations completed within the PA since the submission of the Revised EIS (Atlantic Gold, 2019).

1.1 Regulatory Context

The *Fisheries Act* defines fish as "(a) parts of fish, (b) shellfish, crustaceans, marine animals and any parts of shellfish, crustaceans or marine animals, and (c) the eggs, sperm, spawn, larvae, spat and juvenile stages of fish, shellfish, crustaceans and marine animals;", and fish habitat as "waters frequented by fish and any other areas on which fish depend directly or indirectly to carry out their life processes, including spawning grounds and nursery, rearing, food supply and migration areas".

Within the *Fisheries Act,* activities which result in the harmful alteration, disruption or destruction (HADD) of fish habitat are prohibited. Permission may be granted to HADD of fish habitat under Section 35(2) of the *Act.*

Section 36(3) of the *Fisheries Act* prohibit the deposition of deleterious substances into waters frequented by fish. Waters frequented by fish means all Canadian waters such as rivers, lakes, creeks, canals and other water bodies. According to the Government of Canada (2020), "if fish use the water, even if only annually for a short period, then such water qualifies as 'waters frequented by fish'". Under the Mineral and Diamond Mining Effluent Regulations (MDMER), a project may obtain permission to deposit deleterious substances in waters frequented by fish, upon approval and addition of the waters to Schedule 2 of the MDMER.

Throughout this report, fish habitat is described in the context of watercourses. The Nova Scotia *Environment Act* defines a watercourse as:

(i) the bed and shore of every river, stream, lake, creek, pond, spring, lagoon or other natural body of water, and the water therein, within the jurisdiction of the Province, whether it contains water or not; and,

(ii) all groundwater.

In addition to the above-mentioned definition and in accordance to the Guide to Altering Watercourses (NSE, 2015), the watercourse parameters listed in this document were used to aid in determining the presence of a watercourse. This guide indicates that at least two of the following characteristics are needed to be present for a water feature to be determined a watercourse:

- Presence of mineral soil channel;
- Sand, gravel and/or cobbles evident in a continuous pattern over a continuous length with no vegetation;
- Indication of water flowing in a path sufficient to erode a channel/pathway;
- Presence of pools, riffles and/or rapids; and,
- Presence of aquatic animals and plants.

1.2 Study Area

The Beaver Dam Mine Site is one component of the larger PA. This report is focused on work completed in 2019-2020 within the Beaver Dam Mine Site component of the PA (Figure 1). A separate report has been prepared for all baseline fish and fish habitat work completed between 2015-2017 within the PA (Appendix H). Through this report, the Beaver Dam Mine Site with the addition of select downgradient watercourses (circled in red on Figure 2, Appendix A) is referred to as the Study Area (SA) for the baseline fish and fish habitat work. Fish and fish habitat data associated with the Haul Road and the Touquoy Mine Site are provided in Appendix H.

The SA is located at the Beaver Dam Mines Road, in Marinette, approximately 18 km northwest from Sheet Harbour, Nova Scotia (Figure 1, Appendix A). The SA was defined based on preliminary and revised infrastructure layouts, and the downstream receiving aquatic environment (West River Sheet Harbour secondary watershed, 1EM-2). The SA is approximately 574 hectares of both crown and private property within the Mine Footprint component of the SA. The Project is centered at coordinates 521480 m east and 4990180 m north (UTM Zone 20 NAD83).

In general, the SA contains a mixture of disturbed and undisturbed habitats, with historic mining activities and timber harvesting representing the dominant developments. Soils are generally nutrient poor and acidic which supports softwoods such as spruce and balsam fir. Herbaceous layers are often dominated by ericaceous shrubs and bryophytes such as Shreber's moss, which indicates nutrient poor soils.

1.2.1 *Surface Water*

The Beaver Dam Mine Site lies within the WRSH Nova Scotia secondary watershed, which is directly east of the Musquodoboit River and Tangier River secondary watersheds (Figure 2). The watershed occupies an area of roughly 576 km^2, a moderately sized watershed in the Province. The area is characterized by rolling till plains, drumlin fields, extensive rockland, and numerous freshwater lakes, streams, bogs and wetlands having relatively low relief, hummocky type terrain. Forests are predominantly coniferous of red and black spruce. According to (Department of Natural Resources (DNR), the site is in the Eastern Ecoregion of the Acadian Ecozone, the only ecozone in Nova Scotia (Neily et al., 2005). The Eastern Ecoregion is underlain by quartzite and slate of the Meguma Super Group with granitic intrusives. A variety of landforms are found in this ecoregion, including rolling till plains, drumlin fields, extensive rockland, and wetlands. The bedrock is highly visible in those areas where the glacial till is very thin, exposing the ridge topography. This inland area is somewhat removed from the immediate climatic influence of the Atlantic Ocean and is characterized by warmer summers and cooler winters (Neily et al., 2005).

The WRSH drainage basin discharges to the WRSH and its tributaries, from north to south. Elevations within the catchment vary from approximately 135 to 165 masl in the headwater areas and gradually decrease to sea level at the final outlet located at Sheet Harbour. The headwaters of the drainage basin are located along the topographic divide separating the Musquodoboit River Valley to the northwest. The Killag River and Cameron Flowage are the main mapped linear watercourses of the Beaver Dam Mine Site, and Crusher Lake and Mud Lake are the major mapped lakes. The complex system of streams, lakes, bogs and wetlands is a direct result of the underlying bedrock geology of greywacke and slate found in the region. These relatively impermeable and poorly jointed rocks result in slow groundwater recharge and most of the excess surface water is retained on the surface, often called a 'deranged' drainage pattern. The basin ultimately drains to the south via the WRSH, and discharge peaks are likely attenuated to a large extent by the numerous lakes and wetlands through which runoff is routed.

The WRSH and Tangier River Secondary boundary runs through the center of the PA along the Haul Road. The haul road component of the PA extends west into the Tangier River secondary watershed (1EL-2). The PA sits within ten tertiary watersheds: four within the Beaver Dam Mine Site (Killag River, Tent Brook, Paul Brook and Cope Brook) and six along the Haul Road footprint (i.e., Tent Brook, Keef Brook, Jack Lowe Brook, Little River, Sandy Pond, and Morgan River watersheds). Tertiary watersheds within the SA are shown on Figure 2, Appendix A.

1.2.2 *Fish and Fish Habitat*

Linear watercourses and selected waterbodies (Crusher Lake, Mud Lake) were originally identified and described across the Beaver Dam Mine Site in the summer of 2015. Each of these systems was evaluated for the presence of fish habitat and potential ability to support fish species during initial assessment and identification. Field assessments to complete fish collection were conducted in September 2015 and June 2016 within linear watercourses and waterbodies in the Beaver Dam Mine Site and the Haul Road PA (results presented in the 2015-2017 Baseline Report, Appendix H). Fishing surveys included electrofishing within 8 linear watercourse reaches and minnow trap, eel pot, and fyke net deployment within Crusher Lake and Cameron Flowage (Atlantic Gold, 2019). Field studies conducted from 2015-2017 for the Beaver Dam Mine Project have confirmed the following species as present within the SA:

- American eel
- banded killifish
- brook trout
- brown bullhead
- golden shiner
- lake chub
- ninespine stickleback
- northern redbelly dace
- white sucker
- yellow perch

A total of 67 individual were captured through electrofishing and trapping efforts within the Beaver Dam Mine. Ninespine stickleback, banded killifish, northern redbelly dace, and brook trout are the most abundant species in linear watercourses, while yellow perch, banded killifish, and golden shiner are most abundant in waterbodies. Brook Trout is confirmed within WC5 north of Crusher Lake (one individual fish), WC12 (three individual fish) between Wetland 56 and Wetland 59, and within WC13, the short tributary leading from Wetland 59 northeast into Cameron Flowage (6 individual fish).

Atlantic salmon (Nova Scotia Southern Uplands population) were not observed within the SA during 2015-2017 field studies but are expected to potentially inhabit watercourses within and adjacent to the SA. Atlantic salmon are divided into unique populations based on genetic distinction and range. For the purposes of this report, we are considering only the Southern Uplands (SU) Population, as outlined by DFO in the Recovery Potential Assessment for the Southern Uplands population of Atlantic salmon (DFO, 2013).

The SU Population of Atlantic Salmon has experienced significant reductions over the last few decades, with adult abundance declining from 88% to 99% from observed abundances in the 1980s (DFO, 2013). Current adult and juvenile abundance has been assessed as critically low in most rivers, and there is strong evidence for river-specific extirpations – only 54% of rivers in the SU region were found to contain salmon in 2000 (Amiro et al., 2000) and only 38% were found to contain salmon in 2008 (Gibson et al., 2010). The main contributing factors to these declines are considered to be degradation of freshwater habitat, acidification, and poor marine survival (Bowlby et al., 2014).

1.2.3 *Fish Habitat Restoration – WRSH Watershed*

The WRSH watershed is one of 72 watersheds within the SU region. The main river channel, the West River, is approximately 30 km long and has two main tributaries – the Killag and Little Rivers. Fish surveys within the watershed have been ongoing since 1965 and have documented a variety of species present. Of particular research interest has been the presence and provision of salmon and salmon habitat within these rivers. According to Ducharme (1972), the Killag River is the most important of the three rivers for Atlantic salmon production due to the presence of excellent spawning grounds. Ducharme (1972) also identified that most of the salmon spawning within the watershed takes place in the Killag River.

The WRSH watershed is home to one of the largest and longest Atlantic salmon restoration projects in Canada – the WRSH Acid Mitigation Project. Like most watersheds in the SU region, the WRSH has experienced acidification, reducing the habitat quality for spawning Atlantic salmon. Before intervention, the pH range of the main WRSH and Killag River was approximately 4.3-5.5 and 4.7-5.5, respectively (Halfyard, 2013). In an effort to improve the quality of fish habitat, the Nova Scotia Salmon Association (NSSA) with support from the Atlantic Salmon Federation and numerous other organizations has operated a continuous lime dosing station in the West River since 2005. A second lime dosing station was installed on the Killag River in 2017 (Figure 2, Appendix A). Their purpose is to increase the pH of the water to a range that is more suitable for juvenile Atlantic salmon (approximate pH levels of 5.5). As a result of Acid Mitigation Project, treated river pH has increased to 5.5-7.5 (Halfyard, 2013). The Acid Mitigation Project has also included physical habitat restoration within the West River, fine sediment removal from spawning habitat within the West and Killag Rivers, and terrestrial liming within the catchment area of Keef Brook (NSSA, 2020).

2.0 FIELD PROGRAM METHODOLOGY

This section summarizes the methods used during evaluation of fish and fish habitat conducted by MEL biologists at linear watercourses and waterbodies throughout the Beaver Dam Mine Site since the submission of the Revised EIS (Atlantic Gold, 2019). Initial watercourse and waterbody identification and characterization within the SA was conducted from 2015-2017 (refer to 2015-2017 Baseline Report,

Appendix H). Additional field delineation of watercourses occurred in 2019 and 2020 based on revisions to infrastructure layouts.

The 2019-2020 field program involved four main tasks within the SA:

- Seasonal trapping across multiple flow regimes within selected watercourses identified within and downstream of the proposed WRSA infrastructure footprint (Summer 2019 – Spring 2020);
- Environmental DNA (eDNA) sampling within selected watercourses identified within and downstream of the proposed WRSA infrastructure footprint;
- Three rounds of fish sampling (electrofishing and trapping) within watercourses and waterbodies predicted to be directly affected, indirectly affected, and within reference sites unlikely to be impacted by Project development (Summer 2020); and,
- Detailed fish habitat characterization and quantification of watercourses predicted to be directly and indirectly affected by Project development (Summer 2020).

2.1 Water Quality

In-situ water quality measurements were recorded at all electrofishing and trapping sites prior to each sampling event. In addition, water quality measurements were recorded for each watercourse reach delineated through detailed habitat assessments. These water quality measurements were collected using a calibrated YSI Multi-Probe water quality instrument or a combination of a Myron Ultrapen DO Pen Probe and Hannah Combo pH/Conductivity/TDS Probe at the time of the sampling event/survey.

2.2 Electrofishing (DFO Licence #341208)

Three rounds of quantitative and qualitative electrofishing surveys were conducted between June 1 and September 30, 2020 to identify seasonal fish usage within different parts of the SA. Sampling reaches of approximately 100 m in length were established within watercourses predicted to be directly impacted, indirectly impacted, and reference sites likely to be unimpacted by Project development (Figure 3, Appendix A). Electrofishing surveys were conducted under DFO Scientific Licence #341208. Direct impacts to fish and fish habitat will predominantly occur during the construction phase of the Project through activities such as mine site road construction, surface infrastructure installation and construction. Indirect impacts which may affect fish and fish habitat include changes in water quality and quantity. These will be described in the Updated EIS (Atlantic Gold, 2021).

Quantitative electrofishing sites were established in areas of confirmed or potential fish habitat within the SA with the goal of providing quantitative data on fish populations in selected watercourse reaches. Watercourse reaches with confirmed or potential fish presence were selected for quantitative surveys based on their locations relative to revised infrastructure layouts. These reaches were isolated by barrier nets to meet the conditions for accurate depletion method estimates. Quantitative electrofishing methodology is further described in Section 2.2.1.

Qualitative electrofishing surveys were performed in aquatic features with the goal of evaluating fish species presence and to measure relative abundance (catch per unit effort) as a function of electrofishing seconds. Electrofishing sites were established in particular aquatic features to confirm the presence of fish in particular features, and where potential barriers to fish passage may prohibit fish access, to support the determination of whether fish are present upstream of the barriers. Qualitative surveys were also performed in open water areas where habitat isolation could not be achieved. Qualitative electrofishing survey reaches were left open – no barrier nets were used to ensure the greatest likelihood of capturing any fish present. Qualitative electrofishing methodology is further described in Section 2.2.2.

Electrofishing was completed using guidance from a McCallum Environmental Ltd. Standard Operating Procedure (SOP) for Fish Collection (Appendix B). The methods and data collection forms outlined in the SOP were developed using the following sources:

- A review of fish sampling methods commonly used in Canadian freshwater habitats (Portt et al., 2006)
- New Brunswick (NB) Aquatic Resources Data Warehouse, the NB Department of Natural Resources and Energy, and the NB Wildlife Council (2002, updated 2006)
- Fisheries and Oceans Canada's Interim Policy for the Use of Backpack Electrofishing Units (2003)

Fisheries and Oceans Canada's Interim Policy for the Use of Backpack Electrofishing Units (2003) was reviewed and followed by all members of the electrofishing crew. This document provides a detailed list of standard equipment, safety, training, and emergency response procedure requirements for electrofishing. Each electrofishing crew consisted of two individuals, one of which (the crew lead) was a qualified person as defined under the DFO Interim Electrofishing Policy. The crew lead is responsible for operating the backpack electrofisher according to their training and the Policy, and for communicating safety policies and electrofishing procedures to the second crew member.

During the sampling period, a DFO Variation Order (FMO-2020-002) was in place prohibiting the fishing of eel under 10 cm in length (elvers). During electrofishing surveys, any eel observed to be less than 10 cm were noted but were left in place and not processed. As such, electrofishing reaches where juvenile eel were identified are presented in the results but are excluded in estimations of abundance as individual juvenile eel were not counted.

Fish were sampled using a Halltech Battery Backpack Electrofisher (HT-2000) with un-pulsed direct current (DC). A crew member walked alongside the electrofisher operator to net any stunned fish using a D-frame landing net (1/8" mesh). All captured fish were held in a live well containing ambient stream water, which was kept out of the sun and fish were checked regularly for any signs of stress. At the conclusion of each pass, fish in the live well were identified (species confirmation) and the first 50 individuals of each species were measured (length and weight). After recuperating, all fish were released back into the watercourse, downstream of the isolated reach.

2.2.1 *Quantitative Electrofishing*

The following seven sampling reaches were selected for quantitative electrofishing surveys in linear watercourses within the SA (Figure 3):

- WC5 (two reaches)
- WC13
- WC14
- WC23
- WC26
- Killag River

WC12 was also selected for fish collection surveys. During each fish survey round, WC12 was assessed, but during all rounds it was completely dry. As such, no fish collection by either electrofishing or trapping was completed in WC12.

Quantitative electrofishing was undertaken using barrier nets (1/8" mesh) that were secured to the stream bed at either end the reach to isolate an area of habitat within each watercourse. Within each isolated reach, a minimum of three passes with the electrofisher were completed. Additional passes were completed if depletion in catch was not obtained after the first three passes. If no fish were captured after two passes, the third pass was abandoned. The number and characteristics of fish collected during each pass were recorded so that quantitative fish population estimates could be calculated. The total seconds of electrofishing effort were also recorded.

Quantitative estimates of overall fish abundance were calculated using the multiple-pass depletion method (Lockwood and Schneider, 2000). The following conditions must be met for accurate depletion method estimates:

- Emigration and immigration by fish during the sampling period must be negligible. This was accomplished by establishing a "closed" reach by installing barrier nets at both upstream and downstream ends of the electrofishing reach;
- All fish within a specified sample group must be equally vulnerable to capture during a pass;
- Vulnerability to capture of fish in a specified sample group must remain constant for each pass (e.g. fish do not become more wary of capture); and,
- Collection effort and conditions which affect collection efficiency, such as water clarity, must remain constant. To minimize error, the amount of effort used on each pass was kept as consistent as possible.

Details of quantitative electrofishing locations and survey dates are provided in Table 2-1. Electrofishing locations are shown on Figure 3, Appendix A, and representative photos of each electrofishing reach and trapping location are provided in Appendix C (Photos 1-14).

Table 2-1: Quantitative Electrofishing Locations and Details

Electrofishing Location	**Stream Order**	**Tertiary Watershed**	**Survey Dates**	**Upstream Coordinates**		**Downstream Coordinates**		**Reach Length (m)**[1]
				Easting	**Northing**	**Easting**	**Northing**	
WC5 Reach A	1	Killag River	June 9 July 7 August 25	521674	4989815	521656	4989907	95
WC5 Reach B	3	Killag River	June 17 July 6 August 25	521553	4990351	521481	4990390	95
WC13	2	Killag River	June 10 July 6 August 26	522760	4990137	522730	4990167	86
WC14	1	Killag River	June 10[2]	522697	4990232	522762	4990250	44

Electrofishing Location	Stream Order	Tertiary Watershed	Survey Dates	Upstream Coordinates		Downstream Coordinates		Reach Length (m)[1]
				Easting	Northing	Easting	Northing	
WC23	1	Cope Brook	June 16 July 9	519693	4989358	519708	4989288	74
WC26	1	Killag River	June 15 July 7 August 25	520182	4990851	520125	4990924	102
Killag River	4	Killag River	June 11 July 8 August 26	523580	4990014	523350	4989953	95

[1] Field crews attempted to establish 100 m linear sampling reaches but were often limited by site conditions and overall watercourse length.

[2]Only 1 round of fishing was conducted on WC14 due to dry channel conditions during Rounds 2 and 3.

2.2.2 *Qualitative Electrofishing*

To increase sampling efficiency and improve information for streams with expected low abundance, qualitative electrofishing surveys employed an "open" site methodology – no barrier nets were used as there was greater chance of setting up a closed site where no fish were present. One pass with a backpack electrofisher was performed unless crew members noted a high number of fish that evaded capture. In that case, a second or third pass was performed to obtain greater species representation. In the Salmonid Field Protocols Handbook: Techniques for Assessing Status and Trends in Salmon and Trout Populations, Temple and Pearsons (2007) describe the use of single-pass electrofishing without barrier nets and provide a summary of academic reports supporting this method (Johnson et al., 2007). Though the technique does not support estimates of absolute abundance or population estimates, research has found that single-pass electrofishing works well to determine species richness (Simonson and Lyons, 1995), and relative abundance (Kruse et al., 1998).

Qualitative electrofishing was performed within aquatic features within and downstream of the proposed WRSA infrastructure footprint to support the understanding and determination of waters frequented by fish. Watercourses 20-22, and within standing water within their associated wetland habitats (WL205 and WL220) were surveyed 9 times through the sampling period. Instead of conducting surveys in distinct reaches, electrofishing was conducted wherever water depths were sufficient to submerge the anode probe throughout these habitats to maximize the electrofishing effort and coverage to the greatest extent practicable. WC23 was originally electrofished as a closed reach but was switched to a qualitative, open reach after successive attempts at quantitative electrofishing (2 rounds) revealed extremely low catch numbers. All aquatic features within or downstream of the proposed WRSA footprint fall within the Cope Brook tertiary watershed and are considered first order streams.

A single qualitative electrofishing survey was also performed within an open water feature of WL56 to confirm fish presence. Flooding within this wetland is the result of historic mine workings, but the wetland has been assessed as potentially seasonally connected to downstream, known fish-bearing features (WL59). This open water feature falls within the Killag River tertiary watershed. Qualitative, as opposed to quantitative electrofishing, was performed due to site characteristics present within WL56 and the inability to isolate the sampling location.

Qualitative species abundance estimates were calculated using electrofishing Catch-per-Unit Effort (CPUE) indices, standardized to 300 seconds of effort (Scruton and Gibson, 1995).

Details of qualitative electrofishing locations and survey dates are provided in Table 2-2. Electrofishing locations are shown on Figure 3 and 4, Appendix A.

Table 2-2: Qualitative Electrofishing Locations and Details

Electrofishing Location	Survey Dates	Upstream Coordinates (UTM)		Downstream Coordinates (UTM)	
		Easting	Northing	Easting	Northing
WC21/WL220	June 8 June 17 July 3 July 9 July 28 August 21 August 27 September 21 September 28	519916/520057	4990200/4990163	519954/520094	4990185/4990142
WC20/WC22/ WL205	June 8 June 17 July 3 July 9 July 28 August 21 August 27 September 21 September 28	520056	4989898	520015	4989883
WC23	July 3 August 21 August 27	519642	4989352	519710	4984205
WL56	September 30	Central location = 522025 mE, 4990383 mN			

2.3 Trapping (DFO Licence #341208 and #357626)

Prior to Summer 2020, the overarching goal of the fish collection program (developed in consultation with DFO and Wood) was to saturate selected watercourses with a variety of gear types for extended periods of time in order to clearly establish the presence of fish during a range of seasonal flow conditions and ecological periods such as spring spawning. An extended scientific license (#357626) was obtained which allowed MEL to deploy passive gear types (i.e. minnow traps, fyke nets and eel pots) past September 30th and prior to June 1st, when fish collection is not typically permitted. It is important to note that while trap set times often extended across multiple days, passive gear for fish collection (eel pots, minnow traps and fyke nets) were checked at every 24 hours. Any fish captured were identified, measured and released at this time.

During the Summer 2020 fishing program, trapping was used to supplement fish collection efforts when electrofishing was not practical (e.g. in open water areas, unconsolidated substrate, temperatures exceeding 22°C, etc.). At each sampling location, MEL biologists placed fyke nets, eel pots, minnow traps, or any combination thereof depending on physical habitat characteristics to capture and record fish presence to support qualitative descriptions of habitat usage and relative abundance. The fyke nets were fixed in place by stakes driven into the substrate of the watercourse or waterbody through each wing of the net. Eel pots and minnow traps were baited with cat and dog food. At each lentic sampling location, traps were placed in the shallow, in-shore littoral zone.

The selection of gear types was driven primarily by habitat and by survey timing. It is important to note that all gear types have certain limitations, including but not limited to catch selectivity and sampling efficacy. The best fish collection studies employ a variety of gear types to sample as many habitat types as possible, thus ensuring the widest possible range of fish species and sizes are collected (Port et al., 2006).

CPUE was determined for each trap type based on trapping effort, which was calculated as total catch per wetted hour.

Details of fish collection locations, survey dates, and traps deployed provided in Table 2-3. Trap locations are shown on Figures 3 and 4, Appendix A. Detailed information on trap locations, survey effort and fish capture results are presented in Appendix E.

Table 2-3: Trapping Locations and Details

Trapping Location	Stream Order	Tertiary Watershed	Survey Dates	Traps Deployed[1] (#)
WC20/WC22/ WL205	1	Cope Brook	September 9-10, 2019 September 17-18-2019 November 6-7, 2019 November 21-22, 2019 December 4-5, 2019 December 16-17, 2019 April 8-9, 2020 April 22-23, 2020 May 13-15, 2020 May 18-20, 2020 May 25-29, 2020	MT(3) MT(3) MT(3) MT(5) MT(5) MT(5) MT(5) MT(6), EP(1) MT(11), EP(3), FN(1) MT(20), EP(6), FN(2) MT(28), EP(2), FN(1)
WC21/WL220	1	Cope Brook	September 9-10, 2019 September 17-18-2019 November 6-7, 2019 November 21-22, 2019 December 4-5, 2019 December 16-17, 2019 April 8-9, 2020 April 22-23, 2020 May 13-15, 2020 May 18-20, 2020 May 25-29, 2020	MT(1) MT(1) MT(1) MT(1) MT(1) MT(1) MT(1) MT(1) MT(6), EP(1) MT(4), EP(1) MT(2), EP(1), FN(1)
WC23	1	Cope Brook	November 6-7, 2019 November 21-22, 2019 December 4-5, 2019 December 16-17, 2019 April 8-9, 2020	MT(2) MT(2), FN(1) MT(2), FN(1) MT(2), FN(1) MT(2), FN(1)

Trapping Location	Stream Order	Tertiary Watershed	Survey Dates	Traps Deployed[1] (#)
			April 22-23, 2020 May 13-15, 2020 May 18-20, 2020 May 25-29, 2020	MT(1), EP(1), FN(2) MT(6), EP(1), FN(1) MT(16), EP(5), FN(2) MT(16), EP(1), FN(1)
Cameron Flowage	4	Killag River	June 10-11, 2020 July 7-8, 2020 August 26-27, 2020	MT(10), EP(3), FN(1) MT(10), EP(2), FN(1) MT(8), EP(2), FN(1)
Crusher Lake	N/A	Killag River	June 8-9, 2020 July 6-7, 2020 August 25-26, 2020	MT(10), EP(3), FN(1) MT(10), EP(2), FN(1) MT(8), EP2), FN(1)
Mud Lake/WC27 (Outlet)	N/A/3	Killag River	June 15-16-2020 July 7-8, 2020 August 26-27, 2020	MT(10), EP(3), FN(1) MT(10), EP(2), FN(1) MT(8), E(2), FN(1)
WL59	N/A	Killag River	June 9-10, 2020 July 6-7, 2020 August 25-26, 2020	MT(10), EP(3), FN(1) MT(10), EP(2), FN(1) MT(8), EP(2), FN(1)

[1]Trap Types - Eel Pot (EP), Fyke Net (FN), Minnow Trap (MT).

2.4 eDNA

Environmental DNA (eDNA) is a well-established technique which identifies environmental or exogenous DNA molecules from aquatic or semi-aquatic organisms. The premise of eDNA is that all organisms shed genetic material into the environment: water samples are collected, filtered and analyzed using a qPCR (quantitative polymerase chain reaction) technique to extract eDNA and identify organisms present within the aquatic environment. When genetic material found in the collected water sample matches with a known genetic primer for the target species or taxa, a positive result is provided by the production of fluorescence in the qPCR process. Genetic primers can be species-specific (i.e., based on matching 20 base pairs of a genetic sequence), or generic (i.e., identifying presence of particular taxa such as fish, amphibians, etc., based on a shorter genetic sequence of 10 base pairs). One example of a generic test is the eFish primer, developed by the University of Victoria, and used extensively by Bureau Veritas (BV) Laboratory (Bureau Veritas, n.d.).

MEL completed a study design through consultation with Wood and BV, to identify presence of fish in aquatic habitats underlain by the proposed WRSA using the eFish primer. Study design was completed to include two sites with confirmed or suspected fish presence, and four sites where fish presence was not expected based on habitat assessments and fish collection completed from September 2019 through July 2020 (Figure 5). To date, fish collection effort has only resulted in identification of brook trout at Site 5, which is located on WC23. Fish collection has not been completed at Site 6; however, habitat assessments and a desktop review have identified contiguous surface flow between Sites 5 and 6, so it is expected that Site 6 is accessible to fish as well. Sample locations 1 through 4 were selected within watercourses 20 and 21, and within standing water within their respective wetland habitats. These sites are expected to be inaccessible to fish, based on the presence of the subterranean barrier between WC21 and WC23. Sample locations are shown on Figure 5, Appendix A.

Typically, sample timelines are chosen to reflect the highest genetic output of the target species. Given that the eFish primer targets the entire taxa rather than an individual species, the sample timing was selected based on flow regimes and highest potential for access into upstream habitats, rather than based on seasonally high genetic output windows for an individual species. The study design involved sample collection during early July of 2020, based on regional hydrometeorological data, which suggests the highest flow regime occurs through April and into May (ECCC, 2020). If fish were to move upstream into these habitats upstream of the subterranean barrier between WC23 and WC20, eDNA should be present in the water when sampled in early July. Furthermore, July sample collection would detect any resident populations of forage fishes.

Sample collection was completed on July 9, 2020. Standard protocols outlined by the British Columbia Ministry of Environment (MOE) were strictly adhered to for sample collection, labelling, filtration and sanitization between samples at every stage of the process (BC Ministry of Environment, 2017). Sample filtration occurred in the evening of July 9, 2020.

Filtered, preserved eDNA samples were shipped via courier to BV Laboratory in Guelph, Ontario, within a week of sample collection. Samples, once filtered and preserved, remain stable for months, if not longer. A detailed Chain of Custody (CoC) accompanied the samples, and an electronic version of the sample collection and filtration data was provided to BV via e-mail.

Prior to the submission of eDNA samples, MEL collected a fin clip sample of genetic DNA (or gDNA) from a brook trout (*Salvelinus fontinalis*) identified within the Beaver Dam Mine Site. The sample was submitted to BV laboratory to confirm detection of this species using the eFish primer, which had not previously been tested using this species. BV laboratory confirmed detection of the brook trout gDNA using the eFish assay (e-mail confirmation is provided in Appendix D).

The laboratory completed a quantitative polymerase chain reaction (qPCR) analysis with each sample, using the eFish primer assay to identify presence of fish DNA in each sample. The laboratory assay includes checks for false positive and false negative errors in the laboratory analysis stage. This includes a check for DNA integrity, assay inhibition and contamination using the field blank (negative control).

To improve detection probability and statistical confidence in assay results, each sample is analyzed using eight technical replicates per sample, on each of the three field replicates per Site. The results are presented as a fraction of eight; the numerator indicates the number of detections (amplification of fish DNA) observed in the qPCR analysis out of the eight technical replicates. As each site contains three samples, results are provided for 1A, 1B, and 1C (and so on); the interpretation of the overall site result is determined considering the results of all three replicates per site. Interpretation of the sample results is as follows (NRTG, 2019):

- If any replicate yields ≥3/8, the interpretation of that result is positive, or the target species or taxa has been detected.
- If at least one replicate yields a positive qPCR result for 2/8 runs and the other replicates yield a score >0 the site is categorized as suspected. The Site is categorized as suspected if result is 2/8 for all three replicates, 2/8 for two replicates and 1/8 or 0/8 for third. The target species or taxa is not confirmed to be present but is suspected and is determined based on site specific information or further studies.
- If no replicate yields a positive qPCR result >1/8 runs the site is categorized as negative. The Site is considered negative if the result is 0/8 or 1/8 (no higher) for all replicates. This site can be interpreted as negative if the site is 2/8 for only one replicate regardless of the other two

replicates. If result is 2/8 for one and 1/8 or 0/8 for the other replicates. The target species or taxa is not detected.

2.5 Detailed Fish Habitat Surveys

Detailed fish habitat surveys were completed for watercourses providing fish habitat predicted to be directly and indirectly affected by Project development. Fish habitat characterization was completed using guidance from the MEL Standard Operating Procedure for Fish Habitat Assessments in the lotic environment (Appendix B). The methods outlined in the SOP were derived from the following sources:

- The Nova Scotia Fish Habitat Assessment Protocol: A Field Methods Manual for the Assessment of Freshwater Fish Habitat (NSLC, 2018);
- DNR / DFO – New Brunswick Stream Habitat Inventory Datasheets;
- Standard Methods Guide for the Classification and Quantification of Fish Habitat in Rivers of Newfoundland and Labrador for the Determination of Harmful Alteration, Disruption and Destruction of Fish Habitat (DFO, 2012a);
- Reconnaissance (1:20,000) Fish and Fish Habitat Inventory (RIC, 2001);
- The US EPA Rapid Bioassessment Protocols For Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates, and Fish (Barbour et al., 1999); and,
- The Canadian Aquatic Biomonitoring Network Field Manual, Wadeable Streams (EC, 2012).

To support fish habitat assessment, each surveyed watercourse was delineated into individual reaches defined by discrete homogeneous units (e.g., riffle, run, pool, flat, etc.) as determined in the field in an upstream to downstream direction. Each habitat type contains discrete gradient, substrate types, water depth, and velocity ranges which have been determined using the described biological 'preferences' outlined in Grant and Lee (2004), whenever possible. In smaller, first-order streams, habitat types were often found to be extremely short and variable. For efficiency in the field, when individual habitat types were less than five m in overall length, they were be grouped together into one reach containing multiple smaller habitat units. The upstream and downstream ends of each reach were recorded with handheld GPS device. Fish habitat reaches are presented on Figures 6-9, Appendix A.

For each reach (i.e., homogenous section of watercourse), a detailed fish habitat survey was completed which included water quality measurements, designation of substrate and cover types, riparian habitat descriptions, and barrier assessments. Cross-sectional measurements (transects) were established to describe morphological (i.e., channel and wetted widths, bank heights) and flow characteristics (i.e., velocities and depths) within the reach. Transect measurements were recorded at every 50 m length of reach – for example, if a reach was 150 m in total length, three transects were established within the reach. If multiple habitat types (<5 m in length) were grouped together to form a reach, transects were established within each habitat type represented within the reach. The amount of transects and transect locations were selected and modified as needed in the field based on specific habitat features observed, or limitations related to access, wadeability, and safety concerns.

There have been many habitat descriptions and habitat survey methodologies developed and used both within Atlantic Canada and elsewhere. The former Beak (1980) method, which has previously been used to characterize habitat is limited by its focus on salmonid species, mainly Atlantic salmon (*Salmo salar*) and to a lesser degree brook trout (*Salvelinus fontinalis*), as evident in the descriptions. The revised classification system used within this document attempts to broaden the classification of habitat types to encompass all freshwater species, thereby contributing to a more consistent approach to HADD quantification (DFO, 2012a).

For shallow (<2 m) open water features (e.g. the ponded area of WL59), depth and substrate checks were performed at various locations throughout the feature, and any cover types (vegetation, woody debris, large substrate) were documented and total cover (%) was estimated.

Modified fish habitat surveys were performed within a 1.7 km stretch of Cameron Flowage/Killag River from December 8-16, 2020. Nine cross-sectional measurements were taken at representative habitats throughout the system by boat or on foot depending on wadeability at the transect location. Widths, depths, velocities, and substrate observations were recorded whenever possible. When surveying by boat and wading was not possible due to high flows, measurements were taken from the shoreline.

2.5.1 *Fish Passage Assessment*

According to Bourne et al. (2011), and Fullerton et al. (2010), understanding a fish's ability to navigate through or over obstacles can be difficult to define and measure, as it combines the physical characteristics of a barrier with fish physiology in a dynamic environment. Much of the literature surrounding barriers to fish passage is related to anthropogenic features such as culverts (i.e. Bourne et al., 2011; Fisheries and Oceans Canada, 2015), or natural obstacles such as waterfalls (i.e. Government of British Columbia, 1998), but specific assessments for passability of subterranean watercourses or boulder-fields are limited. Parameters which affect passability for commonly researched barriers such as waterfalls or culverts can be applied to other types of impediments such as subterranean reaches. Features such as the species of interest and their swimming capability, the variability in stream flow, length of the barrier, slope, drop height and outflow pool are all to be taken into consideration when determining the passability of an obstacle.

Throughout baseline watercourse mapping and fish habitat surveys, an assessment of potential fish passage obstacles was completed. When a potential obstacle is encountered, biologists recorded the type of obstacle, height and length of the obstacle, depth of water, along with an estimate of slope where relevant. The contiguity and spatial relationships of discontinuous pools are described, with the intent of understanding a fish's ability to move and/or jump from one step-pool or isolated pool to another. When discontinuous pools were observed, biologists walked the most obvious flow path based on topography while identifying individual pools. Each pool was marked with a GPS unit, measured (maximum length and width) and water depth was recorded in order to determine the extent and depth of water from which fish would have to jump from one pool to another. In addition, the distance between one pool and the next was measured along the most obvious flow path, with the goal of identifying the distance and vertical height a fish would have to travel.

If a potential barrier is an anthropogenic in nature (i.e. improperly installed culverts), the type of culvert is noted, along with any issues associated with installation that could be remediated to improve passage. The temporal nature of an obstacle is noted as well, recognizing that natural and anthropogenic barriers can change with time (i.e. logjams or beaver dams) or remediation (i.e. culvert installation), while others limit passage seasonally (i.e. ephemeral or intermittent streams), and others may be permanent barriers (i.e. some waterfalls). Where an obstacle was identified but the temporal nature of it was uncertain or if it was dependent on flow regime, multiple site assessments and additional fish sampling were conducted to confirm its passability. Except in extreme circumstances, logjams and beaver dams are not considered barriers to fish passage.

Further to the typical physical characteristics, the ecological context was used to identify evidence of flow and hydrologic connectivity that would provide passage for fish. NSE guidance for watercourse determination is used to support the discussion of whether a regulated watercourse (i.e. defined, natural channel). This guidance includes identifying whether:

- a mineral soil channel is present;
- there is sand, gravel and/or cobbles evident in a continuous pattern over a continuous length with little to no vegetation;
- there is an indication that water has flowed in a path for a length of time and rate sufficient to erode a channel or pathway;
- there are aquatic plants, animals, or fish; or,
- there is aquatic vegetation.

Hydrology indicators are used to identify evidence of flow if an initial assessment occurs during a period of low flow. Some examples of hydrology indicators used include water marks on trees, sediment deposits, drift deposits, algal mats, sparsely vegetated concave surface, water-stained leaves, surface soil cracks, drainage patterns, or moss trim lines. Vegetation communities can provide indication of flow (or absence thereof) as well. The presence of some species provides evidence of flowing water, even if the water level has subsided. These include but are not limited to species such as bur-reed (*Sparganium* spp.), royal fern (*Osmunda regalis*), and certain species within the genera *Glyceria*, *Juncus*, and *Carex*, to name a few. Guidance on vegetation species habits was provided by the Wetland indicator Plant List (Reed, 1988). Vegetative growth patterns, including growth and species composition of mosses, can provide evidence of water level fluctuations as well. Within the Beaver Dam Mine Site, bare rocks or boulders have not been considered as a reliable indicator of hydrology, based on deposition of glacial erratics through the SA, and presence of bare rocks and boulder fields in both upland, wetland and lotic habitats. As such, the observation of bare rocks is not considered a strong indicator of hydrology.

Understanding the swimming capabilities of fishes is key to the determination of barriers to fish passage. Swimming capabilities of fishes is dependent upon abiotic factors such as water depth, flow rate, water temperature, height and length of obstacles, and biotic factors such as fish species, length, darting speed, behavioral adaptations, and life history stage. Plunge-pool depth appears to be a common thread in determining fish passage ability through obstacles of various types. In a waterfall scenario, turbulent water in a shallow plunge pool can disorient fish. If a pool is too shallow, fish may not build the appropriate propulsive force to jump out of a pool – regardless of whether that pool is part of a waterfall, a subterranean reach, or another barrier type such as a culvert. Generally speaking, “fish need a pool depth at least two times as deep as the fish is long in order for the fish to achieve maximum leaping ability” (Meixler, Bain, and Walter, 2009).

The following species are known or expected to be present within the West River Sheet Harbour system: American eel, Atlantic salmon, banded killifish, brook trout, brown bullhead, golden shiner, lake chub, ninespine stickleback, northern redbelly dace, white sucker and white and yellow perch. Swimming capabilities herein will be focused on non-forage fish species of American eel, Atlantic salmon, brook trout, white sucker, and white and yellow perch, as specific detailed studies of forage fish swimming abilities are limited in availability and specificity.

Atlantic salmon are known to be present within the West River Sheet Harbour watershed, as documented by regional electrofishing programs outlined by Bowlby, Gibson, and Levy (2013). Four Atlantic salmon were captured in the Killag River during baseline fish surveys completed in 2020 (98-111 mm). Atlantic salmon are strong swimmers and can jump to heights of more than 3 m. In general, a minimum water depth of 30.5 cm should be provided in a pool below an obstacle (Evans & Johnston, 1980). Salmonids have been shown to pass through pool-and-weir, Denil, vertical-slot and nature-like fishways with almost 100% efficiency, with highest passage results in nature-like fishways (Roscoe & Hinch, 2008; Bunt, Castro-Santos & Haro, 2011). Chanseau, Croze and Larinier (1999) found that Atlantic salmon were able to pass over weirs less than 1.5 m within 24 hours, whereas weirs over 2.5 m required either longer attempt periods, or were unpassable. The jump pool depth must be at least 1.5 times the jump height (United States Department of Agriculture, 2007). Newton et al. (2018) found Atlantic salmon with smaller fork lengths and low fat contents that exerted greater searching efforts for passage channels were more likely to have successful first attempts of passage across barriers. Sigourney et al. (2015) also found larger salmon were less likely to successfully ascend barriers, as larger caudal fins are less efficient in the shallower waters preceding barriers. Fishways with excessive turbulence (Mallen-Cooper & Brand, 2007) will challenge upstream migration.

American eel were captured at four locations across the Beaver Dam Mine Site (WC13, WC27, Killag River and Cameron Flowage) and were identified in several watercourses through the Haul Road, ranging from 10-64 cm. American eel, particularly immature yellow eels, are capable of climbing vertical surfaces, provided they are rough and wet (GOMC, 2007). It has been documented that American eel are not restricted to contiguous watercourses as they possess the ability to traverse over land in wet, low lying grass habitats (MacGregor, 2011). Eel can, therefore, navigate across systems which do not even meet the regulatory definition of a watercourse. As such, it is our opinion that this is an inappropriately low threshold to meet when determining waters frequented by fish and identifying the spatial and temporal scale of fish habitat.

Brook trout are known to be present within the Beaver Dam Mine Site and Haul Road PA. During fish collection surveys, 194 brook trout were observed (186 in the Mine Site, 8 along the Haul Road), ranging in size between 3-19 cm. Brook trout are relatively strong swimmers, capable of navigating barriers from 4.7-7.7 times their body length. Kondratieff and Myrick (2006) found that in a controlled environment mimicking waterfall conditions with water temperatures at 11˚C, the highest obstacle jumped by 8.6-34 cm brook trout was 73.5 cm, provided plunge pool depth was at least 40 cm. According to Kondratieff and Myrick (2006) "Shallow pools severely limited jumping ability, brook trout only being able to jump a maximum of 33.5 cm from a 10-cm pool".

White sucker were identified in Cameron Flowage, the Killag River, WC13 and WC27 and in two watercourses along the Haul Road PA (WC-N and WC-AA), ranging in length between 2 cm and 24 cm. White sucker are not particularly strong swimmers based on physical characteristics and have been shown to actively seek out slower moving waters by Haro, Castro-Santos, Noreika and Odeh (2004). Underwood, Myrick and Compton (2014) determined that white sucker is generally a slow swimmer, lacking the behavioral adaptations to higher flow shown by other sucker species (i.e. station holding, and mouth holding). While they may not show station holding and mouth holding behaviors of other sucker species, Rahel and McLaughlin (2018) found that compared with walleye (which has similar swimming capabilities to white sucker) that when faced with a barrier, white sucker showed a higher attempt rate, resulting in a higher passage rate. Garadunio (2014) found that white sucker are capable of navigating a barrier (i.e. a waterfall) up to 86% of their total length, with smaller individuals showing more success navigating barriers than larger individuals (based somewhat on repeated attempts by smaller fish). Shallow plunge pool depth is a limiting factor for this species, particularly for larger fish.

Yellow perch were captured during fish collection in Cameron Flowage, the Killag River, and WC27, and a single yellow perch was collected along the Haul Road (in WC-N – West River Sheet Harbour). The 45 yellow perch identified ranged in size between 4 and 18 cm. Generally speaking, of the species listed above, yellow perch are weak swimmers. White perch have not been observed during any fish collection surveys within the Beaver Dam Mine Site or Haul Road but have been documented within the West River Sheet Harbour watershed (Alexander, Kerekes & Sabean, 1986, Halfyard, 2007). Yellow perch swimming speed is relatively low, and their performance is strongest when water temperatures are in the range of 20-25˚C (Brown et al., 2009). Meixler et al. (2009) found that neither yellow nor white perch could navigate the smallest barrier they faced (0.3 m in height).

3.0 RESULTS

3.1 Water Quality

Water quality results are reported and discussed as it relates to the chemical characteristics required for suitable fish habitat. Where applicable, water quality sampling results are measured against the CCME Guidelines for the Protection of Freshwater Aquatic Life (FWALs). Summaries of water quality measurements are presented in Table 3-1 and Table 3-2**.** for sampling conducted during fish surveys and detailed habitat descriptions, respectively. Water quality measurement sites, which include watercourse reaches and fish survey locations, are presented on Figures 3, 4, and 6-9, Appendix A.

Table 3-1. Summary of In-situ Water Quality Measurements recorded during Electrofishing and Trapping Surveys

Site	Sampling Dates	Water Temp (°C)	pH	DO (mg/L)	Conductivity (µS/cm)	TDS (mg/L)
WC5 Reach A	June 9	11.6	5.55	9.10	18.2	16.25
	July 7	17.3	6.00	6.50	29.7	22.75
	August 25	17.6	5.64	**3.41**	52.1	39.65
WC5 Reach B	June 17	15.5	5.30	**4.80**	17.3	13.65
	July 6	17.1	-	**5.30**	18.7	14.30
	August 25	20.2	5.73	**1.97**	65.3	46.15
WC13	June 10	15.9	6.62	5.90	32.2	25.35
	July 6	20.4	6.43	**4.50**	33.6	24.05
	August 26	21.0	6.33	**4.10**	36.3	25.35
WC14	June 10	8.3	6.36	10.4	15.9	14.95
WC20	April 23	3.9	**4.51**	8.67	-	15.60
	May 28	12.9	**4.11**	**4.38**	22.1	16.90
	June 8	9.5	5.00	**5.10**	18.5	16.90
	June 17	13.7	**4.50**	**3.50**	19.2	16.90
	July 9	12.5	**4.84**	6.30	25.5	21.45
	July 28	17.1	**4.86**	**1.77**	23.9	18.20
	August 21	14.6	5.31	**3.10**	34.2	27.95
	September 21	9.9	**4.44**	6.10	27.9	25.35
	September 28	14.6	**4.9**	**1.89**	38.8	31.20
WC21	April 23	3.7	**4.18**	6.03	-	17.55
	May 14	6.6	**4.24**	7.27	17.6	17.55
	May 15		**4.18**	6.30	17.9	

Site	Sampling Dates	Water Temp (^oC)	pH	DO (mg/L)	Conductivity (µS/cm)	TDS (mg/L)
	June 8	6.9	**4.68**	**4.20**	22.9	17.55
	June 17	11.0	**4.50**	**2.70**	21.3	20.15
	July 9	13.7	**4.72**	**3.10**	29.4	17.55
	July 28	15.9	**4.50**	**1.25**	32.7	23.40
	August 21	17.8	**4.53**	-	31.2	24.70
	August 27	16.0	**4.63**	**1.53**	32.1	24.70
	September 21	15.3	**4.96**	**1.60**	23.6	25.35
	September 28	11.9	5.06	**2.64**	43.3	20.80
		14.5				35.10
WC23	April 23	2.5	**4.33**	11.29	-	17.55
	May 14	4.8	**3.43**	11.04	16.8	17.55
	May 15	4.6	**3.50**	11.34	16.6	17.55
	May 28	9.9	5.21	-	16.8	14.95
	June 16	14.0	5.03	10.2	19.1	15.60
	July 3	14.8	5.27	7.06	42.1	32.50
	July 9	11.8	**4.74**	8.09	24.1	20.80
	August 21	11.3	5.18	7.31	20.3	18.20
	August 27	11.0	5.17	7.63	20.6	18.20
WC25	September 30	15.6	6.0	**3.60**	49.0	39.00
WC26	June 15	18.0	5.90	**2.70**	20.9	16.25
	July 7	19.4	**4.96**	**2.72**	40.8	29.25
	August 25	20.0	5.13	**2.60**	27.3	19.50
WC27 (Mud Lake Outlet)	June 15	17.8	5.42	8.00	27.2	19.50
	July 7	16.6	5.74	6.29	28.7	22.10
	August 26	17.3	5.23	6.93	19.7	14.95
WL56	September 30	19.3	5.18	**4.6**	50.9	37.05
WL59	June 9	21.0	7.03	8.40	56.7	40.95
	July 6	18.9	6.50	**3.00**	97.3	71.50
	August 25	22.9	6.68	6.50	34.3	23.40
Cameron Flowage	June 10	19.2	6.41	7.40	22.1	16.90
	July 7	22.9	6.62	5.90	36.6	24.70
	August 26	24.5	5.54	8.20	24.9	16.25
Crusher Lake	June 8	18.7	5.40	8.00	16.5	12.35
	July 6	17.2	5.23	6.05	16.9	13.00
	August 25	19.7	5.35	**1.56**	30.9	22.10
Killag River	June 11	16.0	6.24	8.40	17.5	14.30
	July 8	17.5	6.35	5.70	26.1	19.50
	August 26	20.6	6.07	6.62	24.8	17.55

Note: Values in bold indicate parameters recorded as below CCME guidelines for the protection of aquatic life, including: DO levels not suitable for any life stage of warm or cold-water fish species (<5.5 mg/L) (1999), and pH levels below 5.0 (CCREM, 1987). Missing measurements reflect equipment malfunctions in the field.

Table 3-2. Summary of In-situ Water Quality Measurements recorded during Detailed Fish Habitat Surveys (2020)

Site	Reach #	Sampling Date	Water Temp (^oC)	pH	DO (mg/L)	Conductivity (µS/cm)	TDS (mg/L)	Turbidity[1]
WC5[2]	1	July 14	23.1	5.35	6.51	20.0	-	C
	2	July 14	24.0	5.42	5.88	21.0	-	C
	3	July 14	24.4	5.43	5.95	20.0	-	L

Site	Reach #	Sampling Date	Water Temp (°C)	pH	DO (mg/L)	Conductivity (µS/cm)	TDS (mg/L)	Turbidity[1]
	4	July 14	22.4	5.11	**4.62**	24.0	-	M
	5	July 15	22.1	5.11	**5.04**	23.0	-	L - M
	7	July 15	23.1	5.35	6.51	20.0	-	C
	8	July 15	24.0	5.42	5.88	21.0	-	C
WC13	1	July 13	23.4	6.41	7.06	35.0	-	C
	2	July 13	24.2	6.1	6.75	35.0	-	C
	3	July 13	24.7	6.54	6.26	35.0	-	C
	4	July 13	25.9	6.31	5.69	42.0	-	L - M
	5	July 13	25.6	6.33	6.21	41.0	-	L
WC14	1A	July 13	23.5	5.36	6.09	23.0	-	C
WC14	1B	July 13	17.9	5.99	7.05	26.0	-	C
WC14	2	July 13	16.1	5.81	6.52	24.0	-	C
WC20	1	July 17	14.4	**4.79**	**3.50**	25.0	20.15	C
WC21	1	July 17	15.1	**4.47**	**2.60**	30.0	25.35	C
	2	July 17	15.1	**4.46**	**2.40**	31.5	25.35	C
WC22	1	July 17	15.1	**4.82**	**4.00**	25.0	20.15	C
WC23	1	July 16	12.9	5.01	8.50	22.8	19.20	C
	2	July 16	13.2	**4.76**	7.70	23.3	19.50	C
	3	July 16	13.3	**4.73**	8.50	23.7	20.15	C
WC26	1	July 16	19.3	5.15	**4.88**	30.0	-	M
	2	July 16	15.8	**4.87**	6.09	31.0	-	L
WC27	1	July 22	22.7	5.39	**3.70**	29.7	-	C
WL59	N/A	July 21	23.2-27.0	6.33-6.91	**3.82**-9.21	25.6-74.1	16.25-55.5	L

Note: Values in bold indicate parameters recorded as below CCME guidelines for the protection of aquatic life, including: DO levels not suitable for any life stage of warm or cold-water fish species (<5.5 mg/L) (1999), and pH levels below 5.0 (CCREM 1987). Missing measurements reflect equipment malfunctions in the field.

[1]Turbidity assessed visually as Clear (C), Light (L), Moderate (M), or Turbid (T)

[2]WC5 reach 6 not sampled – classified as "no defined channel"

3.1.1 *Temperature*

Water temperature affects the metabolic rates and biological activity of aquatic organisms, thus influencing the use of habitat by aquatic biota. There are no CCME guidelines related to temperature and aquatic biota. Temperature preferences of fish vary between species, as well as with size, age, and season.

Salmonids are cold-water fish species, meaning they require cold water to live and reproduce (Bowlby et al., 2014). The optimal temperature range for these species (growth of juvenile) is 10-20˚C (The Stream

Steward n.d.) to 16-20˚C (DFO, 2012b) (brook trout and Atlantic salmon, respectively). The Nova Scotia Trout Management Plan (NSDAF, 2005) identifies three classes of streams based on water quality and pH for trout species. Class A streams (cool) require the average summer temperature to be <16.5˚C. Class B streams (intermediate) temperature (average summer) ranges from 16.5-19˚C. Finally, Class C streams (warm) require temperatures above 19˚ or pH of <4.7 (NSDAF, 2005). The identification, maintenance, protection, and enhancement of instream habitats of Class A and Class B waters can benefit the Brook trout fishery.

Other species documented within the SA have higher temperature ranges: Yellow Perch 21-24˚C (Brown et al., 2009), and white sucker 19-26˚C (Kelly, 2014). American eel have a broader temperature range and can tolerate temperatures from 4 to 25 ºC (Fuller et al., 2019).

The results shown in the tables above generally provide a snapshot of temperatures from early (June), mid (July), and late summer (August) for watercourses and waterbodies within the SA. Throughout the SA, recorded summer temperatures ranged from widely, from 8.3℃ in WC14 to 27℃ in the flooded portion of WL59.

Within the Killag River tertiary watershed, most watercourses displayed a general warming trend from early to late summer, with the majority of sites measuring at or above 20℃ by the end of August. Consecutive temperatures recorded upstream to downstream during habitat assessments were relatively consistent throughout each watercourse, ranging within a couple degrees. WC14 displayed the largest temperature range, from 23.5℃ in the northern branch (A) of the watercourse, to 16.1℃ below the confluence of the two branches. This temperature difference would suggest groundwater seeps contributing to the lower portion of the watercourse. WC26 also displayed a trend of decreasing temperature trend towards its downstream extent (19.8℃ to 15.8℃), which can be attributed to increasing water depths and shade towards its confluence with the Killag River. Temperatures measured within Cameron Flowage were above the suitable range for cold-water fish species by mid July.

As part of fishing efforts in Watercourses 20, 21, and 23, water quality was measured more frequently and over a longer time period (April – September 2020) than other sites. All three first order streams had temperatures which remained within the suitable range for cold-water fish species throughout the sampling period, with highest temperatures recorded in July (17.1℃, 17.8℃, and 14.8℃ for WC20, WC21, and WC23, respectively).

Of the waterbodies and open water features measured within the SA, suitable temperatures for cold-water species were consistently recorded in Crusher Lake. The Mud Lake Outlet (WC27), which in reality a narrowed extension of lake habitat, was also regularly measured as below 20℃, except for one temperature recorded on July 22nd (22.7℃). The flooded portion of WL59 ranged above and below 20℃ throughout the summer months. WL59 had the highest recorded temperature of all sites at 27℃, and no areas of thermal refuge under 20℃ were identified through measurements taken throughout the flooded area during habitat assessments completed on July 21st. For all other lentic systems, only discrete in-situ water quality measurements were taken from shore. As such, the records presented are expected to represent the upper extent of the thermal range within each system at the time of assessment. It is likely that some of these features may provide areas of thermal refuge in areas comprising deeper water (e.g. Crusher Lake, Cameron Flowage).

3.1.2 *pH*

CCME FWALs establish that a range of pH from 6.5 to 9.0 is suitable within freshwater habitat. Kalff (2002) indicates that the loss of fish populations is gradual and depends on fish species, but decline is evident when pH is <6.5. Kalff (2002) further states that a 10-20% species loss is apparent when pH <5.5.

The survival of juvenile rearing of Atlantic salmon requires freshwater pH >4.7, while a significant mortality of fry occurs at pH levels below 5.0 (Farmer, 2000). The Recovery Potential Assessment for salmon completed by DFO indicates that acidification is an extreme threat to the salmon population (Bowlby et al., 2014), particularly through watersheds of the SU area of Nova Scotia. Yellow perch are found in Ontario lakes with a pH range from approximately 3.9 to 9.5. Yellow perch are relatively tolerant of low pH, but reproductive success is reduced in lakes with pH < 5.5 (Krieger, Terrell & Nelson 1983). White sucker have been collected from areas with a pH as low as 4.3 (Dunson and Martin, 1973, as cited in Twomey et al., 1984), but Beamish (1972) reported sharp declines in white sucker populations in Canadian lakes when the pH was lowered to 4.5 to 5.0 as a result of acid precipitation. Brook Trout tolerate acidic conditions particularly well, compared with other species. They have been known to survive at pH 3.5 in laboratory settings (Daye and Garside, 1975). Raleigh (1982) proposed an optimal pH range for brook trout as 6.5-8.0, with a tolerance range of 4.0-9.5. American eel are also more tolerant of low pH than many other species, although densities and growth rates may be adversely affected by direct mortalities or declining abundance of prey as productivity declines at low pH (Jessop, 1995).

The pH range for aquatic features sampled within the SA was 4.44 to 7.03, with an average pH of 5.47. Only three sampling sites (Watercourses 13, Cameron Flowage, and WL59) exhibited pH levels within CCME recommended range for freshwater aquatic life (6.5-9). Twenty-eight percent of measurements recorded in-situ during fishing efforts and habitat assessment exhibited pH levels so low (<5.0) as to expect to cause harm to salmonid species (CCREM, 1987; Farmer, 2000). The majority of these low pH measurements were recorded in first order streams within the Cope Brook tertiary watershed (WC20, WC21, and WC23). Streams within the Cope Brook tertiary watershed were generally more acidic than those in the Killag River tertiary watershed.

The NSSA is currently conducting a liming project in tertiary watersheds that are located within the PA. In order to offset the acidity of watercourses and improve water quality for Atlantic salmon, the project uses lime dosers (an automated system that combines powdered limestone with the watercourse) as well as helicopters that add lime to the soils. Two lime dosers are currently in use, they are located within the WRSH and the Killag River. The Killag River lime doser was installed in November 2017 and is located approximately 400 m downstream of the Beaver Dam Mine Site, and downstream of where the Killag River crosses the Beaver Dam Mines Road. All pH records for the Killag River presented in Table 3-1 were recorded downstream of the lime doser, which ranged from 6.07-6.35.

3.1.3 *Dissolved Oxygen*

The atmosphere and photosynthesis by aquatic vegetation are the major sources of DO in water (CCME, 1999). However, the amount of oxygen available for aquatic life (i.e., the concentration of oxygen in water) is affected by several independent variables including water temperature, atmospheric and hydrostatic pressure, microbial respiration, and growth of aquatic vegetation; DO can vary daily and seasonally (CCME, 1999). The CCME FWALs establish a minimum recommended concentration of DO of 9.5 mg/L for early life stages of cold-water biota and 6.5 mg/L for other life stages. For warm-water biota, the CCME guidelines recommend 6.0 mg/L for early life stages, and 5.5 mg/L for all other life stages.

Ninety-seven percent (97%) of DO levels recorded across aquatic features within the SA were below the minimum CCME recommended concentration of DO for early life stages of cold-water fishes (<9.5 mg/L). Forty-eight percent (48%) of DO levels recorded for watercourses were below levels suitable for any life stage of cold-water fishes (<6.5 mg/L), and 44% were below levels suitable for any life stage of cold or warm-water fishes (<5.5 mg/L). Low DO levels are typically associated with small, sluggish systems where DO would likely be consumed more quickly.

A trend in decreasing DO levels was recorded in the late summer, which correlates to a general increase in water temperatures. Consistently low DO concentrations were predominantly associated with slow-moving streams and lentic habitats whose riparian habitat is dominated by organic wetlands, including WC20, WC21, WC25, WC26, and WL59. In general, most aquatic features within the SA were at some point measured as having DO concentrations suitable for aquatic life. However, it is likely that DO concentrations within some of these features limit the quality of fish habitat, at least seasonally, and particularly for cold-water species like salmon and trout.

3.1.4 *Conductivity, Total Dissolved Solids, Turbidity*

Total Dissolved Solids (TDS) is a measurement of inorganic salts, organic matter and other dissolved materials in water. Conductivity, which is a measure of water's capacity to conduct an electrical current, is correlated to TDS as increases in the mineral and salt content of water will increase its capacity to carry a charge. Toxicity in fish can be achieved through large increases in salinity, changes in the ionic composition of the water and toxicity of individual ions. A study by Weber-Scannell and Duffy (2007) reported a variety of studies that evaluated the effect of elevated TDS on freshwater aquatic invertebrates. These studies reported the commencement of effect at 499 mg/L, with most effects not observed until >1000 mg/L. With fish, research is limited, but preliminary studies reported in Weber-Scannell and Duffy (2007) demonstrated survival rates of salmonid embryos to elevated TDS (38% survival when exposed to 2229 mg/L for brook trout, and 35% survival when exposed to 1395 mg/L). Environment Canada has established a freshwater conductivity target of 500 µS/cm (conductivity must not exceed target) as part of its Environmental Performance Water Quality Index (EC, 2011).

Turbidity is the measure of light clarity. High turbidity levels can negatively affect fish in a number of ways, including decreases in food sources and DO levels, reduction in foraging and predation success, egg suffocation, and direct mortality (ENR, 2013)

Conductivity, TDS, and turbidity are often used as baseline for comparison with background measurements. Significant changes in these three parameters could indicate that a discharge or some other source of pollution has entered the aquatic resource. Conductivity, TDS and turbidity levels measured within the SA are considered acceptable for aquatic life.

3.2 Fish Surveys

As a result of fishing efforts (i.e. all electrofishing and trapping surveys) completed between September 2019 and September 2020 within the SA, a total 11 species and 1732 individual fish were captured across ten of the fourteen survey locations, including:

- WC5 Reach B

- WC13
- WC23
- WC26
- WL56
- WL59
- Killag River
- Cameron Flowage
- Crusher Lake
- Mud Lake/WC27

No fish were captured during any survey conducted in WC5 Reach A, WC14, WC21/WL220, and WC20/WC22/WL205. The results of the 2019-2020 electrofishing and trapping surveys within the SA are presented on Figure 3, Appendix A.

Table 3-3 outlines a summary of fish species captured through all electrofishing and trapping surveys within the SA, listed in order of abundance. Individual data for fish captured at each sampling site within the SA are presented in Appendix F, and representative photos of each species captured are presented in Appendix C (Photos 15-25).

Table 3-3. Fish Species Captured within the SA (2019-2020)

Species	SRank	SARA/COSEWIC/NSESA	Total Catch	
			Total #	% Catch
banded killifish (*Fundulus diaphanus)*	S5	COSEWIC: Not at Risk	577	33
golden shiner (*Notemigonus crysoleucas*)	S4	N/A	457	26
lake chub *(Couesius plumbeus*)	S5	N/A	323	19
brook trout (*Salvelinus fontinalis*)	S3	N/A	181	10
white sucker (*Catostomus commersonii*)	S5	N/A	89	5
yellow perch (*Perca flavescens*)	S5	N/A	29	2
ninespine stickleback (*Pungitius pungitius*)	S5	N/A	28	2
brown bullhead (*Ameiurus nebulosus*)	S5	N/A	21	1
American eel (*Anguilla rostrata)**	S2	COSEWIC: Threatened	17	1
creek chub (*Semotilus atromaculatus)*	S5	N/A	6	0.5
Atlantic salmon (*Salmo salar)*	S1	COSEWIC: Endangered (Nova Scotia Southern Upland population)	4	0.5
Total			**1732**	

*Does not include observed elvers due to DFO Variation Order FMO-2020-002.

3.2.1 *Fish Species Observed*

Within the SA, eleven different species of fish were identified through electrofishing and trapping surveys. Banded killifish and golden shiner were the most commonly captured species, representing 33% and 26% of the total catch for all fishing efforts, respectively. Lake chub and brook trout were more frequently represented, while numbers of white sucker, yellow perch, ninespine stickleback, brown bullhead, and American eel were relatively lower. The least represented species, creek chub and Atlantic salmon, were less widely distributed. Six individual creek chub were captured across two sites (WC13 and Cameron Flowage), while a total of four individual Atlantic salmon were captured only in the Killag River, downstream of the dosing station. Life stage and freshwater habitat descriptions for all species captured within the SA during the 2019-2020 fishing efforts are provided in the following paragraphs.

3.2.1.1 Atlantic Salmon

SU Atlantic salmon have been found along the entire coast of Nova Scotia, from the Bay of Fundy to Cape Breton. Atlantic salmon spawn in fresh water from October to November and spend one to four years as juveniles in fresh water. The majority of juveniles migrate to the sea after two years of being in fresh water. In spring, the salmon leave the rivers and by mid-summer migrate to the Atlantic Ocean. They spend one to three years in the Atlantic Ocean before returning as adults to fresh water to spawn. The majority of adults leave the rivers in spring after spawning and recondition out at sea before spawning in freshwater again.

Within the freshwater environment, Atlantic salmon are found in cool, clear, well-oxygenated waters that support a reliable food source of aquatic invertebrates. Gravel and cobble are the preferred substrates for spawning (Bowlby et al., 2013), with redd sites typically located in well aerated areas - a riffle above a pool, or at the tail of pools on the upstream edge of riffles with depths of 10-70 cm (Grant and Lee, 2004). Young of year (YOY) will remain near the redd for a few months, after which they disperse downstream, occupying areas of faster velocities as they increase in size (Grant and Lee, 2004). Juveniles can be found occupying a variety of habitats. In summer and fall, they are typically found in moderate velocity runs with clean, rocky substrate free of sand, silt, and detritus (Rimmer et al., 1983). Older parr are usually found in riffles, whereas deeper pools are the preferred habitat during low water levels, high temperatures, and winter freeze (Grant and Lee, 2004).

The SU Population of Atlantic salmon has been assessed as endangered by COSEWIC (2010) and is considered provincially critically imperiled by the ACCDC (S1). This population is not currently protected under SARA or NSESA. During the 2019-2020 field program, Atlantic salmon parr were captured within the Killag River. No salmon were captured within any other watercourse or waterbody within the SA.

3.2.1.2 American Eel

Suitable habitat for eel is varied. As a catadromous species, eel spend the majority of their lives in freshwater, moving to the Sargasso Sea to spawn. Once hatched, American eel larvae drift back to the coast, undergoing several phases of metamorphosis. By the time they reach freshwater, young glass eel have developed pigment and are now referred to as elvers (Scott and Crossman, 1973). In freshwater, elvers develop into yellow eels - immature adults and at which point sexual differentiation occurs. As growth proceeds, the yellow eel metamorphoses into silver eel, or mature adults that are now physiologically prepared to return to the sea to spawn (COSEWIC, 2012).

American eel are frequently found in watercourses that offer structural complexity and shade in the form of coarse woody debris, rocks, in-stream vegetation for daytime cover, and an available food source of forage fish, invertebrates, molluscs and vegetation. Migrating elvers are bottom dwellers and spend most of their time burrowed or hidden, including directly into soft bottom sediments (Tomie, 2011). In freshwater, yellow eel continue their migration upstream into rivers, streams, and muddy or silt bottomed lakes (Scott and Crossman, 1998). Like elvers, yellow eel are primarily nocturnal, spending most of the day under cover or buried in soft substrates. These soft substrates are particularly important for overwintering, where the eel hibernate by burying themselves into the bottoms of lakes and rivers (Smith and Saunders, 1995; Scott and Scott, 1998). Trautman (1981) also reported that eel partially or completely bury themselves in mud, sand and gravel during the day, emerging at dusk to begin feeding.

American eel have been assessed as threatened by COSEWIC (2012) and are considered provincially imperiled by the ACCDC (S2). American eel are not currently protected under SARA or NSESA. During the 2019-2020 field program, adult American eel were confirmed in Mud Lake/Outlet (WC27), Cameron Flowage, WC13, and the Killag River. Juvenile eel were also observed in WC13.

3.2.1.3 Banded Killifish

Banded killifish are freshwater habitat generalists found within the quiet waters of lakes, ponds, and sluggish streams, tolerating a broad temperature, salinity, and DO range (COSEWIC, 2014). Adults tend to school in shallow water characterized by sand, gravel, or muddy substrate, with submerged aquatic plants (Scott and Crossman, 1973). Banded killifish are generally not considered a strong swimmer, and high velocities are thought to limit the species' movement within a watershed (DFO, 2011). Seasonal movement by the species has not been documented, and it is not considered migratory (COSEWIC, 2014).

Banded killifish spawning has been seldom documented; however, it is thought that aquatic vegetation within quiet shallows is a key component in spawning habitat as an attachment point for externally fertilized eggs (Richardson, 1939).

Banded killifish are considered provincially secure by the ACCDC (S5). During the 2019-2020 field program, adult and juvenile banded killifish were captured in Mud Lake/Outlet, Cameron Flowage, WC13, and the flooded portion of WL59.

3.2.1.1 Golden Shiner

Golden shiner are habitat generalists, primarily found schooling in well vegetated lakes with extensive shallows (Scott and Crossman, 1973). The species can tolerate a wide range of oxygen concentrations and temperatures (Murdy et al., 1997).

Spawning takes place from June to August, when temperatures reach 20°C, during which adhesive eggs are scattered over the substrate, attaching to filamentous algae or other aquatic vegetation (Scott and Crossman, 1973).

Golden shiner are considered provincially apparently secure by the ACCDC (S4). During the 2019-2020 field program, adult and juvenile golden shiner were captured in Mud Lake/Outlet, Crusher Lake, WL59 and Cameron Flowage.

3.2.1.1 Lake Chub

Lake chub are a common fish of lakes and rivers, preferring cool, clear water and gravel bottomed streams and lake edges (Page and Burr, 2011). The species is mostly found in shallow water but may move into deeper areas to escape high temperatures (Scott and Crossman, 1973).

When inhabiting lakes and larger rivers, schools of lake chub will undergo spawning migrations to shallow areas of slow tributary streams in the spring, with seasonal movements occasionally being extensive (Scott and Crossman 1973; Stasiak, 2006). During spawning, non-adhesive eggs are scattered over gravel or rocky substrate (Scott and Crossman, 1973; Stasiak, 2006). Young of the year and juveniles prefer slow, shallow water. Young of the year are often found in submerged vegetation (Brown et al. 1970), while older juveniles have been found over a variety of substrates (Mecum, 1984).

Lake chub are considered provincially secure by the ACCDC (S5). During the 2019-2020 field program, adult lake chub were captured in Mud Lake/Outlet, WC5 Reach B, WC13, and the Killag River. Small juveniles were also documented in the Killag River, WC5 Reach B and WC13.

3.2.1.2 Brook trout

Brook trout are known to inhabit a wide range of cool, freshwater environments, from small headwater streams to large lakes. Water temperature is a critical factor influencing brook trout distribution and production. Though typically not anadromous, brook trout require free passage along streams to move between areas of use, including spawning grounds, overwintering areas, and summer rearing areas.

In Nova Scotia, mature brook trout migrate to spawn in lakes or streams in the fall of the year. Brook trout spawning sites are usually near groundwater upwelling or spring seeps and within a lake or stream with gravel substrate (NSDAF, 2005). Optimal spawning conditions for brook trout include clear substrate 3-8 mm in size in shallow water with limited fines (<5%), and velocities of 25-75 cm/s (Raleigh, 1982).

Young of the year brook trout require cold water, stable, low velocities and an abundance of in-stream cover. Optimal temperature for juvenile growth is 10-16℃, while cover in the form rubble, vegetation, undercut banks, and woody debris should account for a minimum of 15% of total stream area (Raleigh, 1982). In winter, brook trout aggregate in pools beneath silt-free rocky substrate and close to point sources of groundwater discharge (Raleigh, 1982; Cunjak and Power, 1986). Adults use both pools and riffles, with more than 25% in-stream cover being optimal (Raleigh, 1982). Brook trout respond negatively to flashy or hydrologically dynamic systems, and require stable flow for all life stages (Raleigh, 1982).

Brook trout are considered provincially vulnerable by the ACCDC (S3), but have not been assessed by COSEWIC nor are they currently listed under SARA or NSESA. During the 2019-2020 field program, adult brook trout were captured within Crusher Lake, WC5 Reach B, Mud Lake/Outlet, Cameron Flowage, WC13, and WC23. Juvenile brook trout (young of the year and parr) were also documented in WC13, WL59, Crusher Lake, WC5, and the Killag River.

3.2.1.1 White Sucker

White sucker are generalist bottom dwellers found in warm, shallow water areas of lakes and quiet streams. They are most abundant in areas with aquatic vegetation and underwater debris that provide cover.

White sucker are active year-round, spawning in May-June when they migrate into small streams and tributaries with water temperatures of 10-18°C (NSSA, 2005). Preferred spawning habitat for white sucker is shallow gravel riffles of moderate water velocity. Lake populations sometimes spawn on gravel shoals where there is wave action (NSSA, 2005). The adults leave the spawning ground after a week or two and return to the river or lake from which they originated (Scott and Crossman, 1973).

Young of the year are typically found over sand and gravel substrates in moderate currents (Twomey et al., 1984). Older juveniles are typically found in shallow backwaters and riffles with moderate water velocities and sand/rubble substrate (Propst, 1982). In-stream cover in the form of rocky substrates, vegetation, and larger woody debris are important for all life stages of white sucker.

White sucker are considered provincially secure by the ACCDC (S5). During the 2019-2020 field program, adult white sucker were captured within Mud Lake/Outlet, Cameron Flowage, WC13, and the Killag River. Juvenile sucker were captured in WC13 and the Killag River. Schools of young of the year white sucker were also observed in the Killag River, but largely evaded capture via electrofishing.

3.2.1.1 Yellow Perch

Yellow perch are a schooling, shallow water fish that can adapt to a wide variety of warm or cool habitats. Most yellow perch do not appear to migrate, but some do in patterns which tend to be short and local (Brown et al., 2009). Adults and juveniles are found in large lakes, small ponds, or gentle rivers but are most abundant in clear, highly vegetated lakes (1-10 m depth) that have muck, sand, or gravel bottoms (Brown et al., 2009). They prefer summer temperatures of 21-24°C.

Spawning occurs in the spring, with adults moving to lake shallows or low velocity areas of rivers with moderate vegetation. Within 1 to 2 months of emergence, young of the year perch move to open water (Krieger, Terrell & Nelson, 1983).

Yellow perch are considered provincially secure by the ACCDC (S5). During the 2019-2020 field program, juvenile and adult yellow perch were captured in Mud Lake/Outlet and Cameron Flowage. A single juvenile was captured in the Killag River during the second round of electrofishing.

3.2.1.1 Ninespine Stickleback

Ninespine stickleback are found in both brackish waters and the shallow areas of freshwater lakes and ponds. In rivers and streams, the species is generally found in sluggish, cool pools where there is plenty of aquatic vegetation.

Spawning takes place over the summer in fresh water, during which the male constructs a nest off the substrate by binding plant fragments together (Scott and Crossman, 1973). Spawning habitat is primarily characterized by shallow depths, low velocity, dense aquatic vegetation, and mud and silt substrates (McPhail and Lindsey, 1970; Scott and Scott, 1988)

Ninespine stickleback are considered provincially secure by the ACCDC (S5). During the 2019-2020 field program, stickleback were captured in Mud Lake/Outlet, Crusher Lake, WL56, WL59, and WC13, and WC26.

3.2.1.2 Brown Bullhead

Brown bullhead are bottom dwellers that prefer sluggish and warm water in slow-moving streams, ponds, and lakes with abundant aquatic vegetation. The species is resistant to increased levels of pollution and is tolerant of low oxygen concentrations and temperatures up to 31.6 °C (Scott and Crossman, 1973). Brown bullhead spawning occurs in late spring and summer when water temperatures reach 21℃ (Scott and Crossman, 1973). Adhesive eggs are deposited into shallow nests that are excavated in mud or sand substrate, covered by at least 15 cm of water (Scott and Crossman, 1973).

Adults can be found in lakes and rivers with a variety of substrates but are typically associated with muddy bottoms. These fish are omnivorous night-feeders and will forage on all types of plant and animal materials that they locate with their barbels.

Brown bullhead are considered provincially secure by the ACCDC (S5). During the 2019-2020 field program, adult brown bullhead were captured in Mud Lake/Outlet and WL59.

3.2.1.3 Creek Chub

Creek chub are widely distributed and are considered one of the most common stream minnows in Eastern North America (Scott and Crossman, 1973). Adults prefer small, clear, and cool streams, although the species has been known inhabit the shore waters of small lakes. Optimum habitat is characterized by moderate to high gradients, gravel substrates, and riffle-run and pool habitat with abundant cover (McMahon, 1982).

Spawning occurs in spring in small streams with clean gravel substrate. Males create a pit by swimming vigorously against the stream bottom into which eggs are deposited and then covered with stones (Scott and Crossman, 1973). These pits are most often located just above or below a riffle (McMahon, 1982). Young of the year are often found in shallow areas along the edges of low velocity pools (McMahon, 1982).

Creek chub are considered provincially secure by the ACCDC (S5). During the 2019-2020 field program, 6 individual adult creek chub captured across Cameron Flowage and WC13.

3.2.2 *Quantitative Electrofishing*

The results of quantitative electrofishing surveys are presented in Table 3-4. When practical, population estimates, the probability of capture, and standard errors of population estimates have been provided for each individual survey. Quantitative estimates of overall fish abundance were calculated using a multiple-pass depletion method based on the total number of fish captured within a closed site through each successive pass. Population estimates were not able to be calculated for those surveys resulting in no catch or very low catch numbers, nor were they calculated for individual species. Detailed results for individual fish captured and processed (lengths and weights) have been provided in Appendix F.

Table 3-4. Summary of Quantitative Electrofishing Efforts within the SA

Site	Survey Dates	Fish Species Collected	Catch Per Species	Total Catch	Total Catch Per Electrofishing Pass (1st/2nd/3rd etc.)	Population Estimate (*N*)	Probability of Capture (*p*)	Standard Error	95% Confidence Limit
WC5 Reach A (Upper)	June 9	None	0	0	0/0	N/A	N/A	N/A	N/A
	July 7	None	0	0	0/0	N/A	N/A	N/A	N/A
	August 25	None	0	0	0/0	N/A	N/A	N/A	N/A
WC5 Reach B (Lower)	June 17	brook trout	4	4	3/0/1	N/A	N/A	N/A	N/A
	July 6	brook trout	27	27	6/13/6/2	32	0.346	4.1	32 ± 8.2
	August 25	brook trout lake chub	17 1	18	13/4/1	18	0.750	0	N/A
WC13	June 10	banded killifish brook trout lake chub ninespine stickleback	7 57 9 7	80	37/19/15/9	90	0.408	5.5	90 ± 11.0
	July 6	American eel[1] banded killifish brook trout creek chub lake chub ninespine stickleback	1 5 54 3 1 3	67	34/15/12/6	72	0.465	3.3	72 ± 6.6
	August 26	banded killifish brook trout lake chub ninespine stickleback white sucker	2 3 4 5 6	20	13/4/3	20	0.666	0	N/A

Site	Survey Dates	Fish Species Collected	Catch Per Species	Total Catch	Total Catch Per Electrofishing Pass (1st/2nd/3rd etc.)	Population Estimate (*N*)	Probability of Capture (*p*)	Standard Error	95% Confidence Limit
WC14	June 10	None	0	0	0/0	N/A	N/A	N/A	N/A
WC23	June 16	brook trout	1	1	1/0	N/A	N/A	N/A	N/A
	July 9	brook trout	2	2	2	N/A	N/A	N/A	N/A
WC26	June 15	ninespine stickleback	1	1	0/1/0	N/A	N/A	N/A	N/A
	July 7	None	0	0	0/0	N/A	N/A	N/A	N/A
	August 25	None	0	0	0/0	N/A	N/A	N/A	N/A
Killag River	June 11[2]	American eel brook trout lake chub white sucker	3 1 61 8	73	36/31/7	83	0.506	5.3	83 ± 10.6
	July 8[2]	American eel Atlantic salmon brook trout lake chub white sucker	7 4 1 223 20	255	135/84/36	291	0.491	11.5	291 ± 23.0
	August 26	American eel lake chub white sucker yellow perch	4 23 13 1	41	20/16/5	46	0.500	3.8	46 ± 7.6

[1]Two individual elvers observed but not processed. Not included in population estimates.

[2]Schools of young-of-the-year white sucker (<20 mm) also observed with electrofishing reach but were not captured due to small size. Population estimates do not include these observations, and are therefore considered conservatively low.

N/A Indicates that no fish were caught, or fish were captured in low abundance limiting the ability to provide statistically relevant population estimates.

No fish were captured within the upstream reach of WC5 (Reach A, a first order tributary to Crusher Lake) through three rounds of electrofishing, nor were any fish captured in WC14, a first order tributary to WL59. Only one round of electrofishing was completed in WC14 in June due to the watercourse drying up through mid to late summer. WC12 was also proposed for electrofishing due to the confirmed presence of brook trout in 2015 but could not be fished in Summer 2020 due to dry channel conditions.

Two quantitative electrofishing surveys in WC23 resulted in a total catch of three adult brook trout, with one individual captured during the June survey, and two captured in July. Three rounds of surveys in WC26, a first order tributary to the Killag River, resulted in only individual ninespine stickleback captured. No fish were captured during the second or third electrofishing rounds in July and August. However, it is important to note that this reach is located near the headwater wetland (WL207), and it is likely that greater species abundance and diversity is present near its confluence with the Killag River. Further details on fish presence in WC26 is provided in Section 4.1.9. Population estimates were not calculated for these reaches due to extremely low catch numbers.

Population estimates calculated within the SA ranged from 18 fish (WC5 Reach B) to 291 fish ± 23 individuals (Killag River). Generally, survey sites within higher order streams were observed to support a greater number of fish that first order streams. Both WC5 Reach B and the Killag River showed similar population trends, with their largest respective population estimates calculated during mid-summer. Fishing efforts in WC13 demonstrated a decreasing population trend throughout the summer sampling period. Notably, the number of brook trout captured in WC13 dropped from 57 individuals in June to 3 individuals in late August. It is likely that the observed decline in population estimates can be attributed to increasing summer water temperatures and the movement of brook trout to areas of thermal refuge.

Similarly, higher order streams exhibited greater species diversity than first order steams. The highest species diversity was recorded in WC13, followed by the Killag River, with 7 and 6 species present of the total of 11 species captured during fishing efforts within the SA, respectively. Clear trends were not observed between species diversity and the time of the sampling event.

3.2.3 *Qualitative Electrofishing*

The results of qualitative electrofishing surveys are presented in Table 3-5. Relative abundance has been expressed through CPUE calculated as the number of fish captured per 300 seconds of electrofishing effort. Detailed results for individual fish captured and measured (lengths and weights) have been provided in Appendix F.

Table 3-5. Summary of Qualitative Electrofishing Efforts within the SA

Site	Survey Date	Fish Species Collected	Catch Per Species	Total Catch	Total Effort (seconds)	CPUE (fish/300 seconds)
WC21/WL220	June 8	None	0	0	366.1	0
	June 17	None	0	0	269.3	0
	July 3	None	0	0	626.6	0
	July 9	None	0	0	383.6	0
	July 28	None	0	0	688.8	0

Site	Survey Date	Fish Species Collected	Catch Per Species	Total Catch	Total Effort (seconds)	CPUE (fish/300 seconds)
	August 21	None	0	0	186.4	0
	August 27	None	0	0	307.3	0
	September 21	None	0	0	327.0	0
	September 28	None	0	0	520.4	0
WC20/WC22/WL205	June 8	None	0	0	548.4	0
	June 17	None	0	0	340.7	0
	July 3	None	0	0	629.5	0
	July 9	None	0	0	719.7	0
	July 28	None	0	0	549.6	0
	August 21	None	0	0	434.1	0
	August 27	None	0	0	514.8	0
	September 21	None	0	0	610.7	0
	September 28	None	0	0	390.6	0
WC23	July 3	brook trout	1	1	715.0	0.35
	August 21	brook trout	1	1	272.0	1.10
	August 27	None	0	0	417.2	0
WL56	September 30	ninespine stickleback	3	3	516.3	1.74

No fish were captured within the WC21/WL220 system or the WC20/WC22/WL205 system through nine rounds of electrofishing, respectively, accumulating to a total of 8,414 seconds of electrofishing effort across the two systems.

Open site electrofishing in WC23 provided similarly low catch results as closed site electrofishing. Over three sampling events, only two individual brook trout were captured, and no fish were captured in late August. The single electrofishing event in the open water area of WL56 resulted in the capture of three individual ninespine stickleback. No other species were documented within this site.

3.2.4 *Trapping*

The results of trapping efforts are presented in Table 3-6. Relative abundance has been expressed through CPUE per trap type and per species. Detailed results for individual fish captured and processed (lengths and weights) have been provided in Appendix F.

Table 3-6. Summary of Trapping Efforts within the SA

Site	Survey Date	Fish Species Collected	Total Catch	Total Effort Per Trap Type (hours)	Total Catch Per Trap Type	CPUE (per trap type)	CPUE (per species)
WC21	September 9, 2019	No fish	0	MT- 21.25 hrs	0	0	0
WC20	September 9, 2019	No fish	0	MT- 61.67 hrs	0	0	0
WC21	September 17, 2019	No fish	0	MT- 22.50 hrs	0	0	0
WC20	September 17, 2019	No fish	0	MT- 64.50 hrs	0	0	0
WC21	November 6, 2019	No fish	0	MT- 25.17 hrs	0	0	0
WC20	November 6, 2019	No fish	0	MT- 73.92 hrs	0	0	0
WC23	November 6, 2019	No fish	0	MT- 50.83 hrs	0	0	0
WC21	November 21, 2019	No fish	0	MT- 23.92 hrs	0	0	0
WC20	November 21, 2019	No fish	0	MT- 115.00 hrs	0	0	0
WC23	November 21, 2019	brook trout	1	MT- 56.00 hrs FN- 28.00 hrs	0 1	0 0.035	 brook trout - 0.012
WC21	December 4, 2019	No fish	0	MT- 25.00 hrs	0	0	0
WC20	December 4, 2019	No fish	0	MT- 125.00 hrs	0	0	0
WC23	December 4, 2019	No fish	0	MT- 54.40 hrs FN- 27.42 hrs	0 0	0 0	0 0
WC21	December 16, 2019	No fish	0	MT- 24.67 hrs	0	0	0
WC20	December 16, 2019	No fish	0	MT- 121.75 hrs FN- 24.67 hrs	0 0	0 0	0
WC21	April 8, 2020	No fish	0	MT- 24.50 hrs	0	0	0
WC20	April 8, 2020	No fish	0	MT- 119.67	0	0	0
WC23	April 8, 2020	No fish	0	MT- 47.25 hrs FN- 23.58 hrs	0 0	0 0	0
WC21	April 22, 2020	No fish	0	MT- 24.17 hrs	0	0	0
WL205	April 22, 2020	No fish	0	MT- 48.33 hrs	0	0	0
WC22	April 22, 2020	No fish	0	MT- 48.33 hrs	0	0	0
WC20	April 22, 2020	No fish	0	MT- 45.58 hrs EP- 21.05 hrs	0 0	0 0	0

Site	Survey Date	Fish Species Collected	Total Catch	Total Effort Per Trap Type (hours)	Total Catch Per Trap Type	CPUE (per trap type)	CPUE (per species)
WC23	April 22, 2020	brook trout	1	MT- 21.50 hrs EP- 21.58 hrs FN- 43.42 hrs	0 1 0	0 0.046 0	brook trout - 0.012
WL220	May 13, 2020	No fish	0	MT- 92.58 hrs	0	0	0
WC21	May 13, 2020	No fish	0	MT- 184.50 hrs	0	0	0
WL205	May 13, 2020	No fish	0	MT- 139.08 hrs	0	0	0
WL220	May 13, 2020	No fish	0	EP- 46.42 hrs	0	0	0
WL205	May 13, 2020	No fish	0	EP- 46.33 hrs	0	0	0
WC20	May 13, 2020	No fish	0	MT- 281.00 hrs EP- 93.33 hrs FN- 47.33 hrs	0 0 0	0 0 0	0
WC23	May 13, 2020	brook trout	1	MT- 283.17 hrs EP- 47.33 hrs FN- 46.75 hrs	1 0 0	0.003 0 0	brook trout 0.003
WC20	May 18, 2020	No fish	0	MT- 97.50 hrs	0	0	0
WL205	May 18, 2020	No fish	0	MT- 145.5 hrs	0	0	0
WL220	May 18, 2020	No fish	0	MT- 49.00 hrs EP- 48.83 hrs	0 0	0 0	0
WC20	May 18, 2020	No fish	0	MT- 243.83 hrs EP- 97.83 hrs FN- 48.83 hrs	0 0 0	0 0 0	0
WC23	May 18, 2020	No fish	0	MT- 485.67 hrs EP- 145.08 hrs FN- 48.58 hrs	0 0 0	0 0 0	0
WC21	May 20, 2020	No fish	0	MT- 94.00 hrs EP- 47.00 hrs	0 0	0 0	0
WC20	May 20, 2020	No fish	0	MT- 662.83 hrs EP- 142.25 hrs FN- 47.67 hrs	0 0 0	0 0 0	0
WC23	May 20, 2020	brook trout	2	MT- 285.42 hrs EP- 97.50 hrs FN- 47.86 hrs	0 2 0	0 0.020 0	brook trout - 0.005
WC21	May 25, 2020	No fish	0	MT- 195.67 hrs EP- 95.67 hrs	0 0	0 0	0

Site	Survey Date	Fish Species Collected	Total Catch	Total Effort Per Trap Type (hours)	Total Catch Per Trap Type	CPUE (per trap type)	CPUE (per species)
				FN- 24.42 hrs	0	0	
WC20	May 25, 2020	No fish	0	MT- 723.50 hrs EP- 192.17 hrs FN- 95.75 hrs	0 0 0	0 0 0	0
WC23	May 25, 2020	No fish	0	MT- 174.17 hrs EP- 95.58 hrs	0 0	0 0	0
WC20	May 26, 2020	No fish	0	MT- 79.50 hrs	0	0	0
WC23	May 26, 2020	No fish	0	MT- 101.67 FN- 67.75 hrs	0 0	0 0	0
WC20	May 27, 2020	No fish	0	MT- 227.34 hrs	0	0	0
WC22	May 27, 2020	No fish	0	MT- 90.67 hrs	0	0	0
WC23	May 27, 2020	No fish	0	MT- 132.58 hrs	0	0	0
WC20	May 28, 2020	No fish	0	MT- 141.33 hrs	0	0	0
Crusher Lake	June 8, 2020	brook trout ninespine stickleback	2 1	MT- 232.33 hrs EP- 72.50 hrs FN- 25.17 hrs	1 0 2	0.004 0 0.079	brook trout - 0.006 ninespine stickleback - 0.003
	July 7, 2020	brook trout golden shiner	1 1	MT- 179.50 hrs EP- 35.80 hrs FN- 17.42 hrs	0 0 2	0 0 0.114	brook trout - 0.004 golden shiner - 0.004
	August 25, 2020	No fish	0	MT- 198.67 EP- 49.67 hrs FN- 24.83 hrs	0 0 0	0 0 0	0
WL59	June 9, 2020	banded killifish brook trout brown bullhead golden shiner	224 2 10 56	MT- 253.75 hrs EP- 75.75 hrs FN- 25.67 hrs	280 11 1	1.103 0.145 0.039	banded killifish - 0.631 brook trout - 0.006 brown bullhead - 0.028 golden shiner - 0.158
	July 6, 2020	banded killifish brown bullhead golden shiner ninespine stickleback	21 1 90 1	MT- 240.25 hrs EP- 46.75 hrs FN- 23.42 hrs	109 2 2	0.453 0.042 0.086	banded killifish - 0.068 brown bullhead - 0.003 golden shiner - 0.290 ninespine stickleback - 0.003
	August 25, 2020	banded killifish brown bullhead golden shiner	9 1 7	MT- 200.00 hrs EP- 50.00 hrs FN- 25.58 hrs	9 7 1	0.045 0.140 0.039	banded killifish - 0.033 brown bullhead - 0.004 golden shiner - 0.025

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Site	Survey Date	Fish Species Collected	Total Catch	Total Effort Per Trap Type (hours)	Total Catch Per Trap Type	CPUE (per trap type)	CPUE (per species)
Cameron Flowage	June 10, 2020	American eel banded killifish golden shiner white sucker yellow perch	1 48 1 2 2	MT- 216.92 EP- 65.25 hrs FN- 21.42 hrs	53 1 0	0.244 0.015 0	American eel - 0.003 banded killifish - 0.158 golden shiner - 0.003 white sucker - 0.007 yellow perch - 0.007
	July 7, 2020	banded killifish creek chub white sucker	179 3 1	MT- 259.83 hrs EP- 51.67 hrs FN- 26.17 hrs	182 1 0	0.700 0.019 0	banded killifish - 0.530 creek chub - 0.009 white sucker - 0.003
	August 26, 2020	banded killifish brook trout golden shiner white sucker yellow perch	21 1 8 1 3	MT- 168.67 hrs EP- 42.17 hrs FN- 21.17 hrs	32 1 1	0.189 0.023 0.094	banded killifish - 0.091 brook trout - 0.004 golden shiner - 0.034 white sucker - 0.004 yellow perch - 0.013
Mud Lake and Outlet	June 15, 2020	American eel banded killifish brook trout brown bullhead golden shiner ninespine stickleback white sucker yellow perch	1 18 1 1 165 7 30 8	MT- 240.58 EP- 72.00 hrs FN- 24.00 hrs	187 10 35	0.777 0.138 1.458	American eel - 0.003 banded killifish - 0.053 brook trout - 0.003 brown bullhead - 0.003 golden shiner - 0.490 ninespine stickleback - 0.021 white sucker - 0.089 yellow perch - 0.024
	July 7, 2020	banded killifish golden shiner lake chub white sucker yellow perch	42 120 1 2 6	MT- 270.00 hrs EP- 54.00 hrs FN- 27.00 hrs	165 6 0	0.611 0.111 0	banded killifish - 0.120 golden shiner - 0.342 lake chub - 0.003 white sucker - 0.006 yellow perch - 0.017
	August 26, 2020	banded killifish brown bullhead golden shiner white sucker yellow perch	1 8 9 6 9	MT- 172.00 hrs EP- 43.33 hrs FN- 21.92 hrs	14 1 18	0.081 0.023 0.821	banded killifish - 0.004 brown bullhead - 0.034 golden shiner - 0.038 white sucker - 0.025 yellow perch - 0.038

Extensive trapping surveys from September 2019 – Spring 2020 within the watercourses and wetlands directly associated with the Waste Rock Storage Area (WRSA) footprint (WC20-22, WL205 and WL220) for a total of 5,558 hours and 10 mins of total effort. No fish were caught as a result of these efforts. Individual trap locations specific to survey effort associated with WRSA are presented on Figure 4, Appendix A.

Of the watercourses, waterbodies and open water features sampled within the SA, Mud Lake and its outlet had the highest diversity of all sites, with nine species present of the total of 11 species captured during fishing efforts within the SA. Nine of the 27 trap groupings (i.e. collection of a single trap type) resulted in zero catch, with six of these nine trap groupings located in Crusher Lake. CPUE by trap type ranged from 0.004 (minnow traps in Crusher Lake) to 1.458 (fyke net in Mud Lake Outlet). Each lentic system is discussed individually in the paragraphs that follow.

Crusher Lake

Three species of fish were recorded in Crusher Lake across three trapping events: brook trout, ninespine stickleback, and golden shiner. A total of three individual fish were captured in early summer, and two individuals were captured in July. No fish were captured in late August, likely as a result of fish moving to areas of deeper water, away from the shoreline for thermal refuge. Of all lentic systems sampled, Crusher Lake had the lowest abundance and diversity, and correspondingly the lowest overall CPUE for both trap type and species.

Wetland 59

Five species of fish were recorded in the flooded portion of WL59, including schools of banded killifish and golden shiner, brown bullhead, ninespine stickleback, and brook trout. Brook trout (two individuals) were only captured during the June trapping event, and were not captured again throughout the rest of the summer. The two most common species in WL59 were banded killifish and golden shiner (highest CPUE), which were observed to congregate in large schools along the shoreline. The most effective trapping mechanism for these two species were minnow traps, which correspondingly had the highest CPUE of all trap types. In general, CPUE was observed to decline from early summer to late summer.

Cameron Flowage

Seven species of fish were recorded in Cameron Flowage. Schools of banded killifish accounted for the most individuals, whereas American eel, golden shiner, white sucker, yellow perch, creek chub, and brook trout were present in much smaller numbers. Minnow traps were the most effective trap type in terms of overall catch, whereas fyke nets only accounted for one individual fish being caught in late summer. The highest CPUE per trap type was recorded in mid-summer, though this also corresponded to the lowest diversity representation of all trapping events and can be attributed to a relatively large school of banded killifish being captured in minnow traps.

Mud Lake and Outlet

As previously noted, Mud Lake and its outlet (WC27 – a narrow extension of lake habitat) recorded the highest species diversity of all lentic sites, with schools of golden shiner and banded killifish, and lesser amounts of white sucker, ninespine stickleback, yellow perch, and brown bullhead. Only one individual adult American eel, brook trout, and lake chub were captured across all three sampling events. CPUE was highest for all trap types in early summer, which trended down towards the end of August (with the exception of fyke netting, which resulted zero catch in July).

3.3 eDNA

The results of eDNA samples collected at the Beaver Dam Mine Site on July 9, 2020 are provided in Table 3-7. The laboratory results report is available in Appendix D.

Table 3-7. Summary of eDNA Sample Results.

Site ID	WC Number	Interpretation
1	Channelized open water within WL220	Negative
2	WC21 – connection between WL220 and WL205	Negative
3	Standing water in WL205	Negative
4	Channelized WC21 within WL205, upstream of subterranean barrier	Negative
5*	WC23, downstream of subterranean barrier	Positive
6*	WC23, downstream of subterranean barrier	Suspected (Field determination: Positive**)

*Positive control sites where fish are known to be present.

**Suspected result is interpreted as positive based on confirmed presence of brook trout in contiguous watercourse upstream.

Sample results are relatively consistent with expectations based on site knowledge and fish collection efforts to date. Sites 5 and 6 were identified as positive control sites. Brook trout was identified at Site 5 in the afternoon of July 9th, following sample collection, confirming presence of fish in that reach and providing confidence in the positive control site. For control Site 6, the result is considered ‘suspected’ presence of the target taxa. The biologist interpretation of sites with suspected results may be determined as positive or negative, based on supplementary site-specific information. For instance, while fish collection has not been completed at Site 6, it has been confirmed through habitat assessments that it is downstream of, and directly connected by surface flow to Site 5. As such, it was selected as a positive control location, and a ‘suspected’ result is interpreted to be positive in this case. It is likely that genetic material was not present in high enough concentrations at this site based on low flow or low abundance of fishes.

Fish presence was not confirmed within Sites 1-4, based on biologists’ interpretation of results provided in Section 2.4. This was expected based on all previous fish collection and habitat survey results.

3.4 Detailed Fish Habitat Surveys

Each stream reach potentially affected by Project development has been identified using the existing project infrastructure layout and aquatic habitat mapping. Each habitat type has been characterized via surveys using standard methodologies to gather key measurements such as reach length (m), reach wetted and bankfull width (m), reach slope (%), stream substrate composition (% composition), water depths (m), water velocities (m/s), cover (%), and riparian habitat. The data was used to determine the overall habitat area within each reach as well as the habitat suitability based on measured stream substrate, water depths, and water velocities (habitat parameters) for each fish species identified within the SA.

A summary of key fish habitat characteristics within each linear watercourse and open water feature surveyed, and the fish species and life stages they support, are presented in Table 3-8 and Table 3-9. Fully tabulated fish habitat data is presented in Appendix G. Delineated watercourse reaches are presented on Figures 6-9, Appendix A, and representative photos are presented in Appendix C (Photos 26-55).

Table 3-8: Summary of Key Diagnostic Features of Fish Habitat within Linear Watercourses

Water-course	Reach	Stream Order	Flow Type[1]	Reach Characteristics										Fish Support[6]					
				Channel Width (m)[2]	Wetted Width (m)[2]	Reach Length (m)	Dominant Habitat Type	Other Habitats Present	Slope (%)[3]	Average Velocity (m/s)	Average Depth (m)	Dominant Substrate	Cover (%)[4]	Confirmed Species (2019-2020)	Probable Species[5]	Spawning	YOY	Juvenile	Adult
5	1	2	P	2.0	1.2	15	Cascade	-	20 (F)	0.11	0.11	Boulder	40	BKT, LKC	EEL, BKF, BBH, GSH, 9SP, NRD, WHS, YLP	-	-	BKT	EEL, BKT
	2	2	P	1.7-4.0	0.9-1.2	55	Run	Riffle, Chute	4 (E)	0.32	0.07	Gravel	10			BKT, LKC	BKT	BKT	EEL, BKT
	3*	2-3	P	1.6-2.5	1.3-1.7	195	Flat	Riffle	<1 – 1 (E)	0.08	0.39	Muck/Detritus	33			BKT, LKC, NRD,	BKT, LKC, NRD	EEL, BKT, LKC, NRD	EEL, BKT, LKC, NRD
	4*	3	P	2.3	1.7-1.8	66	Pool	Run	2 (E)	0.07	0.28	Muck/Detritus	70			NRD	BKT, LKC, NRD	EEL, BKT, LKC, NRD	EEL, BKT, LKC, NRD
	5*	3	P	2.1-3.2	1.4-2.9	53	Run	Riffle, Pool	4 (E)	0.17	0.09	Rubble	17			BKT, LKC, NRD	BKT, LKC, NRD	EEL, BKT, LKC, NRD	EEL, BKT, LKC, NRD
	6	3	P	N/A	N/A	43	No defined channel	-	4 (E)	0.42	0.24	Boulder	32			-	-	-	-
	7*	3	P	1.7-2.3	0.9-2.3	65	Rapid	Run, Flat, Pool, Cascade	6 (F)	0.23	0.09	Boulder	33			-	BKT	EEL, BKT	EEL, BKT
	8*	3	P	1.4-3.6	1.4-3.6	340	Flat	-	<1 (E)	0.05	0.48	Muck/Detritus	45			BKF, BBH, 9SP, NRD, YLP	BKF, BBH, 9SP, NRD, YLP	EEL, BKF, BBH, 9SP, NRD, YLP	EEL, BKF, BKT, BBH, GSH, 9SP, NRD, WHS, YLP
12	1	1	E	1.0	Dry	50	N/A – Groundwater Seep	-	2 (E)	N/A	Dry	Cobble	61	None	BKT	-	BKT	BKT	BKT
13	1*	2	P	3.3-4.8	1.7-3.0	32	Riffle	Flat	1 (F)	0.11	0.07	Gravel	10	EEL, BKF, BKT, CKC, LKC, 9SP, WHS	BBH, NRD	BKT, CKC, LKC, WHS	BKT, LKC, WHS	BKT	BKT, CKC, LKC
	2	2	P	3.1	2.5	8	Pool	-	<1 (E)	0.06	0.10	Muck/Detritus	10			-	BKT, CKC	EEL, BKT, LKC	EEL, BKT, LKC
	3	2	P	1.1	0.8	20	Riffle	-	2 (E)	0.10	0.02	Cobble/Gravel	10			BKT, CKC, LKC, WHS	BKT, WHS	BKT, WHS	BKT, CKC, LKC
	4	2	P	3.0	2.7	35	Flat	-	<1 (E)	0.05	0.46	Muck/Detritus	45			BKF, BBH, 9SP, NRD	BKF, BBH, LKC, 9SP, NRD	EEL, BKF, BBH, LKC, 9SP, NRD\	EEL, BKF, BKT, BBH, LKC, 9SP, NRD, WHS
	5	2	P	0.9	0.6	46	Riffle	Pool	2 (E)	0.04	0.11	Rubble	62			BKF, BKT, BBH, CKC, LKC, 9SP, NRD, WHS	BKF, BKT, BBH, CKC, LKC, 9SP, NRD, WHS	EEL, BKF, BKT, BBH, CKC, LKC, 9SP, NRD, WHS	EEL, BKF, BKT, BBH, CKC, LKC, 9SP, NRD, WHS

Water-course	Reach	Stream Order	Flow Type[1]	Reach Characteristics										Fish Support[6]					
				Channel Width (m)[2]	Wetted Width (m)[2]	Reach Length (m)	Dominant Habitat Type	Other Habitats Present	Slope (%)[3]	Average Velocity (m/s)	Average Depth (m)	Dominant Substrate	Cover (%)[4]	Confirmed Species (2019-2020)	Probable Species[5]	Spawning	YOY	Juvenile	Adult
14	1A	1	I	0.5	0.4	30	Run (high flow only)	-	4 (E)	0.05	0.09	Rubble	80	None	EEL, BKT	-	-	BKT	EEL, BKT
	1B	1	I	1.0	0.6	115	Step-pool (high flow only)	No defined channel	10+ (E)	0.04	0.03	Muck/Detritus	25			-	-	EEL, BKT	EEL, BKT
	2	2	I	1.3	0.8	32	Step-pool	-	18 (F)	0.02	0.04	Rubble	5			BKT	BKT	EEL, BKT	EEL, BKT
23	1*	1	P	4.0-4.1	2.3-3.5	150	Flat	-	1 (E)	0.18	0.10	Muck/Detritus	35	BKT	N/A	-	-	BKT	BKT
	2*	1	P	3.9-5.1	2.6-3.6	150	Flat	-	1 (E)	0.01	0.12	Muck/Detritus	82			-	-	BKT	BKT
	3*	1	P	1.1-5.3	0.9-3.0	1320	Flat	Step-pool, Subterranean boulder field	1 (E)	0.05	0.19	Muck/Detritus	44			-	-	BKT	BKT
25	1*	1	P	0.6-1.0	0.3-0.6	33	Flat	Riffle	<1 (E)	0.05	0.07	Muck/Detritus	10	None	EEL, BKF, GSH, WHS, YLP	BKF, GSH, YLP	BKF, GSH, YLP	EEL, BKF, GSH, YLP	EEL, BKF, GSH, WHS, YLP
26	1*	1	I	0.2-0.6	Dry-0.6	205	Flat	No defined channel	<1 (E)	0.05	0.34	Muck/Detritus	55	9SP	EEL, BKF, BKT, BBH, GSH, WHS, YLP	9SP	9SP	9SP	9SP
	2*	1	P	0.7-4.7	0.7-4.7	600	Flat	-	<1 (E)	0.06	0.26	Muck/Detritus	10			BKF, BBH, GSH, YLP	BKF, BBH, GSH, YLP	EEL, BKF, BBH, GSH, YLP	EEL, BKF, BKT, BBH, GSH, WHS, YLP
27	1*	3	P	3.4-9.0	3.4-9.0	228	Flat	-	<1 (E)	0.05	0.58	Muck/Detritus	65	EEL, BKF, BKT, BBH, GSH, LKC, 9SP, WHS, YLP	N/A	BKF, BBH, GSH, 9SP, YLP	BKF, BBH, GSH, LKC, 9SP, YLP	EEL, BKF, BBH, GSH, LKC, 9SP, YLP	EEL, BKF, BKT, BBH, GSH, LKC, 9SP, WHS, YLP
Cameron Flowage/ Killag River[7]	1	4	P	10.0	10.0	196	Rapid	<1	n/a	1.04	0.45	Boulder, Cobble, Rubble	n/a	EEL, BKF, BKT, GSH, WHS, YLP, CRC	BRB, 9SP, LKC	BKF, GSH, YLP	BKF, GSH, YLP, BKT	EEL, WHS, LKC, YLP, BRB, 9SP, BKF, GSH, CRC	EEL, WHS, LKC, YLP, BRB, 9SP, BKF, GSH, CRC
	2	4	P	59.4	59.4	70	Flat		n/a	0.08	1.11	Boulder, Rubble, Muck	n/a						
	3	4	P	62	62	330	Flat		n/a	<0.05	2.72	Muck	n/a						
	4	4	P	76.8	76.8	440	Flat		n/a	<0.05	1.73	Boulder, Rubble, Muck	n/a						
	5	4	P	13.7	13.7	230	Riffle		n/a	0.72	0.44	Boulder, Rubble	n/a						

Water-course	Reach	Stream Order	Flow Type[1]	Reach Characteristics										Fish Support[6]					
				Channel Width (m)[2]	Wetted Width (m)[2]	Reach Length (m)	Dominant Habitat Type	Other Habitats Present	Slope (%)[3]	Average Velocity (m/s)	Average Depth (m)	Dominant Substrate	Cover (%)[4]	Confirmed Species (2019-2020)	Probable Species[5]	Spawning	YOY	Juvenile	Adult
	6	4	P	14.6	14.6	213	Run		n/a	0.35	0.47	Boulder, Rubble, Muck	n/a						
	7	4	P	12	12	108	Run	<1	n/a	0.34	0.47	Rubble, Cobble	n/a	BKT, EEL, WHS, ATS[8], LKC, YLP	BRB, 9SP, BKF, GSH, CRC	ATS, BKT, LKC	BKT, ATS, LKC	EEL, WHS, ATS, LKC, YLP, BRB, 9SP, BKF, GSH, CRC	EEL, WHS, ATS, LKC, YLP, BRB, 9SP, BKF, GSH, CRC
	8	4	P	13.6	13.6	144	Flat		n/a	0.05-0.2	0.75	Rubble, Cobble	n/a						
	9	4	P	7.3	7.5	n/a	Run		n/a	1.2	0.44	Boulder, rubble	n/a						

Note: Habitat assessments also conducted on WC20-22 but excluded from table due to non-fisheries resource designation.

[1]Perennial (P) – A stream that flows continuously throughout the year, Intermittent (I) – Streams that go dry during protracted rainless periods when percolation depletes all flow, Ephemeral (E) - A watercourse that flows during snowmelt and rainfall runoff periods only (AT, 2009).

[2]Ranges are provided for reaches measured through multiple transects.

[3]Whenever possible, slope measurements were taken in-field using a clinometer and meter stick (“F”). If clinometer readings were not possible due to length of reach or visibility obstructions, slopes were estimated based on overall habitat type (“E”,DFO, 2012a).

[4]Cover is calculated as a sum of all available cover types present (large woody debris, boulders, undercut banks, deep pools, overhanging vegetation, emergent vegetation, and submergent vegetation).

[5]Probable species presence determined for watercourses based on direct aquatic connectivity with another fisheries resource with confirmed species presence and habitat suitability, and/or previous baseline studies as presented in Revised EIS (Atlantic Gold, 2019).

[6]Species codes: American Eel (EEL), Atlantic Salmon (ATS), Banded Killifish (BKF), Brook Trout (BKT), Brown Bullhead (BBH), Creek Chub (CKC), Golden Shiner (GSH), Lake Chub (LKC), Ninespine Stickleback (9SP), Northern Redbelly Dace (NRD), White Sucker (WHS), Yellow Perch (YLP).

[7]Some reach-level measurements within Cameron Flowage – Killag River were not recorded, as this was a modified transect method to account for safety considerations during high seasonal flow in December 2020.

[8]Atlantic Salmon identified within Killag River was identified downstream of the NSSA dosing station

* For reaches highlighted with an asterisk; one reach consists of multiple, small (<5 m in length) individual habitat types. These were combined into a single reach; and a minimum of one transect per habitat typer was completed. As such, the measurements provided are a range (widths) or average (depths and velocity) of measurements recorded on each individual transect. Transect level data is provided in the 2019-2020 Baseline Report.

Table 3-9: Summary of Key Diagnostic Features of Fish Habitat within Open Water Features

Waterbody / Wetland	Area (m^2)	Open Water Characteristics			Fish Support[2]					
		Depth Range (m)	Dominant Substrate	Cover (%)	Species Confirmed (2019-2020)	Probable Species[1]	Spawning	YOY	Juvenile	Adult
WL56	1,274 (permanently flooded) 177 (seasonally flooded)	0.27-0.60	Muck/Detritus	20	9SP	BKF, BKT, NRD	BKF, 9SP, NRD	BKF, 9SP, NRD	BKF, 9SP, NRD	BKF, BKF, 9SP, NRD
WL59	36,106 (permanently flooded) 1,052 (seasonally flooded)	0.19-1.88	Muck/Detritus	50	BKF, BKT, BBH, GSH, 9SP	EEL	BKF, BBH, GSH, 9SP	BKF, BBH, GSH, 9SP	EEL, BKF, BBH, GSH, 9SP	EEL, BKF, BKT, BBH, GSH, 9SP
WL61	173	0.30-1.00	Gravel	0	None	EEL, BKF, GSH, WHS, YLP	-	-	EEL, BKF, GSH, YLP	EEL, BKF, GSH, WHS, YLP

[1]Probable species presence determined for open water features based on direct aquatic connectivity with another fisheries resource with confirmed species presence and habitat suitability, and/or previous baseline studies as presented in Revised EIS (Atlantic Gold, 2019).

[2]Species codes: American Eel (EEL), Banded Killifish (BKF), Brook Trout (BKT), Brown Bullhead (BBH), Creek Chub (CKC), Golden Shiner (GSH), Lake Chub (LKC), Ninespine Stickleback (9SP), Northern Redbelly Dace (NRD), White Sucker (WHS), Yellow Perch (YLP).

4.0 SUMMARY OF FISHERIES RESOURCES

4.1.1 *Watercourse 5*

WC5 is a permanent watercourse begins as a first order stream draining northward from its headwater wetland source (WL2) towards Crusher Lake. From Crusher Lake, the watercourse continues northward to Mud Lake, collecting flow from smaller mapped watercourses (WC3, WC6, and WC9) along its path.

During the 2019-2020 field program, quantitative electrofishing surveys were conducted within two reaches of WC5 – one south of Crusher Lake and one north of Crusher Lake (see Figure 3, Appendix A). In addition, a detailed fish habitat assessment was conducted along the entirety of the lower reach from the outlet of Crusher Lake to its confluence with Mud Lake (approximately 830 m of linear watercourse). During the detailed habitat assessment, the watercourse was delineated into eight homogenous fish habitat reaches.

Reach 1 begins at the outlet dam of Crusher Lake. This historic, unmaintained dam is owned by the current landowner (Northern Timber) and has been naturalized over time, being infilled by a beaver dam. Reach 1 is a 15 m long high-gradient (20% slope), highly entrenched cascade. Substrate in this area is dominated by boulders, with rubble, cobble, and bedrock present in lesser amounts. Abundant cover is provided by large woody debris and boulder substrate. Channel and wetted widths are 2.0 and 1.2 m, respectively, and average water depth is 11 cm. This reach has been assessed as a permanent barrier to upstream migration for most fish. In addition to the high gradient, there is a 1.3 m vertical drop within the cascade series which ends in a plunge pool with a maximum depth of 20 cm.

After the cascade series, the watercourse transitions into a flatter, 55 m long series of riffle-runs with occasional chutes (Reach 2). Run habitat is the dominant habitat type within this reach. Channel and wetted widths range from 1.7-4.0 and 0.9-1.2 m, respectively, and gravel substrates dominate the streambed, which is characterized as a mixture of larger to smaller rocky substrates. A small amount of cover is provided by overhanging vegetation, boulder, and large woody debris. Average water depth within this reach is 7 cm.

Within WL14, the watercourse transitions into a low gradient, low velocity flat connected by short riffle sections for a length of 195 m (Reach 3). Average water depth deepens to 39 cm, and channel and wetted widths range from 1.6-2.5 and 1.3-1.7 m, respectively. Deep muck is the dominant substrate type within the flats, rocky substrates dominate the short riffle sections. Moderate cover is provided in various forms (i.e., deep water, overhanging vegetation, undercut banks, boulders, and large woody debris). There are currently two beaver dams located approximately 20 m from the downstream end of the reach which lie approximately 25 m apart.

Reach 4 is characterized as a 66 m long series of beaver dams and debris impoundments (pools) connected by short run sections. Two beaver dams were documented within the reach – one located approximately 35 m from the start of the reach, and another at the end of the reach. Muck substrate dominates the pool sections whereas rocky substrates (bedrock, boulder, and rubble) dominate the short run sections. Channel and wetted widths through the reach are 2.3 m and 1.7-1.8 m, respectively, and average water depth is 28 cm. Abundant in-stream woody debris provides the dominant cover types, while boulders, deep pools, and overhanging vegetation provide other forms of cover.

The channel then transitions into a 53 m long riffle-run series, with run as the dominant habitat type. A short debris impoundment (pool habitat) also exists at the downstream extent of the reach. Channel and wetted widths within this section range from 2.1-3.2 and 1.4-2.9 m respectively, and average water depth is 0.09. Rubble dominates the substrate present in the riffle-run series, which also contains boulder, cobble, and small amounts of gravel of sand, while muck and rubble co-dominate the substrate within the impoundment pool. Moderate cover is provided by a mix of large woody debris, boulders, undercut banks, and overhanging and emergent vegetation.

From Reach 5, the watercourse de-channelizes through mixed-wood forests, following multiple flow paths for 43 m (Reach 6). Debris jams are present throughout the reach, and boulders dominate the substrate. Within this reach, the average depth of surface water (often occurring between boulders when present) is 24 cm. This reach is thought to pose a navigational challenge to fish species, and likely acts as a seasonal barrier as flow paths dry up during low-flow conditions.

WC5 re-channelizes at Reach 7, which is characterized by a series of a variety of minor habitat types (rapid, run, flat, pool, and cascade). Channel and wetted sections within this reach range from 1.7-2.3 and 0.9-2.3, respectively, and average water depth is 9 cm. Boulders dominate the substrate, which are intermixed with rubble, cobble, and bedrock. Trace amounts of gravel and muck were also documented. Cover is provided through overhanging vegetation, boulders, and large woody debris.

The final reach (Reach 8) begins as WC5 transitions into low-gradient habitat within WL17. The remaining 340 m of linear watercourse is described as a low velocity flat characterized by deep muck substrate and highly embedded boulders. Channel and wetted widths range from 1.4-3.6 m, and average water depth is 48 cm. Overhanging and flooded wetland vegetation, undercut banks, and deeper water provide abundant cover. The reach ends as the watercourse discharges into Mud Lake.

No fish were captured in WC5 south of Crusher Lake during either the 2015 baseline electrofishing surveys or during three rounds of electrofishing conducted during the 2019-2020 field program. North of Crusher Lake, one individual brook trout and three northern redbelly dace were captured during 2015 surveys (Appendix H). Over the three electrofishing rounds conducted in Summer 2020, one additional species, lake chub (1 individual) was captured along with brook trout. Population estimates calculated for WC5 peaked in July, with 32 ± 8 individuals. Of all fish survey sites sampled during the 2019-2020 field program, WC5 was the second most productive in terms of brook trout abundance, with 48 individuals captured, accounting for 98% of the total number of fish captured over the three electrofishing surveys (48 of 49 individual fish).

Additional species have been presumed present, specifically within the lowest reach (8) of WC5, based on direct connectivity, species confirmed, and similar habitat characteristics with Mud Lake. Species that are likely to be present include American eel, banded killifish, brown bullhead, golden shiner, ninespine stickleback, white sucker, and yellow perch.

As outlined in Table 3-8, WC5 provides habitat for a variety of life stages of species confirmed and presumed to be present through the delineated fish habitat reaches. In general, Reaches 1 through 7 are considered to provide a variety of suitable habitats for brook trout, lake chub, northern redbelly dace, and American eel. Of the probable species likely to occur in WC5 due to contiguity with Mud Lake (but not confirmed), American eel was the only species presumed to be present in these reaches (confirmed in

Mud Lake) based on their capacity to navigate over and through barriers. Shallow, higher velocity riffle areas dominated by smaller rocky substrate are considered to provide suitable substrate for brook trout and lake chub, while low velocity pools and flats provide suitable spawning areas for northern redbelly dace. Reaches that present a variety of cover types provide suitable habitat for juvenile brook trout and juvenile and adult American eel. Reaches 1 through 7 largely contain multiple, shorter habitat types, and therefore provide a variety of suitable habitats, though the extents of these habitat are naturally small-scale. Reach 6 is considered to provide seasonal passage only. Reach 8 provides suitable habitat for all life stages of banded killifish, brown bullhead, ninespine stickleback, northern redbelly dace, and yellow perch. Suitable habitat was also identified for juvenile and adult American eel, as well as adult life stages of brook trout and white sucker.

Water quality measurements recorded throughout the 2019-2020 field program show a general increase in water temperatures throughout the summer, with peak temperatures recorded during the detailed habitat survey on July 14, 2020. Temperatures recorded through each reach during this assessment were relatively consistent, ranging from 22.1 in reach 7 to 24.4 in reach 3. DO levels varied throughout the summer, with the lowest recorded concentration measured as 1.97 mg/L in late August. During detailed habitat surveys, higher DO concentrations were generally recorded in higher gradient, higher velocity reaches, while low-gradient, low velocity areas had lower concentrations of DO. Half of DO measurements recorded in the lower reach of WC5 throughout the summer of 2020 were below the CCME recommended concentration of DO for any life stage of cold or warm-water fishes (<5.5 mg/L), while 8 of the 10 DO records fell below the recommended DO concentration for other life stages of cold-water fishes (<6.5 mg/L). The watercourse is considered acidic, but not necessarily limiting to fish production as pH levels were consistently recorded as above 5. Summer temperatures and DO levels are potentially limiting to fish in production WC5, particularly for cold-water species.

4.1.2 *Watercourse 12*

WC12 is a first order stream originating in upland habitat east of WL56. The watercourse disperses through WL56, eventually re-channelizing within the wetland's eastern lobe. The watercourse exits the wetland via culvert under a forestry road and continues east to WL59.

WC12 was originally delineated during baseline surveys in 2015. During the 2019-2020 field program, the watercourse was completely dry west of the forestry road up to the permanently flooded portion of WL56 during the 2020 fishing season (June 1st-September 30th). As such, no fishing surveys were performed. East of the forestry road, the watercourse is backwatered from WL59 by a beaver dam located closer to the wetland complex. Due to the lack of water throughout the system, a full detailed fish habitat assessment was not completed. Instead, a spot check for fish habitat characteristics such as channel width and substrate was performed west of the forestry road between WL56 and WL59.

WC12 has more recently been described as an ephemeral groundwater seep. Evidence of groundwater seepage into WC12 was suggested by the presence of ferrihydrite; an orange, bacterial slime which often occurs where groundwater reaches the surface. Substrate is dominated by cobble, with lesser amounts or rubble, gravel, and muck. Average channel width is 1 m, and the channel is almost completely shaded by riparian vegetation, mainly in the form of tall shrubs.

As noted, no fishing surveys were conducted during the 2019-2020 field program. During 2015 baseline surveys, however, three juvenile brook trout were captured in WC12 via electrofishing. It is presumed, therefore, that WC12 may provide suitable juvenile and adult brook trout habitat at some point of the year. Also, Grant and Lee (2004) suggest that groundwater upwelling, as opposed to water velocity, is probably the most critical factor in brook trout spawning site selection. In addition, brook trout have been documented to spawn over silt and detritus providing there is groundwater seepage (Witzel and MacCrimmon, 1983). Based on the likely presence of groundwater seepage within WC12, the watercourse has been assessed as suitable for brook trout spawning. However, the use of habitat by fish in WC12 is extremely restricted and is likely only accessible during high water events.

4.1.3 *Watercourse 13*

WC13 is a second order stream which serves as the outlet channel of WL59. From WL59, the watercourse flows northeast for approximately 280 m through WL61 before emptying into Cameron Flowage.

WC13 has been broken into 5 homogeneous fish habitat reaches. The first and uppermost reach extends for 32 m and is described as a combination of riffle and flat habitat, with an average depth of 7 cm and gravel dominated substrate. Channel and wetted widths range from 3.4-4.8 and 1.7-3.0 m wide, respectively, and a relatively small amount of cover is provided in the form of overhanging vegetation, large woody debris, and emergent vegetation.

Reach 2 is an 8 m long pool, with muck substrate and lesser amounts of cobble, gravel, and sand. Channel and wetted widths are 3.1 and 2.5 m, respectively, and average pool depth is 10 cm. A small amount of cover is provided exclusively by overhanging vegetation. No instream vegetation or woody debris was documented in this reach.

The watercourse then transitions back into a shallow riffle, which extends downstream for 20 m (Reach 3). Gravel and cobble co-dominate the streambed substrate, with lesser amounts of rubble and trace amounts of muck also present. Like Reach 2, cover is provided exclusively by overhanging vegetation. Channel and wetted widths of this reach are 1.1 and 0.8 m, respectively.

Reach 4 is a 35 m long flat, with channel and wetted widths of 3.0 and 2.7 m, respectively. This reach is the deepest section of the watercourse, with an average depth of 46 cm. Deep muck dominates the substrate throughout the reach, and cover is available in the form of undercut banks, and overhanging and emergent riparian wetland vegetation.

The final and most downstream reach (Reach 5) is a 46 m long stretch of riffle-pool habitat, with riffle present as the dominant habitat type measured. Channel and wetted widths are 0.9 and 0.6 m, respectively, and average water depth throughout the reach is 11 cm. Rubble dominates the underlying substrate with lesser amounts of gravel, boulder, and muck also present. Cover is abundant and is provided by overhanging and emergent wetland vegetation, as well as a small percentage of undercut banks.

Brook trout, northern redbelly dace, banded killifish, lake, chub, and brown bullhead were captured in WC13 during 2015 baseline electrofishing surveys. Additional fish species captured during the 2019-2020 field program include American eel, creek chub, ninespine stickleback, and white sucker. Of all fish survey sites sampled during the 2019-2020 field program, WC13 had the highest recorded species diversity and was found to be the most productive in terms of brook trout abundance, with the species accounting for 68% of the total number of fish captured over three electrofishing surveys (114 of 167 individual fish).

Table 3-8 provides details on fish habitat provisions within each reach of WC13 for life stages of species confirmed and presumed to be present. Generally, shallow, higher velocity riffle areas dominated by smaller rocky substrate are considered to provide suitable substrate for brook trout, creek chub, lake chub, and white sucker based on spawning habitat preferences of these species (Reaches 1, 3 and 5). This habitat is also considered mostly suitable for juvenile brook trout and white sucker, as well as adult lake chub, creek chub, and brook trout. Vegetated, low velocity flats and pools provide suitable spawning habitats for banded killifish, brown bullhead, ninespine stickleback, and northern redbelly dace, and provide rearing habitat for young of the year lake chub (Reaches 4 and 5). Suitable juvenile and adult American eel habitat is concentrated in areas of soft substrate and the presence of a variety of cover types (Reaches 2, 4 and 5).

Water quality measurements recorded in WC13 during the 2019-2020 field program show an increase in temperatures over the summer months, with peak temperatures recorded during the detailed fish habitat assessment on July 13, 2020. By early July, temperatures exceeded 20℃, and temperature measurements recorded throughout the watercourse on July 13th were relatively consistent, ranging from 23.4 in reach 1 to 25.9 in reach 4. The increase in summer temperatures also corresponded to a decrease in DO levels, which ranged from 5.9 mg/L in June to 4.10 mg/L in late July, below the CCME recommended concentration of DO for any life stage of cold or warm-water fishes (<5.5 mg/L). Correspondingly, the amount of fish captured during successive electrofishing surveys decreased; more specifically, amount of brook trout captured was dramatically reduced, from 57 and 54 individuals in June and July, to only 3 individuals in August. Summer temperatures and DO levels are considered limiting to fish production in WC13, particularly for cold-water species.

4.1.4 *Watercourse 14*

WC14 is an intermittent, first order stream located south of Cameron Flowage, and serves as one of two tributaries to WL59. The watercourse was originally delineated in 2015. As part of the 2019-2020 field program, the watercourse was electrofished and a detailed fish habitat assessment was performed. The watercourse received a detailed fish habitat assessment on July 13, 2020, during which the watercourse was delineated into three homogenous reaches. The uppermost reaches (1A and 1B) denote the two upper branches of the watercourse - 1A refers to the northern branch that flows east to west, while 1B refers to the southern branch which flows north from WL57. Reach 2 begins as the confluence of 1A and 1B, which continues as a single channel to its outflow at WL59.

Reach 1A is a 30 m long run, with habitat assumed based on conditions during high flow. At the time of the assessment, the watercourse was mostly dry and only residual, shallow pockets of water remained with an average depth of 9 cm and channel width of 50 cm. Rubble is the dominant substrate in this reach, which is intermixed with lesser amounts of muck. Overhanging riparian vegetation (predominantly tree branches) is the major source of cover within the reach.

Reach 1B is 115 m in length, transitioning between steep, step-pool habitat and areas of no defined channel. Like Reach 1A, this channel was predominantly dry during the assessment, with water restricted to residual, isolated pockets with an average depth of 3 cm, while areas of no defined channel (non-channelized areas of forest drainage) were completely dry. Channelized areas have an average width of 1 m. Large woody debris provides a moderate amount of in-stream cover, while muck and detritus dominate substrate, with lesser amounts of rubble.

As reach 1B and 1A converge, the channel becomes contiguous, high-gradient (18% slope), 32 m long series of step-pools. Substrate is dominated by rubble, but also contains boulder, cobble, gravel, and muck. At the time of the assessment, average water depth within residual pools was 3 cm. Average channel width within this reach is 1.3 m.

Water quality measurements recorded during fish habitat assessments suggest groundwater seeps contribute flow to reaches 1B and 2. Temperatures were recorded as 5.6℃ and 7.4℃ lower in reaches 1B and 2, respectively, than in reach 1A, which were taken within 15 minutes of each other and with no significant changes to stream shade or water depths throughout the watercourse. This is also supported by steep channel gradients, which was not observed through reach 1A.

Two passes of with an electrofisher in June in WC14 resulted in no fish capture. Dry channel conditions throughout the remainder of the summer sampling season (up to September 30th) prevented additional attempts at electrofishing. Probable fish presence, based on confirmed species within downstream, fish bearing systems, as well as habitat suitability within the watercourse, include brook trout and American eel. Suitable, seasonal juvenile and adult brook trout habitat is present throughout the watercourse, provided that fish can access the upstream reaches through the high-gradient of reach 2 and non-channelized areas of reach 1B. Potential brook trout spawning habitat is restricted to reach 2, which provides a small amount of suitable spawning substrate and probable groundwater seepage. Habitat for adult American eel was documented throughout the watercourse, with more suitable juvenile habitat (deeper muck) provided in reaches 1B and 2. It should be highlighted that these habitat provisions are temporally restricted and are not viable or accessible during periods of low flow.

4.1.5 *Watercourse 18*

WC18 is an ephemeral channel that was originally delineated and characterized in October 2018. The channel was originally observed to turn subterranean, and then disperse into WL217 (softwood swamp). The watercourse was revisited throughout the 2019-2020 field program to confirm connectivity to downstream, fish-bearing resources, characterize fish habitat, and perform fish surveys (trapping, electrofishing). These assessments occurred during both low and high flow regimes in December 2019, May 2020, and again in September 2020.

WC18 is rarely channelized – the watercourse is characterized by very diffuse flow that is only identifiable during high flow throughout much of its delineated length. During high flow, the wetted portion of the watercourse is infrequent and extremely shallow. When water is at the surface, depths are not sufficient to put any type of trap or to submerge the anode ring of an electrofisher; as such, no fish sampling was conducted. As it flows northeast towards Cameron Flowage, it completely disperses, preventing any surface connectivity to downstream, fish bearing features. Based on these assessments, WC18 has been designated as not frequented by fish and a non-fisheries resource, as shown on Figure 10, Appendix A.

4.1.6 *Watercourses 20-22 and Associated Wetlands*

WL220 is a headwater fen complex located near the western edge of the PA. Standing water is present in discontinuous patches within WL220, the largest of which is approximately 60 m long, 1 m wide and approximately 1 m deep. WL220 did not show any obvious flow pathway for fish access. WL220 is the source of a first order stream, WC21, which exits the wetland via culvert under a forestry road. WC21 appears to have been created by the installation of the culvert which has backed up flow from WL220 and resulted in channelized flow within WC21.

WC21 flows a short distance (20 m) as a flat, before transitioning into 30 m series of step-pools through upland forest habitat before entering WL205. Where WC21 is channelized, it ranges between 30 and 50 cm wide, with average depths of 4 and 6 cm, and organics and rubble substrate dominating the flat and step-pool sections, respectively. As WC21 flows into WL205, the channel completely dissipates as flow disperses into heavily saturated fen habitat.

WL205 is a wetland complex consisting of saturated fen habitat in the north, transitioning to a mixed wood treed swamp and tall shrub swamp through the southern portion. In the northern portion, the wetland habitat is heavily saturated with sphagnum-filled pockets of water and saturated organic soil exceeding 1 m in depth interspersed between treed hummocks. Throughout this section of WL205, standing or flowing water was observed to be present throughout high and low flow regimes only in sparse, discontinuous patches, and the habitat is most suitably described as floating fen habitat with oversaturated sphagnum mosses. The central portion of WL205 is characterized as a mixed wood treed swamp with portions dominated by tall shrub cover rather than mature canopy. Overall, this section is less saturated than the northern section described above, however sparse pockets of standing water are present very sporadically throughout this section. The northern and central portions of WL205 lack contiguous flowing water for a length of approximately 260 m between WC21 and WC20

Approximately 260 m downstream of the WC21 outlet, flow channelizes within WL205, forming WC20. The watercourse flows for 200 m as a flat, with channel widths ranging from 0.9-3.2 m, low to negligible velocity, and predominantly mucky substrate. WC22 is a small, 100 m long tributary to WC20, with similar characteristics and landscape position to WC20. WC20 exits WL205 as an outflow before dissipating into upland forested habitat. This area of upland forested habitat continues for approximately 250 m before flow forms at surface as WC23, which is described in Section 4.1.7.

Extensive fishing efforts within these watercourses and wetlands during the 2019-2020 field program accumulated to 5,558 hours and 10 mins of trapping effort, and 7,787 seconds of electrofishing. No fish were captured or observed within these aquatic features during the 2019-2020 field program.

A fish passage assessment program was completed at the upper end of WC23 and the lower end of WC20. Fish passage assessment for this program was designed to ensure all flow regimes and seasons were evaluated, using Environment and Climate Change Canada data to identify appropriate timing for high flow surveys. The subterranean section between WC20 and WC23 was assessed on the dates provided in Table 4-1. In this table, flow regime of high vs. low were determined based on a review of regional hydrometeorological data (ECCC, 2020). Photos taken throughout the assessment period are provided in Appendix C (Photos 56-69).

Table 4-1. WC20-WC23 Barrier Assessment Dates

Date	Flow Regime	Personnel
15 July 2019	Low	MEL
2 August 2019	Low	MEL
19 August 2019	Low	MEL
22 August 2019	Low	MEL and DFO
9 September 2019	Moderate – following hurricane rains	MEL
17 September 2019	Low	MEL

Date	Flow Regime	Personnel
6 November 2019	High	MEL
22 November 2019	High	MEL
4 December 2019	High	MEL
16 December 2019	High	MEL
8 April 2020	High	MEL
23 April 2020	High	MEL
24 April 2020	High	MEL

The barrier assessment involved following the most obvious flow path, where possible, using flow accumulation data and LiDAR data as guidance in the field. Following the most obvious flow path (using both visual and audible cues), the teams searched for evidence of hydrological flow, using guidance from wetland delineation methodology and watercourse identification guidance. Sample hydrology indicators include presence of surface water, high water table, saturation, water marks on trees, sediment deposits, drift deposits, iron deposits, sparsely vegetated concave surfaces, water stained leaves, aquatic fauna, and drainage patterns. More subtle indicators of hydrological flow include stunted or stressed plants, geomorphic position or microtopographic relief, along with audible evidence of subterranean flow.

The area between WC20 and WC23 was assessed through all flow regimes to identify any indicators of hydrological flow. Hydrologic connectivity could, in theory, indicate potential fish passage through this section. The total length of the section between WC20 and WC23 is 250 m. This area is described as upland forest, with boulder and thin till substrate. Through the majority of this reach (aside from immediately downstream of WC20 and immediately upstream of WC23), visual and audible evidence of flow and hydrology is completely absent. Observations were consistent through all observed flow regimes and seasons (Summer, Fall and Winter 2019, Spring and Summer of 2020).

The upland habitat between WC20 and 23 does not meet any of the defining watercourse criteria provided in Section 1.1. Based on the presence of 250 m of upland forest between WC23 and WC20, which is consistent across all seasons, and the support of fish collection and eDNA survey results, all wetlands and watercourses upstream of this barrier (WL220, WL205, WC20, WC21 and WC22) are determined to be not frequented by fish and non-fisheries resources, as shown on Figure 10, Appendix A.

4.1.7 *Watercourse 23*

Located in the lower western lobe of the PA, WC23 is a first order stream within the Cope Brook tertiary watershed that commences in a boulder field at the southwestern extent of the 250 m expanse of upland forest described in Section 4.1.6. Approximately 1 km of the uppermost extent of the watercourse has been surveyed for fish habitat. The surveyed portion of WC23 has been delineated into three homogenous fish habitat reaches and have been described below.

After accumulating surface water through the boulder field, WC23 flows southwest, transitioning into a flat characterized by low gradient, low velocity, and muck substrate within a slightly entrenched channel through forested swamp. Boulders comprise approximately 25% of the total substrate. In this reach, channel widths and wetted widths range from 4-4.1 m and 2.3-3.5 m, respectively. Average water depth throughout this reach is 18 cm, and a moderate amount of cover is present which is largely provided by overhanging trees and a smaller amount of woody debris. In-stream vegetation is scarce. This reach is approximately 150 m in length.

Within the second reach, WC23 remains as a low gradient flat but transitions into a dense alder swamp, with alder shrubs overhanging the entire channel width, and submerged trunks and branches heavily criss-crossing the watercourse channel. Heavy cover is provided by these overhanging and intruding alders, submerged woody debris, and in-stream vegetation. Flow is visibly stagnant, and average water depth is 12 cm. Muck remains the dominant substrate, with lesser amounts of boulder present than in Reach 1. The watercourse flows south for another 150 m, before crossing a forestry road through a corrugated steel culvert.

Reach 3 begins below the culvert. This reach is 1320 m in length and is characterized by low gradient flats separated by sections of subterranean flow and a short section of high gradient step-pool habitat. Within the wetted portions of the watercourse, channel and wetted withs range from 1.1-5.3 and 0.9-3.0 m, respectively. Substrate is dominated by muck, with lesser amounts of boulder, bedrock, and rubble. Low velocity dominates throughout the reach with the exception of the short step-pool habitat, and average water depth is 18 cm. Cover is mainly provided by overhanging vegetation and large woody debris.

At the time of assessment, there were nine documented sections of subterranean flow within the third reach. The lengths of these subterranean areas range from 6 m to approximately 230 m. These areas are characterized by expanses of vegetated boulder fields with no visible surface flow, though unlike the barrier noted in Section 4.1.6, the area lacks soil and flow is mostly audible beneath the boulders, and as such has been defined as a boulder-bed channel. These areas have been assessed as seasonal barriers to fish passage, as water levels are expected to rise between and above the level of the boulders during periods of high flow. Though not complete barriers, it is likely that these subterranean sections restrict passage by acting as navigational obstacles to upstream and downstream migration.

Throughout the extensive electrofishing and trapping efforts performed during the 2019-2020 field program, only seven brook trout were captured in WC23, with a maximum of two individuals caught during any single survey. No suitable spawning or young of the year habitat within WC23 was identified, but all three reaches have been assessed as supporting juvenile and adult brook trout. The low abundance of trout within the watercourse is likely be attributed to a several factors: the absence of suitable trout spawning and young-of-the-year rearing habitat, the presence of multiple seasonal barriers to downstream and upstream migration, and water quality. Although recorded temperatures remained optimal for brook trout throughout the year, pH levels in WC23 demonstrate that on average, the pH is low enough to potentially cause harm to salmonid species (<5.0).

4.1.8 *Wetland 61 and Watercourse 25*

Wetland 61 is a wetland complex that surrounds the southeastern shoreline of Cameron Flowage. Two streams flow through the wetland that eventually discharge into Cameron Flowage – WC13 (discussed in Section 4.1.3) and WC25 discussed herein, which is associated with a small open water feature. No fishing was conducted in WC25 during either 2015 baseline surveys or the 2019-2020 field program, so fish species presence has been assumed based on hydrological connectivity to Cameron Flowage and species confirmed within the system.

In the northwestern lobe of WL61, there is a 173 m^2 headwater pond with water depths up to 1 m. Wetland habitat surrounds approximately 85% of the pond, while moderately sloped mixed-wood upland is present on the southeastern shoreline. Minimal shade is present as a thin band along the shoreline. No submergent or emergent vegetation were documented within the pond, nor were any other forms of cover with the exception of water depth near the centre of the pond. The visible edges of the pond are gravel dominated, and although not confirmed, substrate towards the centre, deeper portion of the pond is assumed to be muck.

WC25 exists as the pond's sole outflow – a short, first order stream that travels 33 m before emptying into Cameron Flowage. The watercourse was delineated into one reach during fish habitat characterization, which comprises a short riffle section followed by a low gradient flat. The short riffle exists immediately downstream of the pond. Here, the channel is barely visible, only slightly entrenched from the surrounding wetland habitat. Water depths were not observed to exceed 1 cm. This short riffle section is likely a seasonal barrier to most fish, with the exception of American eel which have been documented to traverse over land in wet, low lying grass habitats (MacGregor et al., 2011). The channel then widens up to 1.0 m, and continues as a low gradient, low velocity flat to Cameron Flowage. A relatively small amount of in-stream cover (10%) is provided by wetland vegetation adjacent to the watercourse. Muck substrate is present throughout the watercourse.

Based on direct hydrological connectivity to Cameron Flowage, the following species are expected to use habitat provided by the pond within WL61 and WC25: American eel, banded killifish, golden shiner, white sucker, and yellow perch. No suitable spawning or young of the year habitat has been identified within the pond, based on the lack of cover and absence of vegetation. The pond may provide habitat for juvenile and adult forms of most of these species, provided they exist as residents or are able to navigate through WC25 during periods of high flow. WC25 provides suitable spawning and young-of-the-year habitat to banded killifish, golden shiner, and yellow perch through flooded wetland vegetation and soft substrate in a low velocity stream, though in-stream vegetation is not abundant. The watercourse may also support juvenile and adult American eel, as well as adult white sucker. DO levels in WC25 may limit fish production at least seasonally, which was measured in September 2020 as well below the CCME recommended guidelines for any life stage of cold or warm-water fishes (3.6 mg/L).

4.1.9 *Watercourse 26*

WC26 is a first order stream that originates as flow accumulation within WL207, located along the northwestern edge of the PA. The watercourse flows north for approximately 800 m through wetland habitat before discharging into a wide, flat area of the Killag River. The entire watercourse was described through a detailed fish habitat assessment and was delineated into two homogenous reaches.

The uppermost reach (205 m) is described as flat with sections of no defined channel – surface water exists largely as intermittent, isolated pockets of surface water within wetland habitat with an average depth of 34 cm. Substrate is mostly contiguous wetland surface, with some exposed areas of muck in more inundated areas. Abundant cover is present in the form of inundated wetland vegetation and filamentous algae. During low flow conditions, areas comprising surface water are isolated from each other, impeding fish passage through the reach. It is assumed that during high flow conditions, these inundated areas become hydrologically connected through surface flow. In addition, DO levels recorded throughout the summer within this reach were mostly well below the CCME recommended guidelines for any life stage of cold or warm-water fishes. Overall, this reach has been assessed as low-quality fish habitat.

The remaining 600 m of habitat is characterized as a permanent, low gradient flat, with channel and wetted widths ranging from 0.7-4.7 m, widening as it approaches the Killag River. Abundant cover is available in the forms of overhanging and flooded emergent wetland vegetation, and submergent vegetation within the watercourse channel. Substrate is mostly comprised of muck, with sparse, embedded boulders present at the lower end of the watercourse.

Fishing efforts conducted during the 2019-2020 field program were concentrated within the uppermost reach of the watercourse (see Figure 3, Appendix A). Only one individual ninespine stickleback was captured during the first survey in June, and no other fish were captured during successive surveys, supporting the designation of overall low-quality habitat. However, based on its direct connectivity with the Killag River and habitat characteristics, the lower reach of WC26 has been conservatively presumed to provide habitat for the following species: American eel, banded killifish, brook trout, brown bullhead, golden shiner, white sucker, and yellow perch. The abundant vegetation, low velocity, and soft substrates provide suitable spawning habitat for generalist spawners, including ninespine stickleback, banded killifish, brown bullhead, golden shiner, and yellow perch. No suitable spawning habitat was identified for brook trout or white sucker, but the lower 600 m of the watercourse likely provides refuge and foraging opportunities for adult stages of these species. Although water quality measurements were recorded only once within the lower reach, the temperature recorded in mid July of 15.8 ℃ suggests optimal temperatures for cold-water species likely persist throughout the summer. DO levels were also observed to improve from the upper reach to 6.09 mg/L. Acidity levels, however, may limit the productivity of the stream, particularly for those species that are pH sensitive (i.e. salmonids).

4.1.10 *Mud Lake and Watercourse 27*

Mud Lake, located in the northern portion of the SA, is a main receptor of water within the SA. Its primary source is WC5, which directs water from Crusher Lake north to WL17, emptying into a strip of wetland which separates the eastern and western lobes of the lake.

Mud Lake exists as an open water body within WL17. The entire shoreline of the lake is composed of this peat wetland, predominantly in the form of a low shrub fen. Adjacent to open water, the wetland consists of low ericaceous shrubs and graminoids. The littoral zone is gently sloped and unshaded by any forest canopy cover, but some shade is provided along the wetland edges by emergent and floating wetland vegetation when water levels are high. Substrate through the lake is composed of deep muck and decaying organic material. Within Mud Lake, the substrate is dominated by mud, with emergent vegetation along the edges when the water level is high. While bathymetry data was not collected for Mud Lake, the depth is not believed to exceed 2 m based on direct observation during wetland and fishing surveys.

The outlet of Mud Lake, WC27, directs water northwest to the Killag River. Like Mud Lake, the riparian area of WC27 is composed of wetland habitat in the form of a low shrub fen. In the spring, the riparian wetland floods which significantly extends the wetted perimeter of the outlet. In the summer, channelized flow narrows into multiple braids which meander through wetland vegetation. The characteristics of WC27 are quite similar to Mud Lake – it is more accurately described as a narrowed extension of the lentic habitat observed in Mud Lake than a true lotic watercourse. Still, a detailed habitat assessment was performed on the outlet via boat based on the methodology described in Section 2.5.

WC27 has been delineated into a single homogeneous reach of a low-gradient flat which extends for 228 m before emptying into the Killag River. The main channel ranges from 3.4-9 m wide, velocity is sluggish to visibly stagnant, and the average water depth is 58 cm. Substrate is 100% deep, organic muck - consistent with the substrate in Mud Lake. In-stream cover is abundant, primarily in the form of emergent and submergent vegetation (pickerelweed and various graminoids).

As noted in Section 3.2.4, trapping efforts in Mud Lake and WC27 resulted in the highest species diversity of all lentic sites. The majority of fish captured within this system are considered habitat generalists: golden shiner, banded killifish, white sucker, ninespine stickleback, yellow perch, and brown bullhead. Mud Lake and WC27 support these species' spawning stage by providing abundant in-stream vegetation and soft substrate in a low velocity environment. In addition, the deep muck and vegetation provide usable habitat for juvenile American eel. Although no spawning habitat for lake chub was identified, the system may support young of the year through adult life stages which have been documented over a wider variety of substrates. The system may also provide refuge and feeding opportunities for adult brook trout, but lacks the substrate, flows, and cover diversity to support spawning through juvenile life stages. Water quality within the system is described as generally acidic with areas of low DO but is not considered limiting to overall fish production. Three of the four temperature readings recorded within the Mud Lake/WC27 system over the summer of 2020 were below 20℃, falling within the optimal temperature range for cold-water fishes. Water temperatures were observed to surpass 20℃ in late July, at which point cold-water fishes such as brook trout would likely disperse to areas of thermal refuge.

4.1.11 *Cameron Flowage and Killag River*

Cameron Flowage, located along the northeastern edge of the SA, is the primary receiver for most surface water originating from within the SA prior to it draining offsite through the Killag River to the southeast. No dams or other barriers to fish passage have been observed on Cameron Flowage. The Killag River commences north of Cameron Flowage (Tait Lake) that is located directly northeast of the Beaver Dam PA. The Killag River is one of two major tributaries to the WRSH. The Killag has a rather long and narrow drainage basin, with a main channel length of approximately 27 km. The Killag River system has several associated waterbodies, such as Tait Lake. West Lake, Mud Lake and Crusher Lake are associated with sub-tertiary basins that are tributaries to the Killag River.

The NSSA is currently operating two continuous lime dosers to offset the acidity of watercourses and improve water quality for Atlantic salmon within the WRSH watershed. Two lime dosers are currently in use, one of which is located Killag River approximately 400 m downstream of the southeastern extent of Cameron Flowage. Physical habitat restoration work has been completed in conjunction with the liming program, with the aim of increasing the freshwater production of Atlantic Salmon and Trout in the limed area of the WRSH watershed. This physical restoration work has involved removing fine substrate from selected spawning habitat on the Killag River, and the addition of deflectors and rock sills in the WRSH to restore natural riffle-pool patterns (NSSA, 2020).

Both Cameron Flowage and the Killag River were selected for focused fishing surveys during the 2019-2020 field program to provide additional baseline data for anticipated future monitoring programs. In

December 2020, modified fish habitat surveys were performed within a 1.7 km stretch of this system, from the top of Cameron Flowage (Killag River entrance) to approximately 100 m downstream of the Beaver Dam Road bridge (downstream of the lime doser). Nine cross-sectional measurements (i.e. transects) were taken at representative habitats throughout the system by boat or by wading. However, it is important to note that these surveys were performed during high flow with various instances of bankfull flooding; as such, depths and velocities presented below are reflective of high flow conditions.

The Killag River enters Cameron Flowage from the northeast as a series of rapids through a channel width of 10 m. Water depths and velocities measured here at the time of the assessment ranged from 28-60 cm, and 0.91-1.11 m/s respectively. Substrate was observed to be an even mix of boulder, rubble, and cobble.

As a wide, low velocity flat, habitat within Cameron Flowage is homogenous throughout the first 1 km length. Organic peatlands surround approximately 25% of Cameron Flowage, which is concentrated along its south eastern and northern shorelines. Emergent and floating wetland vegetation is present in the littoral zone adjacent to wetland habitat. Shoreline substrate is comprised of boulders, rubble, and cobble in a muck matrix, which transitions muck-dominance away from the shore. Widths measured along transects ranged from 59.4-76.8 m, and maximum water depths and velocities of 3.7 m and 0.16 m/s were recorded. The remaining 200 m length of Cameron Flowage transitions back into a wide, homogenous flat.

A pinch-point (relatively narrow riffle), located approximately 1 km downstream of the inlet of the Killag, separates the two wider flats of Cameron Flowage. Here, the channel confines to a width of 13.7 m, with water depths and velocities at the time of assessment ranging from 38-52 cm and 0.61-0.80 m/s, respectively. Substrate within the riffle is a boulder, cobble, and rubble mix with traces amounts of muck.

From the outlet of Cameron Flowage to approximately 100 m downstream of the Beaver Dam Road Bridge, the Killag River forms a series of runs, riffles, and slower flats and pools. Channel widths range 7.5 m in confined runs to 14.6 m in wider flats. Water depths and velocities are variable, with depths ranging from 33 cm to just over 1 m in deeper flats and pools, and velocities ranging from slack to 0.45 m/s in faster runs. Immediately below the lime doser, channel width is constricted by constructed banks of riprap. At the time of assessment (December 2020), maximum velocity in this area was measured as 1.2 m/s, and depths ranged from 14-71 cm. Boulder, rubble, and cobble-sized rock dominate substrate throughout the surveyed area of the Killag River.

During the 2019-2020 field program, three rounds of trapping efforts (early, mid, and late summer) resulted in the capture of seven species of fish. Species captured included American eel, creek chub, and brook trout, which were not reflected in trap surveys performed during 2015 baseline studies, and banded killifish, golden shiner, white sucker, and yellow perch. Banded killifish made up the vast majority of individuals captured. Within Cameron Flowage, suitable spawning habitat is available for generalist species that show preference for vegetation and soft substrates within lentic environments, including banded killifish, golden shiner, and yellow perch. Spawning habitat for brook trout, white sucker, and creek chub is limited, given the overall lack of clean gravel substrates observed within the along the shoreline. Cameron Flowage also supports both juvenile and adult life stages of American eel with soft substrate and a diversity of cover types.

As noted in Section 3.2.2, the Killag River recorded the highest abundance of fish of all sites surveyed during the 2019-2020 field program. The Killag River was also the only site with confirmed presence of Atlantic salmon, with four individual parr captured in July 2020. Additional schools of small (<20 mm) white sucker were also observed during electrofishing surveys, but were unable to be captured and are not reflected in population estimates. The Killag River is considered the location of most salmon spawning within the WRSH watershed (Ducharme, 1972), and the most important of the three major rivers (Killag, West, and Little) for overall salmon production. Brook trout, white sucker, and lake chub are also presumed to spawn in this system, which also provides habitat for juvenile and adult American eel.

Water quality parameters recorded within both Cameron Flowage and the Killag River through electrofishing and trapping surveys are generally considered suitable for freshwater fish. One limiting factor identified within the Cameron Flowage/Killag River system, specifically for cold-water species, is summer water temperatures. By mid-July, shoreline temperatures within Cameron Flowage were above the optimal range for cold-water fishes, and temperatures were observed to exceed 20℃ in the Killag River by late August. Temperature surveys within the WRSH and its tributaries conducted by Halfyard (2007) documented temperatures frequently exceeding 20℃ from May 1st to September 30th, with July and August being the hottest months. The maximum recorded temperature in the Killag was 29℃ and was recorded in August during a period of extreme low flow (Halfyard, 2007). According to Halfyard, "given the long duration of high temperatures above that preferred by both salmon and trout, it would be reasonable to expect that Atlantic salmon and brook trout production may be limited by temperature, and that these fish need (to) seek areas of thermal refugia" (2007). A total of 13 significant thermal refuges (springs/seeps) have been identified on the Killag, West, and Little Rivers, with one of the most important identified on the Killag based on the number of congregating trout (Halfyard, 2007). While a specific number of thermal refugia was identified, their specific locations were not provided in the report by Halfyard (2007).

4.1.12 *Crusher Lake*

The fish and fish habitat characterization of the lake has been updated based on the results of the 2019-2020 field program which included three rounds of trapping within its littoral zone. The lake is located in the central northern zone of the PA and receives flow from two tributaries. Water exits the lake over a historic, man-made dam which has since been impounded by beavers (see Section 4.1.1 for details). Bathymetry data has not been collected for Crusher Lake, but it is estimated that the lake does not exceed 10 m in depth.

Organic peatland surrounds approximately 50% of the lake, which is primarily concentrated along the southern and western shorelines. Floating peatland extends into the waterbody in the eastern and western edges. These lacustrine wetlands support a community of submergent and emergent wetland vegetation (e.g., leatherleaf, Marsh St. John's Wort, and a variety of sedges). In spring, these wetlands flood providing additional seasonal fish habitat. In the summer, mud flats and residual, shallow pools can be observed within these peatlands, but are cut off from the central waterbody. Moderately sloped boulder-lined shores surround the remaining margins of the lake, which is dominated by mature upland forest. Deep, organic muck is the dominant substrate within the lake.

During the 2019-2020 field program, Crusher Lake had the lowest abundance of fish observed of all waterbodies and open water features. A total of five individuals were captured representing three species: brook trout, ninespine stickleback, and golden shiner. Crusher Lake is also known to support banded killifish and brown bullhead, though in low abundance, based on the results of baseline fish collection completed in 2016.

The lentic environment, in-stream vegetation, and soft substrate provide suitable spawning habitat for ninespine stickleback, golden shiner, and brown bullhead. However, no suitable spawning habitat (i.e. gravel shoreline) was identified for brook trout spawning. The lake is unlikely to support any life stage of brook trout other than adults, with provisioning restricted to refuge and foraging opportunities. Water quality is generally acidic, and DO levels in shallow, inshore areas adjacent to peatland habitat have been documented to become so low as to be unsuitable for fish survival. However, summer water temperatures are considered suitable for cold-water fishes.

4.1.13 *Wetland 56*

WL56 is a wetland complex located in the just west of WL59 within the northern area of the PA. The wetland consists of coniferous treed swamp, tall shrub swamp, and low shrub bog habitats, and has been heavily altered through historic mining activities including ditching, road building, and some infilling. Scattered patches of open water exist within this wetland as a result of these historic alterations.

The wetland is described as having a throughflow water regime, receiving drainage from WC12 which commences just 53 m west of the wetland. Water drains into the wetland's western edge, and collects in historic ditching, eventually flooding the central portion of the wetland. This area of open water (approximately 1,274 m^2) is permanently flooded. During wetter times of the year (fall and spring runoff), the wetland passively drains east, which seasonally floods an additional wetland area covering approximately 177 m^2. This drainage is eventually channelized through a forestry road culvert and disperses into WL59.

Fish habitat within the permanently flooded area of WL56 was characterized during the 2019-2020 field program, and a single pass, open site electrofishing survey was completed in September 2020. The maximum depth observed within the flooded area is 60 cm, with an average depth of 47 cm. Substrate is largely dominated by organic muck, with lesser amounts of embedded rocky substrate. The flooded area is approximately 20% covered with emergent cattails, grasses, and floating algal mats.

Fish species recorded during previous baseline electrofishing surveys conducted in 2015 included banded killifish and northern redbelly dace, though in extremely low numbers (one individual of each). In 2020, a total of three individual ninespine stickleback were captured. The abundant vegetation cover and soft substrate documented in WL56 provides suitable spawning habitat for all three of these species, and likely supports young of the year through adult life stages. As noted in Section 4.1.2, WC12 acts as the sole outlet of WL56, and was completely dry west of the forestry road up to the permanently flooded portion of WL56 during the 2020 fishing season (June 1st-September 30th). However, three juvenile brook trout were captured in WC12 during 2015 baseline studies (Appendix H). It is presumed, therefore, that brook trout may access the flooded portion of WL56 via WC12 based on a seasonal hydrological connection limited to high flow events. No suitable spawning or juvenile rearing habitat was identified for brook trout in WL56. Overall, the permanently flooded area of WL56 is characterized as supporting a small resident fish population, and may be seasonally accessible to brook trout, though quality habitat for most life stages of trout is absent. A small amount of additional habitat (177 m^2) similar to that of the permanently flooded area (though dry during low-flow seasons) may be accessible to fish during high flow events. In addition, DO was recorded below levels suitable for any life stage of cold or warm-water fishes (<5.5 mg/L). It is likely that DO concentrations limit habitat suitability for fish, at least seasonally, and particularly for cold-water species like trout.

4.1.14 *Wetland 59*

The permanently flooded area of the wetland comprises approximately 3.6 ha which covers the central, southeastern lobe and a small portion of the northwestern lobe of the wetland. Wetland habitat on the western side of the road was observed to be isolated from the open water portion of WL59 based on assessments conducted in 2015. However, beaver activity has caused the road to flood, creating additional, potential seasonal fish habitat (based on assumed hydrological connectivity during high flow regimes). This potential fish habitat (0.1 ha) completely dries during low flow conditions. The wetland receives input from both WC12 and WC14. WC13 acts as the sole outflow, which drains northeast eventually emptying into Cameron Flowage.

A detailed assessment of fish habitat was completed within the southeastern lobe of WL59 by boat on July 21, 2020. Thirty-three discrete points were established throughout the flooded portion of the wetland where substrate, water depth, and vegetation composition were recorded. In-situ water quality measurements were taken at eight randomly selected points out of the 33 discrete points.

The flooded portion of WL59 is surrounded by a thin wetland margin along the eastern, northern, and southern shorelines. The northern shoreline is heavily altered and comprises an old access trail and frequent gravel outcrops that extend from the trail south into the wetland. The western wetland lobe is divided by access road which is currently flooded – the wetland habitat west of this road is gently sloped and characterized by abundant broad-leaved cattail. The southern shoreline is characterized by intact, flooded alder swamp, which transitions to moderately sloped mixed-wood forest towards the east. WL59 was likely historically a treed swamp, as evident by abundant standing and fallen woody debris, and landscape position at the base of a drumlin.

The flooded portion of WL59 is approximately 50% vegetated with dense water lily and bladderwort cover, and less frequent emergent cattail and rushes. Snags and submerged woody debris are abundant throughout. A large beaver dam extends from the southern to northern shorelines approximately 115 m from the western edge. An active beaver lodge is located approximately 110 m west of the eastern shoreline, and an additional beaver dam is located at the outflow dam. The outflow dam, located along the northern eastern shoreline, channelizes water from WL59 into WC13. The dam consists of old concrete barricades which were historically used to flood the wetland. The dam has since eroded away, and old culverts are collapsed, washed out and ineffective. The barricade walls have been infilled by a beaver dam, creating a significant water level drop of approximately 1 m from the south to the north side of the barricade. This beaver dam is considered a seasonal barrier to upstream fish passage from WC13, but likely presents a permanent barrier to fish characterized as weak swimmers.

Substrate throughout the wetland is a thick muck/organic layer. Along the northern shoreline, there is sparse cobble, rubble and gravel sourced from erosion from access trail outcrops. The average water depth within the wetland is 0.75 m, with the maximum water depth recorded of 1.88 m.

Through three rounds of summer trapping efforts, five species of fish were recorded in the central flooded portion of WL59. The most abundant species were banded killifish and golden shiner, which were observed to congregate in large schools along the shoreline. Brown bullhead and ninespine stickleback were caught less frequently, and only two brook trout were captured in early summer. Although no American eel were captured during fish surveys, they are presumed to access WL59 based on confirmed presence in WC13 and their ability to navigate vertical barriers such as the beaver impoundment present at the outflow of WL59. The abundant vegetation and soft substrate within the permanently flooded portion of the wetland provides suitable spawning habitat for banded killifish, golden shiner, brown bullhead, and ninespine stickleback. The wetland may also support juvenile and adult life stages of American eel. No suitable spawning or juvenile habitat for brook trout was identified, but the wetland may provide refuge and foraging opportunities for older trout.

Summer temperatures have been identified as an overall limiting factor for cold-water species within WL59, with the majority of recorded temperatures measuring above 20°C. Although no temperature stratification or thermal refugia was identified within the flooded portion of the wetland, groundwater seeps were identified as likely to occur within the two tributaries of WL59 (WC12 and WC14).

5.0 SUMMARY OF BASELINE CONDITIONS

This Baseline Fish and Fish Habitat 2020 Technical Report was prepared as baseline information to support Environmental Impact Assessment (EIA) for the Beaver Dam Mine Project. The purpose of this report was to further describe the existing baseline conditions of fish and fish habitat within and in the vicinity of the Beaver Dam Mine Site by building on previous baseline studies conducted from 2015-2017 (report presented in Appendix H).

The Study Area is defined as an area of land encompassing aquatic features within the Beaver Dam Mine Site and other potentially affected aquatic habitats and reference areas, including the main stem of the Killag river and selected tributaries, Cameron Flowage, Mud Lake and its outlet watercourse, and a tributary to Cope Brook (WC23).

This Technical Report presented the results of field studies conducted from 2019-2020 and the resulting data collected, supplementing information presented within the Revised EIS (Atlantic Gold, 2019) and published literature. This information will support regulatory applications including the quantification of direct and indirect impacts to fish and fish habitat resulting in the harmful alteration, disruption or destruction of fish habitat (HADD) that will arise as a consequence of the Project, as well as the development of an offsetting plan and the determination of waters frequented by fish as per the Metal and Diamond Mining Effluent Regulations under the Fisheries Act.

Overall, the aquatic ecosystem within the SA is characterized by acidic conditions, with aquatic features within the Cope Brook tertiary watershed exhibiting lower pH levels than aquatic features within the Killag River tertiary watershed. Liming within the WRSH watershed has been ongoing since 2005 to raise pH levels throughout the watershed in an effort to increase habitat suitability for salmonids. Low pH levels, elevated temperatures, and low DO concentrations limit fish habitat quality within select systems, particularly within small, sluggish first order streams and shallow open water features that experience with low water depths during the summer months.

Electrofishing and trapping surveys confirmed the presence of fish species in the SA that would be expected within the WRSH watershed, including American eel, brook trout, banded killifish, brown bullhead, creek chub, golden shiner, lake chub, ninspine stickleback, white sucker, and yellow perch. Atlantic salmon was also confirmed present but only within the sampling reach established in the Killag

River. Population estimates calculated within the SA ranged from 18 fish to 291 fish ± 23 individuals. Generally, survey sites within higher order streams were observed to support a greater number and greater diversity of fish that first order streams. Detailed fish habitat assessments revealed suitable habitat for spawning, young of the year, juvenile, and adult life stages for both cold and warm-water species throughout the SA.

Of the 21 aquatic features evaluated for fish and fish habitat throughout the 2019-2020 field program, six have been designated as non-fisheries resources. Watercourses 18, 20, 21, 22, and Wetlands 205 and 220 do not provide fish habitat and are considered not frequented by fish. These conclusions are support by the results of electrofishing and trapping surveys, eDNA sampling, as well as multiple habitat assessments conducted during both low and high flow regimes.

6.0 CERTIFICATE

This document has been prepared by Environmental Scientist Amber Stoffer (MREM) and reviewed by the undersigned. If you have any questions or require any more information, please feel free to contact me.

Thank you,

<Original signed by>

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APPENDIX A. FIGURES

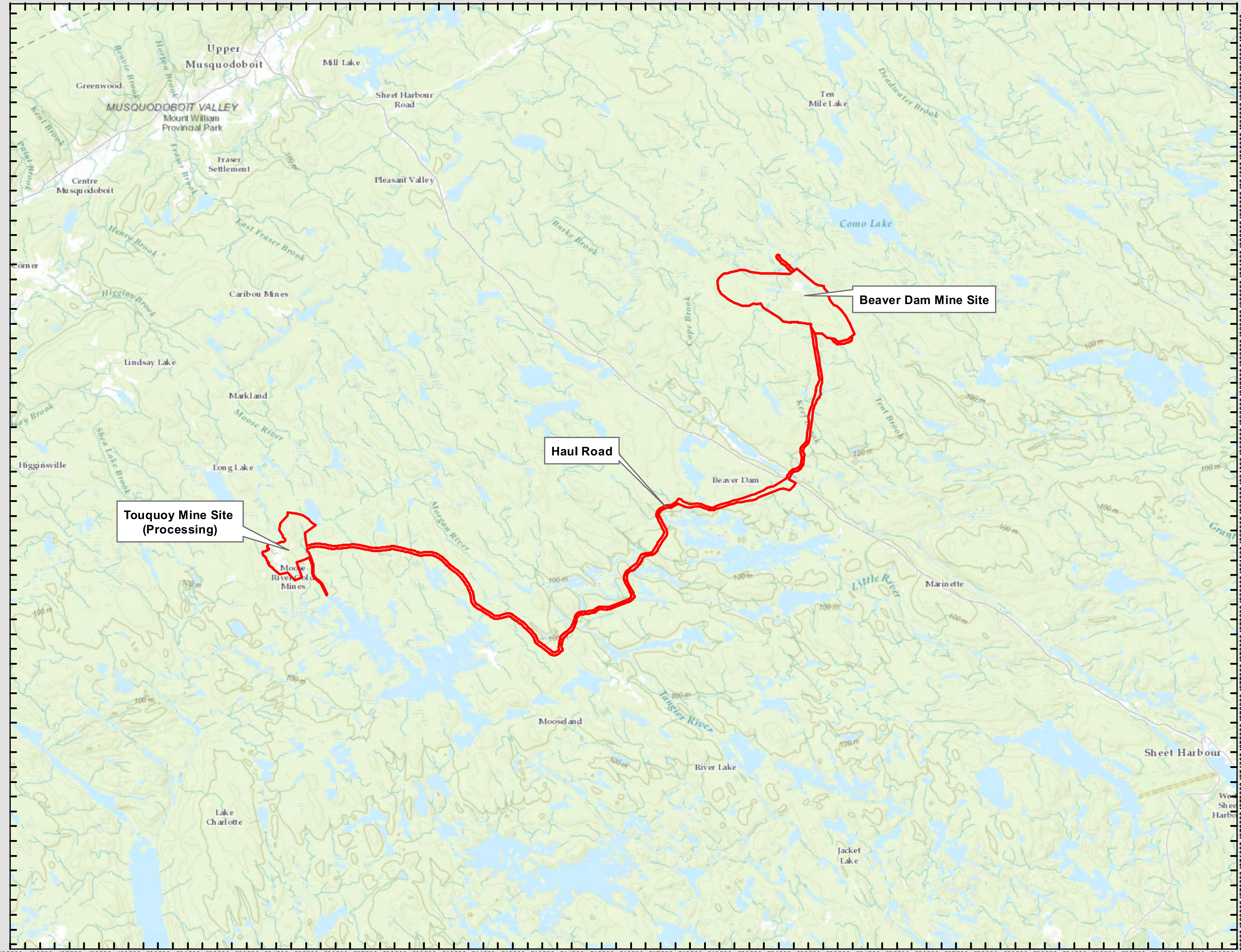

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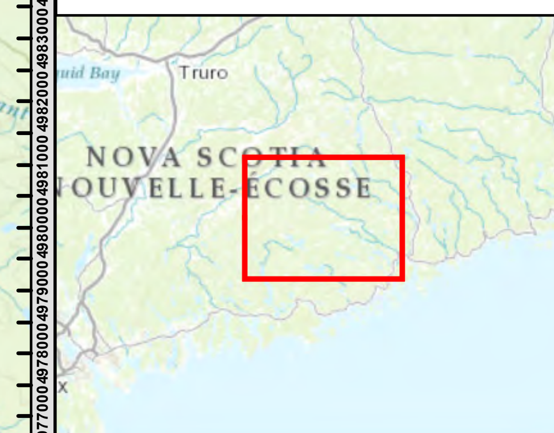
FIGURE 1

Project Location
Beaver Dam Mine Site

Marinette, NS

Project Area



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Drawn By: AS

Date: 2021-01-08

McCallum Environmental Ltd.

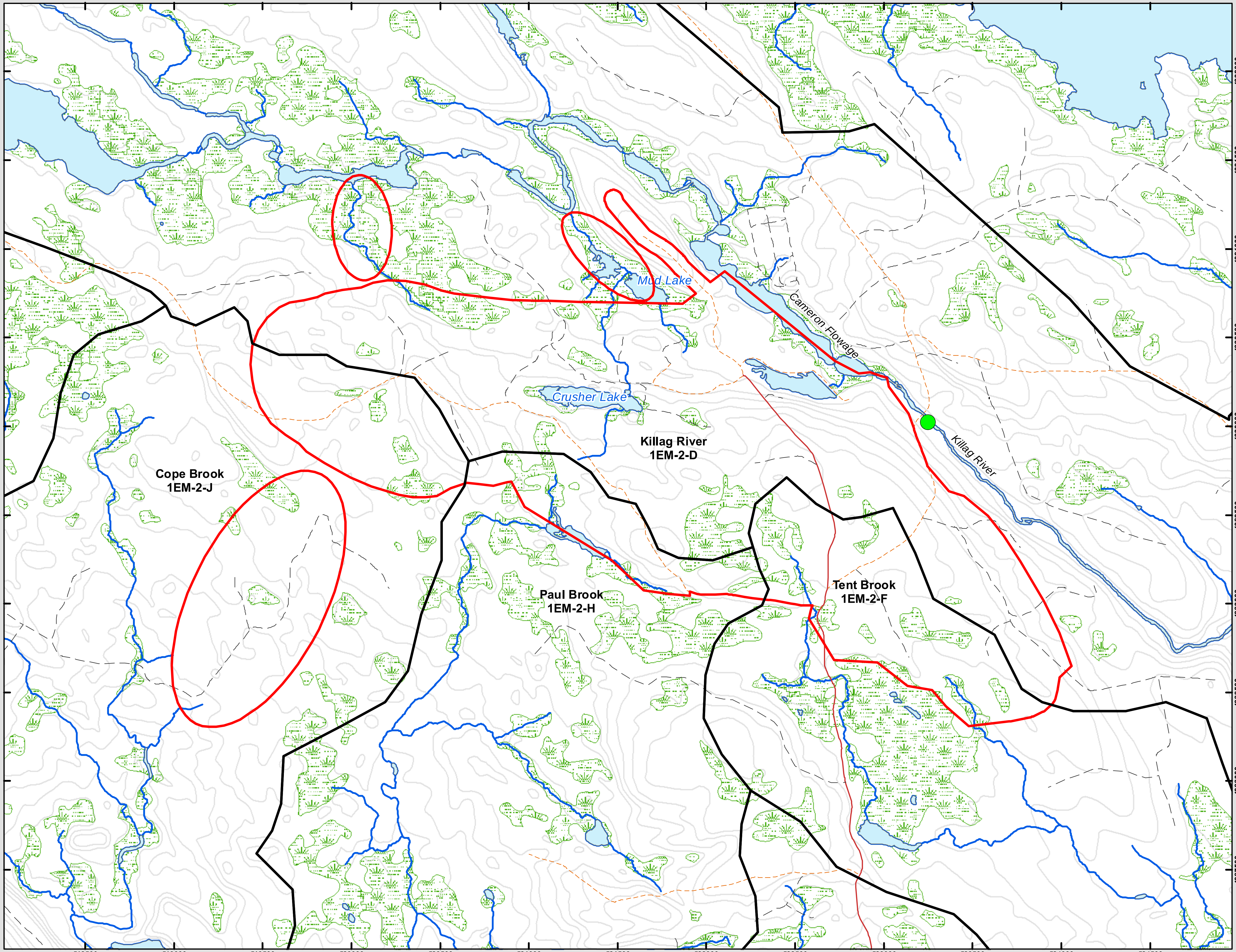

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FIGURE 2

Tertiary Watersheds
Beaver Dam Mine Site

Marinette, NS

- Lime Doser
- NSTDB Mapped Watercourses
- NSE Mapped Wetlands
- Tertiary Watershed Boundaries
- Study Area

Coordinate System: NAD 1983 CSRS UTM Zone 20N
Projection: Transverse Mercator
Datum: North American 1983 CSRS
Units: Meter

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1:20,000 Scale when printed @ 11" x 17"

Drawn By: AS

Date: 2021-01-08

McCallum Environmental Ltd.

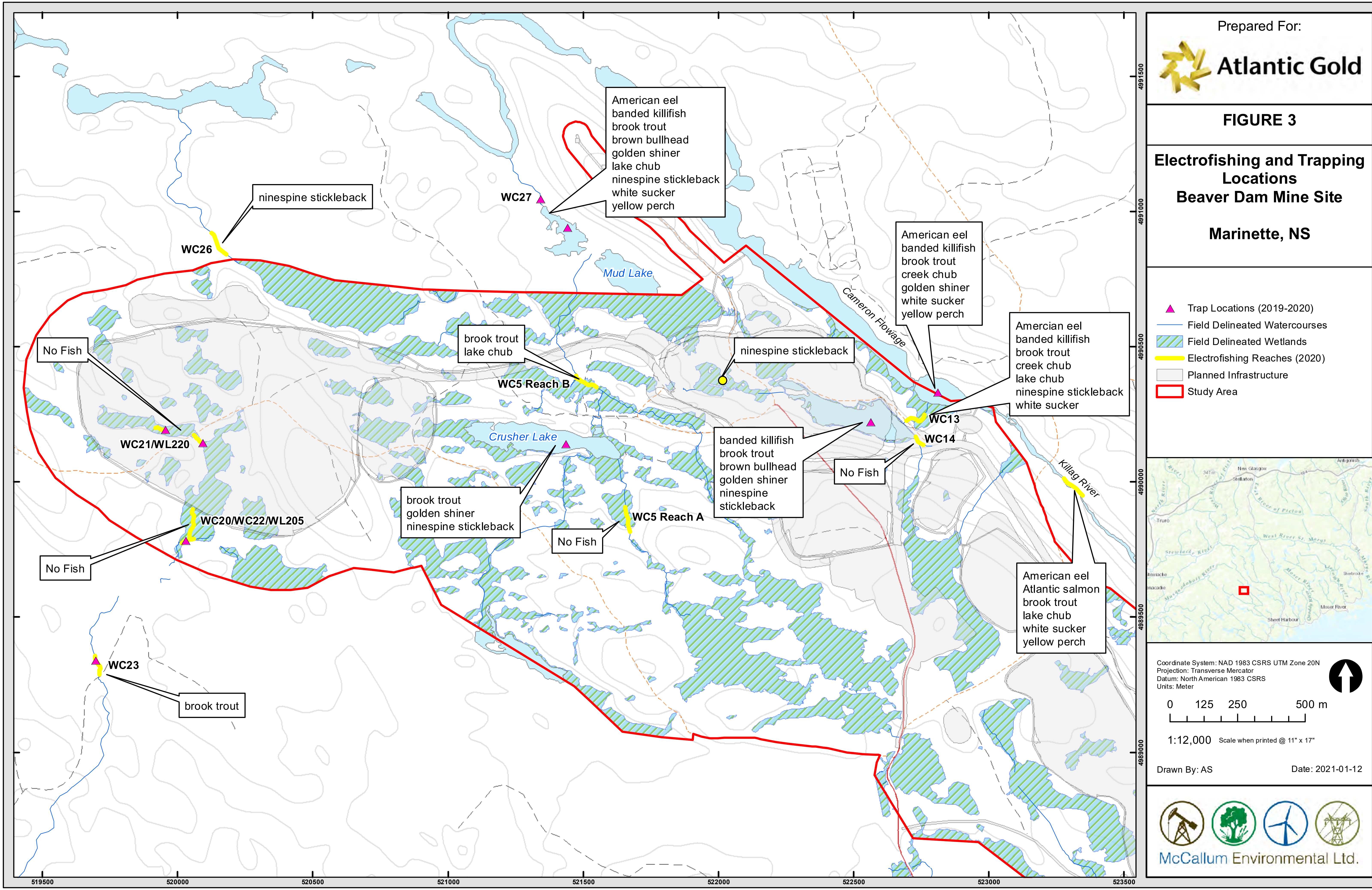

FIGURE 3

Electrofishing and Trapping Locations
Beaver Dam Mine Site

Marinette, NS

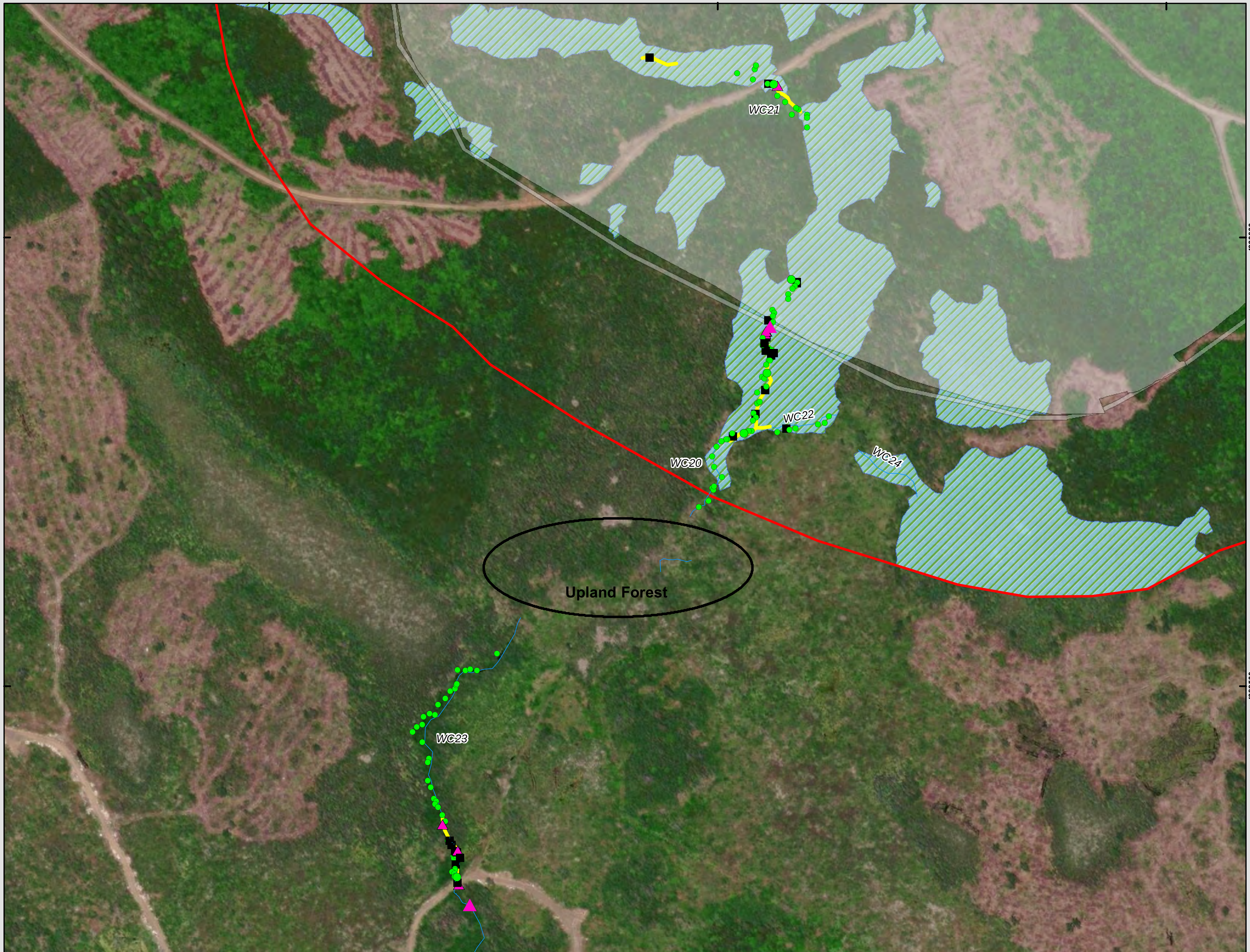

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FIGURE 4

2019-2020 Fishing Effort
Beaver Dam Mine Site

Wasterock Storage Area

Marinette, NS

- Eel Pot
- Fyke Net
- Minnow Traps
- Field Delineated Watercourses
- Electrofishing Survey
- Planned Infrastructure
- Field Delineated Wetlands
- Study Area

Coordinate System: NAD 1983 CSRS UTM Zone 20N
Projection: Transverse Mercator
Datum: North American 1983 CSRS
Units: Meter

0 50 100 200 m

1:4,000 Scale when printed @ 11" x 17"

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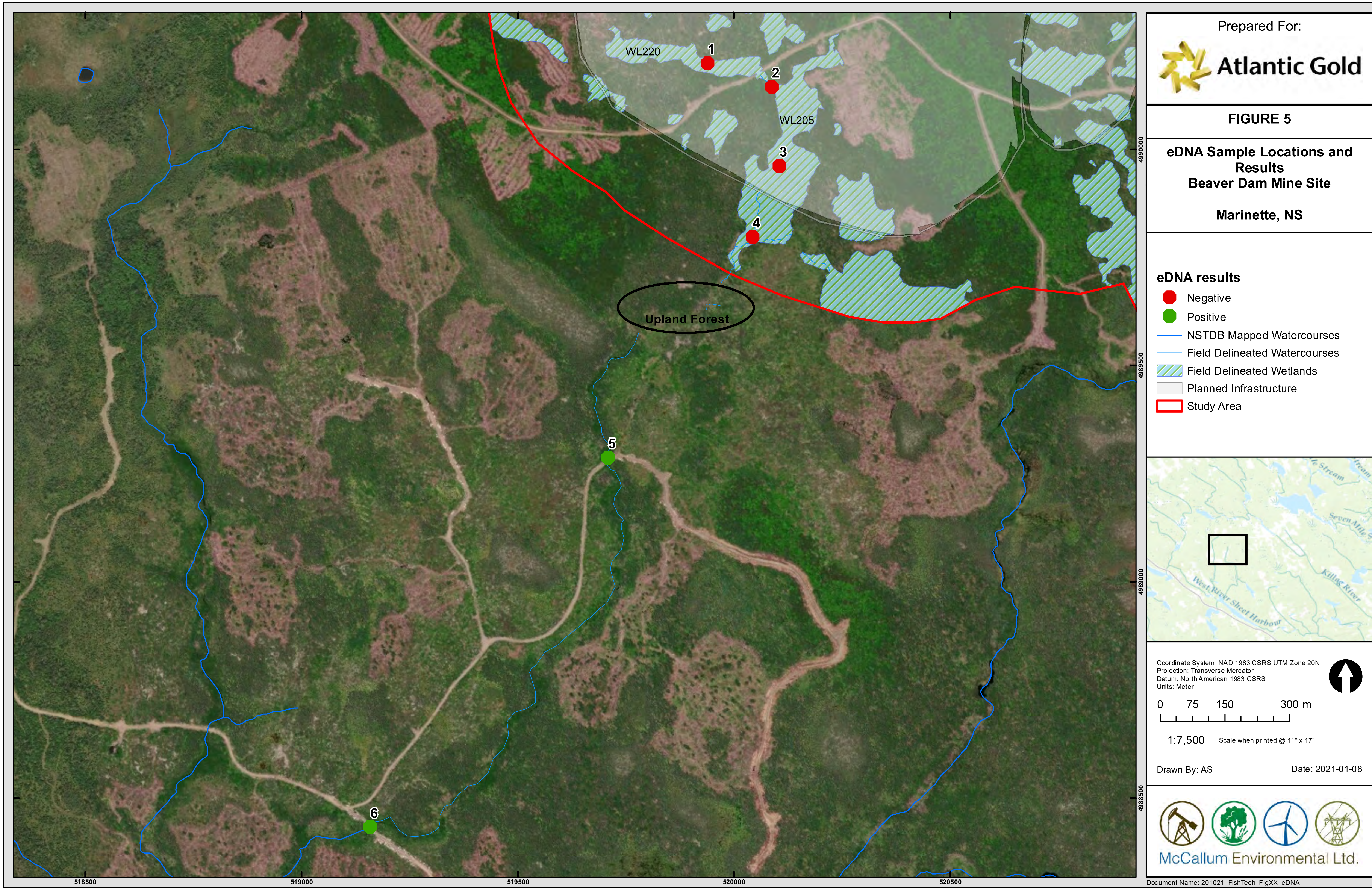

WL220
WL205
1
2
3
4
5
6
Upland Forest
518500
519000
519500
520000
520500
4990000
4989500
4989000
4988500
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FIGURE 5
eDNA Sample Locations and Results
Beaver Dam Mine Site
Marinette, NS
eDNA results
Negative
Positive
NSTDB Mapped Watercourses
Field Delineated Watercourses
Field Delineated Wetlands
Planned Infrastructure
Study Area
West River Sheet Harbour
Killag River
Seven Mile
Coordinate System: NAD 1983 CSRS UTM Zone 20N
Projection: Transverse Mercator
Datum: North American 1983 CSRS
Units: Meter
0 75 150 300 m
1:7,500
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Date: 2021-01-08
McCallum Environmental Ltd.
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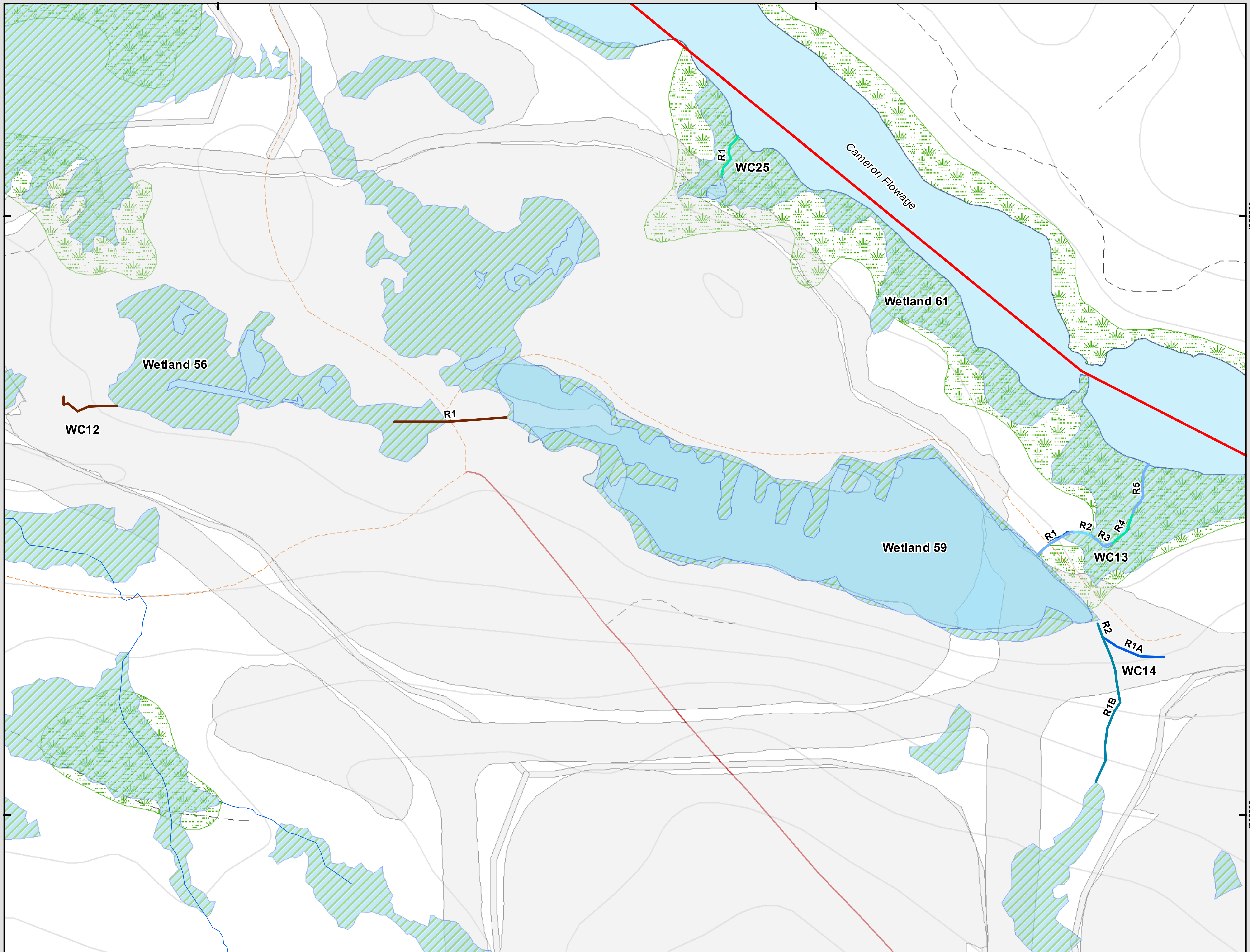

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FIGURE 6

Fish Habitat Reaches WC12, 13, 14 & 25 Beaver Dam Mine Site

Marinette, NS

Dominant Habitat Type

- Step-pool
- Run
- Riffle
- Pool
- Flat
- Seep
- Field Delineated Watercourses
- NSTDB Mapped Streams
- Field Delineated Wetlands
- Open Water
- Planned Infrastructure
- Study Area

Coordinate System: NAD 1983 CSRS UTM Zone 20N
Projection: Transverse Mercator
Datum: North American 1983 CSRS
Units: Meter

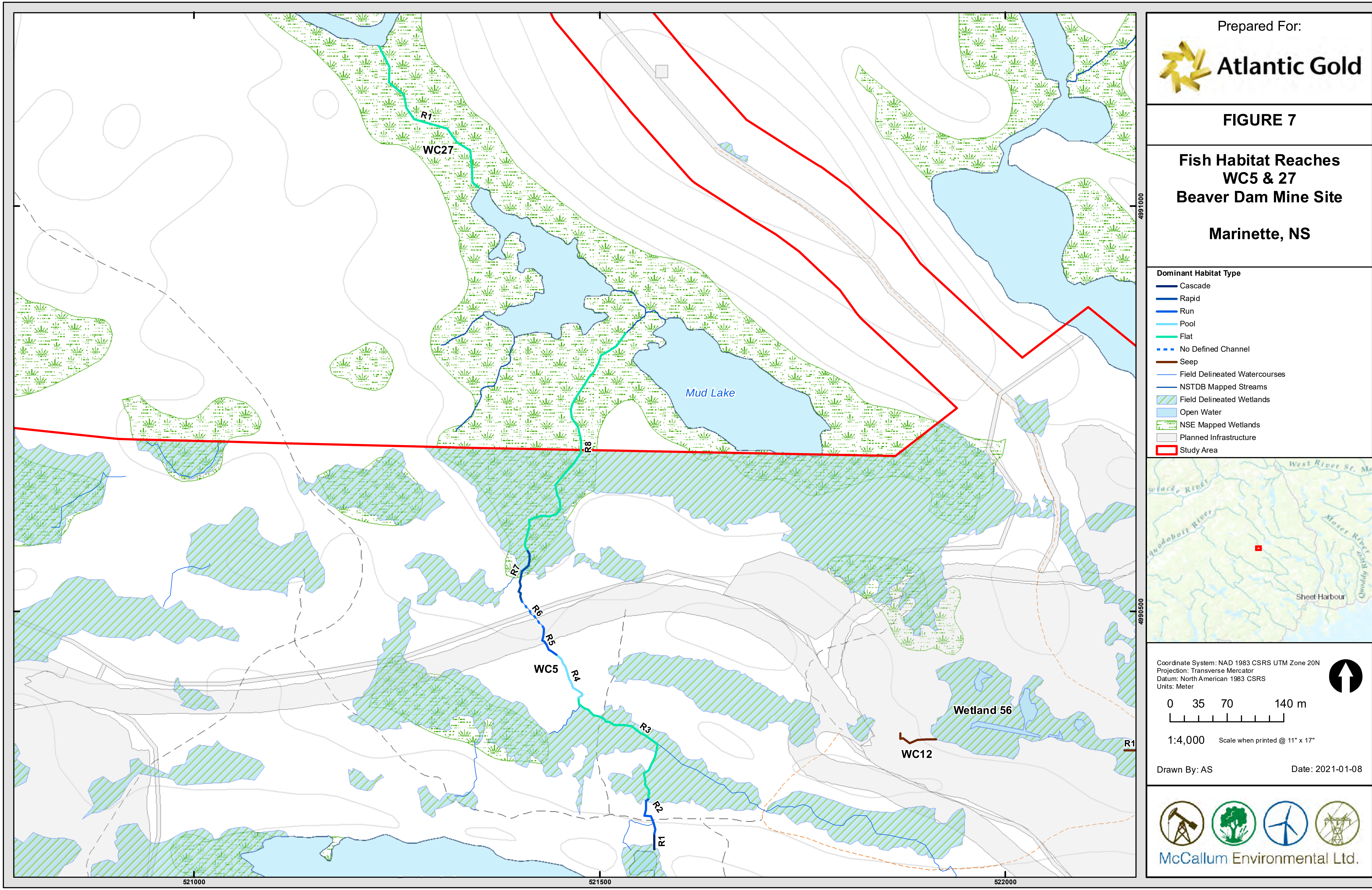
0 25 50 100 m

1:3,000 Scale when printed @ 11" x 17"

Drawn By: AS

Date: 2021-01-08

McCallum Environmental Ltd.



WC27
R1
Mud Lake
R8
R7
R6
R5
WC5
R4
R3
R2
R1
Wetland 56
WC12
R1
4991000
4990500
521000
521500
522000
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FIGURE 7
Fish Habitat Reaches
WC5 & 27
Beaver Dam Mine Site
Marinette, NS
Dominant Habitat Type
Cascade
Rapid
Run
Pool
Flat
No Defined Channel
Seep
Field Delineated Watercourses
NSTDB Mapped Streams
Field Delineated Wetlands
Open Water
NSE Mapped Wetlands
Planned Infrastructure
Study Area
Sheet Harbour
Coordinate System: NAD 1983 CSRS UTM Zone 20N
Projection: Transverse Mercator
Datum: North American 1983 CSRS
Units: Meter
0 35 70 140 m
1:4,000
Scale when printed @ 11" x 17"
Drawn By: AS
Date: 2021-01-08
McCallum Environmental Ltd.

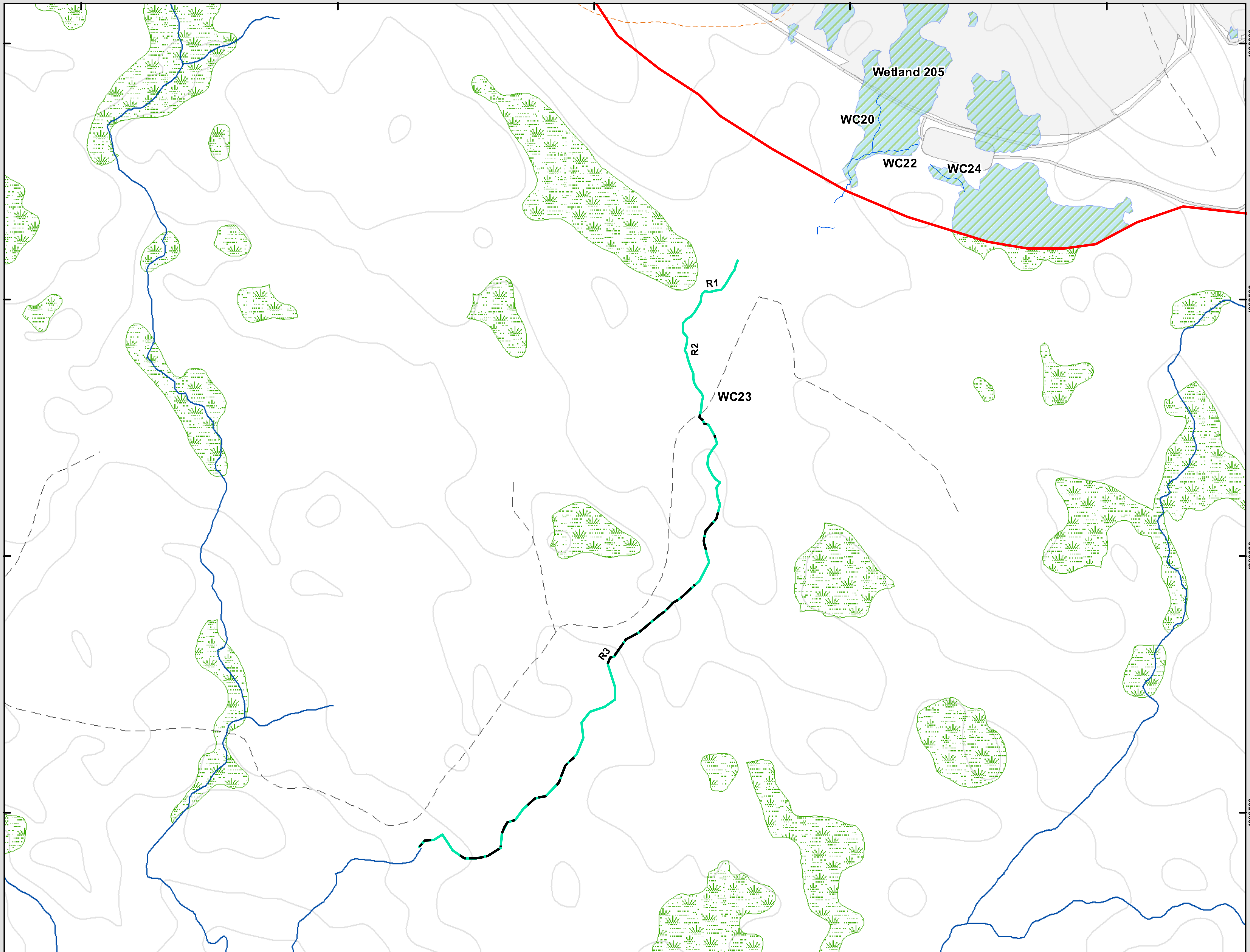

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FIGURE 8

Fish Habitat Reaches WC23 Beaver Dam Mine Site

Marinette, NS

Dominant Habitat Type

- Flat
- Boulder Fields (subterranean flow)
- Field Delineated Watercourses
- NSTDB Mapped Streams
- Field Delineated Wetlands
- NSE Mapped Wetlands
- Planned Infrastructure
- Study Area

Coordinate System: NAD 1983 CSRS UTM Zone 20N
Projection: Transverse Mercator
Datum: North American 1983 CSRS
Units: Meter

0 62.5 125 250 m

1:7,000 Scale when printed @ 11" x 17"

Drawn By: AS

Date: 2021-05-18

McCallum Environmental Ltd.

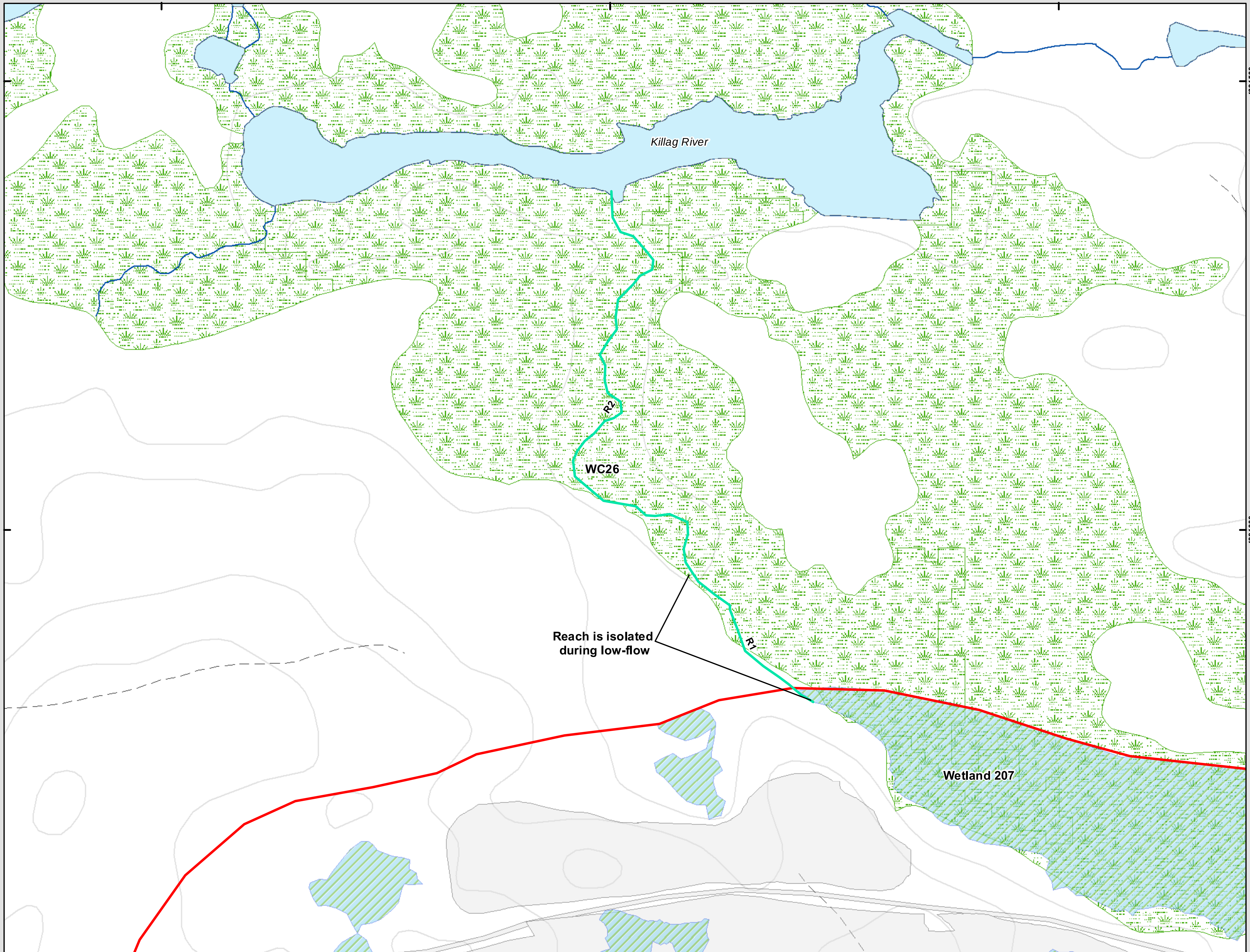

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FIGURE 9

Fish Habitat Reaches
WC26
Beaver Dam Mine Site

Marinette, NS

Dominant Habitat Type

- Flat
- Field Delineated Watercourses
- NSTDB Mapped Streams
- Field Delineated Wetlands
- NSE Mapped Wetlands
- Planned Infrastructure
- Study Area

Coordinate System: NAD 1983 CSRS UTM Zone 20N
Projection: Transverse Mercator
Datum: North American 1983 CSRS
Units: Meter

0 35 70 140 m

1:4,000 Scale when printed @ 11" x 17"

Drawn By: AS

Date: 2021-01-08

McCallum Environmental Ltd.

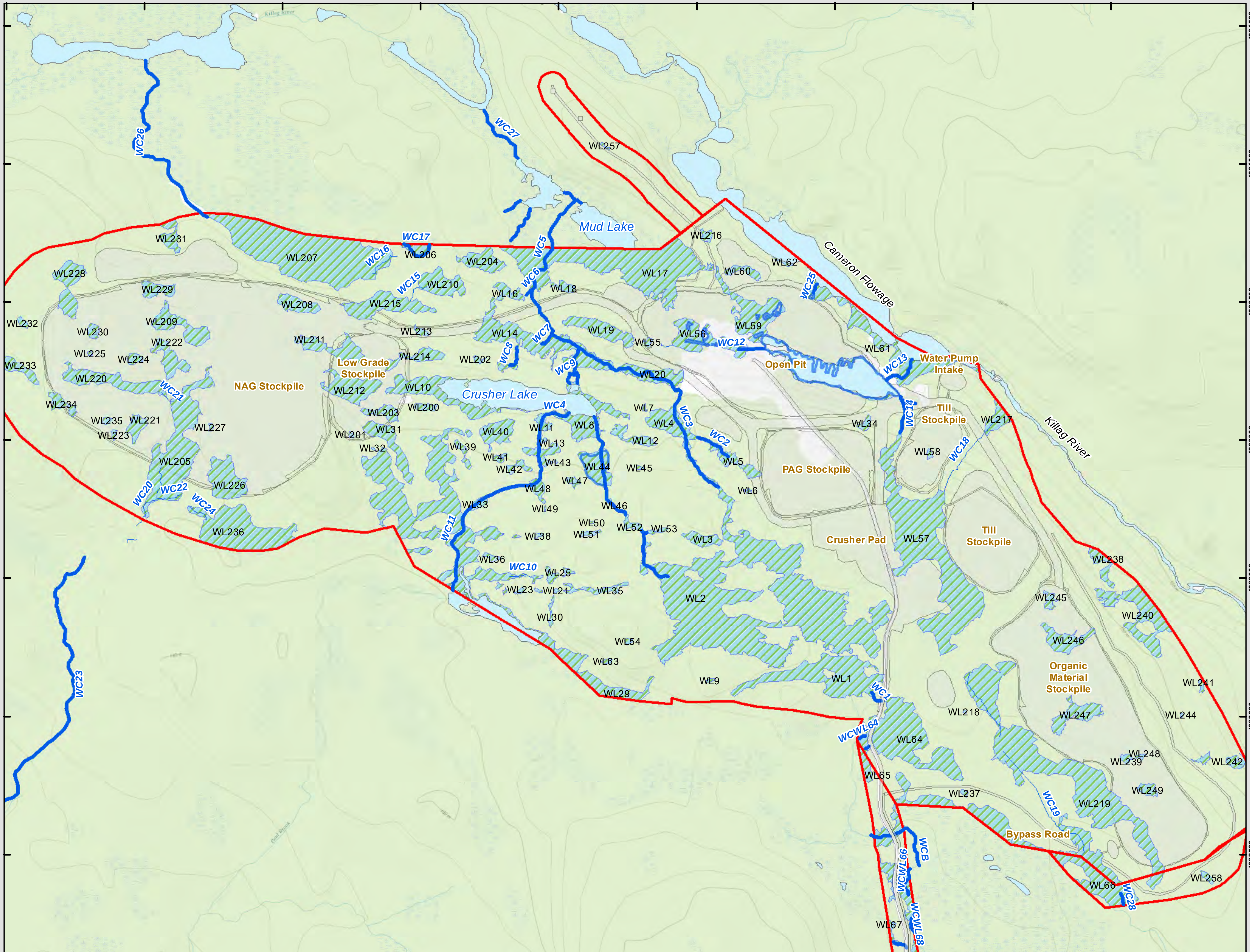
Prepared For:

Atlantic Gold

FIGURE 10

Wetlands and Watercourses Beaver Dam Mine Site

Marinette, NS



- Known or Assumed Fisheries Resources
- Field Delineated Watercourses
- Field Delineated Wetlands
- Planned Infrastructure
- Study Area

Coordinate System: NAD 1983 CSRS UTM Zone 20N
Projection: Transverse Mercator
Datum: North American 1983 CSRS
Units: Meter

0 137.5 275 550 m

1:13,000 Scale when printed @ 11" x 17"

Drawn By: AS

Date: 2021-01-12

McCallum Environmental Ltd.

APPENDIX B. STANDARD OPERATING PROCEDURES

STANDARD OPERATING PROCEDURE: DETAILED FISH HABITAT ASSESSMENT – STREAMS

1 PURPOSE

The purpose of this document is to provide standard methods for detailed fish habitat assessments performed by McCallum Environmental Ltd. (MEL) employees and subconsultants in lotic, freshwater habitats.

2 SCOPE

This document provides standards for data collection for detailed fish habitat assessments and describes a limited range of field-based measures for linear watercourses (i.e. lotic systems).

Fish habitat is inherently difficult to measure and quantify directly. Therefore, this SOP incorporates measures that evaluate specific features that are characteristics of, or inherent to a function of fish habitat and can indicate the extent to which a particular fish habitat characteristic or function is provided within a stream. This SOP aims to provide procedures for detailed fish habitat assessments which may be modified depending on the requirements and scope of a particular project.

Measures are habitat variables that can be quantified directly, or if not, visually estimated in the field. This SOP aims to incorporate measures of fish habitat with the following criteria, whenever possible:

- Quantifiable – habitat variables can be measured numerically, or when not possible, visual-based methods are standardized to the maximum practical extent.
- Rapid – habitat variables can be measured within the expected time frame of assessment (1/2 – 1 day per watercourse depending on watercourse size).
- Repeatable – a clear protocol for taking measurements can be described such that different users taking the measurement on the site would arrive at similar conclusions.
- Sensitive – changes or impacts to the stream would result in changes/impacts in the habitat variable. Variables are responsive to changes in the stream system.

It is important to note that the methods outlined in the SOP are best suited for previously mapped watercourses as they employ the use of transects. MEL defines watercourses based on guidance from Nova Scotia Environment (NSE, 2015). The following parameters were used to define watercourses:

- Presence of a mineral soil channel;
- Presence of sand, gravel and/or cobbles evident in a continuous patter over a continuous length with little to no vegetation;
- Indication that water has flowed in a path or channel for a length of time and rate sufficient to erode a channel or pathway;
- Presence of pools, riffles or rapids;
- Presence of aquatic animals, insects or fish; and,
- Presence of aquatic plants.

According the guidance provided by NSE, any surface feature which meets two of the criteria above meets the definition of a regulated watercourse. In MEL's experience, many first-order, headwater streams which meet the criteria of a regulated watercourse in Nova Scotia are not represented on topographic mapping or through provincial GIS layers. As such, it is critical that a general reconnaissance of watercourses within a study area is completed prior to undertaking detailed fish habitat assessments as outlined in this SOP.

It is also important to note that many rivers and stream comprise areas of "open water" – areas where the watercourse takes on more pond-like conditions, often times caused by beaver dams or other natural or anthropogenic obstructions. "Open water" areas are defined in this SOP as areas of stillwater, or a flat, wide portion of a watercourse with no visible current. The scope of this SOP for fish habitat assessment in streams includes open water habitat up to a maximum depth of 2 m. For open water areas with depths greater than 2 m, fish habitat assessments procedures for lentic areas (ponds and lakes) should be followed. However, the decision of whether to apply lotic or lentic fish habitat assessments to open water areas depend on a number of other factors, including overall goals of the survey, and will ultimately be at the discretion of the Project Coordinator. Procedures for fish habitat assessments in lentic systems are outlined in a separate SOP.

Prior to conducting fish habitat assessments, all field staff should acquire knowledge on the habitat preferences of fish expected to be encountered within a particular freshwater system. All field staff should possess a general understanding of the biology and habitat preferences of anticipated local fish species and age classes. This knowledge will provide important context to empirical habitat assessments and will help field crews identify unique habitat features in the field. Detailed information on the biology of fishes in Nova Scotia can be found in Scott and Crossman (1973), McPhail and Lindsey (1970), and the Nova Scotia Adopt A Stream Manual (2005).

3 SAFETY

The following documents provide important safety considerations and Personal Protective Equipment (PPE) for this type of work, and should be consulted before proceeding with any fish collection survey:

- MEL HSE Policy;
- MEL Remote Work Policy; and,
- MEL Working Near Shallow Water Policy.

A Field Work Tracking Sheet must be completed and signed by all field crew members prior to departing for any field work. Refer to Section 6.1 for details on field planning.

Water levels can change dramatically and can be hazardous to those working in large river flows. Field crews should not enter watercourses with swift water or dangerous currents. Discuss any potential safety concerns when completing the Field Work Tracking Sheet with the entire field crew, and before entering any streams.

4 FISH HABITAT ASSESSMENT - THEORY

Field approaches to fish habitat assessments and evaluations are incredibly varied. The selection of appropriate habitat assessment tools or evaluation methods is determined by the questions you wish to answer about a particular system. Depending on survey objectives, a variety of methods may be employed. Overall, fish habitat assessments are site-specific and methods must be tailored to the freshwater habitats being investigated.

As described by DFO (2012), methods for fish habitat assessments fall into three stages based on the potential impacts of a project – Primary, Secondary, and Tertiary. A Primary assessment is generally desktop based and may incorporate a rapid field reconnaissance to qualitatively assess fish habitat. This stage of assessment is usually sufficient when the magnitude of effect from a project is considered relatively low. A Secondary assessment is heavily field-based and involves validating habitat types within a Project Area by quantitatively measuring stream features. This stage of assessment is required when predicted fish habitat impacts from a project cannot be fully mitigated. Tertiary assessments are typically reserved for anticipated impacts on large river systems and changes in natural flow patterns, which fall outside the scope of this SOP. The methods outlined in this SOP fall under the Secondary stage of assessment methods. This SOP has been designed specifically to collect data to define existing fish habitat attributes in targeted mapped or field-delineated streams. Streams may be targeted for detailed fish habitat assessments for a number of project-related reasons, including project design, assessment of anticipated project-related effects, and restoration or engineering work. However, the scope of this SOP does not include fine-scale delineation of fish habitat (i.e. habitat mapping).

The measurable features outlined in this SOP are based on the following general attributes that are important in influencing fish habitat within a given stream. These include:

- channel dimensions, gradient, and velocities
- channel substrate size and type
- habitat complexity and cover
- riparian vegetation cover and structure
- anthropogenic alterations or disturbance

The methods outlined in this SOP and the field sheet (Detailed Fish Habitat Assessment – Streams", Appendix A, herein referred to as "field sheet") were derived from the following sources:

- The Nova Scotia Fish Habitat Assessment Protocol: A Field Methods Manual for the Assessment of Freshwater Fish Habitat (2018);
- DNR / DFO – New Brunswick Stream Habitat Inventory Datasheets;
- Standard Methods Guide for the Classification and Quantification of Fish Habitat in Rivers of Newfoundland and Labrador for the Determination of Harmful Alteration, Disruption and Destruction of Fish Habitat (2012);
- Reconnaissance (1:20,000) Fish and Fish Habitat Inventory (2001);
- The US EPA Rapid Bioassessment Protocols For Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates, and Fish (1999); and,
- The Canadian Aquatic Biomonitoring Network Field Manual, Wadeable Streams (2012)**.**

Specific stream terminology is used and referred to throughout the procedures outlined in Section 6. Definitions of specific terms and associated acronyms, as well as diagrams and calculations are provided in a Glossary at the end of the document (Section 8).

For larger river systems (typically 3rd order streams and over), detailed, low-elevation aerial imagery can be interpreted to support habitat descriptions. This technique is particularly useful when habitat complexity increases or water depths/flows reduce wadeability. In addition, aerial imagery interpretation is helpful when assessing areas that have been historically altered through anthropogenic activities, such as freshwater systems that have been ditched or diverted, which are difficult to delineate in the field.

Low-elevation aerial imagery is especially effective in determining channel dimensions (bankfull and wetted widths) and instream habitat features (e.g. islands, gravel bars, etc.) for larger rivers that are not obscured by crown closure. However, for smaller, headwater streams, channel size and crown closure eliminate the effectiveness of aerial interpretation. Drones can be used to collect fine-scale aerial imagery if not already publicly available. Whenever possible, aerial imagery should be followed with field verification using the procedures outlined in this SOP.

5 MATERIALS

- standard MEL PPE
- chest waders with wading belt
- polarized sunglasses (useful for reducing glare)
- field sheets on write-in-the-rain paper
- pencils
- multi-parameter water quality instrument (YSI or equivalent)
- GPS
- velocity meter
- measuring tape
- meter stick (2 m length)
- clinometer
- phone or digital camera
- a copy of the Stream Habitat Mapping Legend (Appendix B)

6 FISH HABITAT ASSESSMENT METHODS – PROCEDURES

A watercourse, as defined in Section 2, is bound by distinct downstream and upstream endpoints when delineated in the field. MEL biologists typically identify unnamed, linear watercourses with numbers starting with first-order, headwater streams. When first order streams combine, the second order stream will be designated with a new number, unless flow is significantly disproportionate across headwater streams (i.e. one first-order stream contributes the vast majority of flow to the second order stream).

A reach is length of stream comprising one homogenous habitat type (i.e. a run). Reaches are numbered from an upstream – downstream orientation. Larger streams comprising variable habitat types are therefore divided into multiple reaches. In smaller, first-order streams, major habitat types may be so short as to not warrant the continuous establishment of very small reaches. For efficiency in the field, <u>when individual habitat types are small in overall length (<5 m), they may be lumped together into one reach.</u>

A **transect** is a particular location within a reach where a cross-sectional survey is performed. A transect is line across a stream perpendicular to the flow and along which measurements are taken (e.g. velocities, depths, etc.), so that morphological and flow characteristics along the line are described from bank to bank. Transects are numbered from an upstream-downstream orientation. For the purposes of this SOP, one transect is to be completed for every 50 m length of reach (e.g. if a run is 150 m in length, 3 transects would be established along the run). If multiple habitat types have been lumped together (< 5 m in length) to form a reach, a transect must be established within each habitat type represented within the reach. However, the amount of transects and transect locations may be shifted slightly or altered during the field assessment based on specific habitat features observed, or access, wadeability, and safety concerns.

The watercourses to be surveyed will be defined by the Project Coordinator – these may comprise an entire watercourse, or a section of a watercourse.

The procedures outlined in Section 6 include both reach-scale and transect-scale data collection – that is to say that some measurements are taken repeatedly at cross-sections (predominantly quantitative measurements), whereas other measurements are based on reach averages (predominantly qualitative, visual-based assessments). Generally speaking, a detailed habitat assessment for streams involves walking the length of the watercourse chosen for assessment, establishing reaches for each change in habitat type, and stopping to take specific cross-sectional measurements along the length of each reach.

6.1 Planning: Before You Leave

1. Review detailed written scope provided to you by the Project Coordinator. This will identify priority deliverables, timelines, and budget allowed for each task. Detailed methods should be provided in this scope (i.e. watercourses to be surveyed).
2. Determine your field crew – fish habitat assessments should be completed with a minimum crew size of 2 people.
3. Determine the location(s) of the survey, size of area to be surveyed and easiest access to the site based on the work scope provided by the Project Coordinator. Sample design should be verified by the Project Coordinator.
4. Complete a review of available data from watercourse delineation surveys. If fish collection surveys have been completed, review the results of those surveys prior to commencing field work. A desktop review of fish species distribution records should be conducted if no fish collection surveys have been completed.
5. Print field sheets and prepare site maps and GPS units as required.
6. Fill out a field tracking sheet. Have all crew members review and sign off on the field tracking sheet.

6.2 Field Procedure

6.2.1 Site Setup

1. It is preferable to begin surveys at the top (upstream end) of the watercourse to be surveyed as reaches and transects are to be numbered in an upstream-downstream orientation.
2. Record general survey data including Project name, date, crew member names, weather, and watercourse identification information. If stream order is known, record on the field sheet. Stream order can be identified through desktop mapping prior to or after field data collection.
3. Begin to establish a reach. Identify the habitat type present. If smaller (<5 m in length) habitat types are to be lumped together, identify all present. Record the upstream boundary coordinate (for smaller reaches the upstream and downstream coordinates can likely be established at the same time). For longer reaches, when the downstream end can't be seen from the upstream end, the downstream boundary coordinate can be recorded once the entire reach has been surveyed.
4. Describe and record general reach characteristics including flow type and entrenchment.
5. Measure the gradient of the stream:

- If conditions allow (clear visibility of the meter stick is obtainable along the entire reach), measure the gradient of the reach in the field using a clinometer. To use the clinometer, first determine the height from the ground to the eyes of the person holding the clinometer. This height can be flagged on the meter stick, which will be held vertical from the base of the survey point by a second team member at the downstream end of the reach. Starting at horizontal from the upstream end of the reach, the observer will tilt or lower the clinometer until it is aligned with the flagged point on the meter stick, and then will read the degrees changed off the clinometer.
- If the clinometer cannot be used to measure gradient in-field, estimate the gradient based on the following morphological thresholds:
    i. <1% (flat)
    ii. 1-4% (riffle/run)
    iii. 4-7% (rapids)
    iv. >7% (step-pool, cascade, falls)
- Estimated gradients should verified by desktop mapping using elevation data such as Digital Elevation Models (DEM) or Google Earth.

6. Measure and record water quality parameters, including temperature, conductivity (SpC), total dissolved solids (TDS), pH, dissolved oxygen (DO). Record turbidity based on a visual assessment of the watercourse if not included as a parameter on the water quality meter (refer to Section 8 – Glossary).
7. Begin a field sketch (aerial view) which will be completed for each reach. The Stream Habitat Mapping Legend (Appendix B) can be used as a drawing and labelling guide. Note the locations of the transects and width measurements used in the assessment. Indicate left and right banks, flow direction, orientation, significant landmarks and landscape, barriers, channel shape and habitat types.

    Note: the legend presented in Appendix B is extensive and incorporates a number of habitats/features that MEL biologists do not frequently encounter within Nova Scotia's headwater inland systems. New symbols/labels can be created so long as they are described in a legend superimposed on the field sketch.

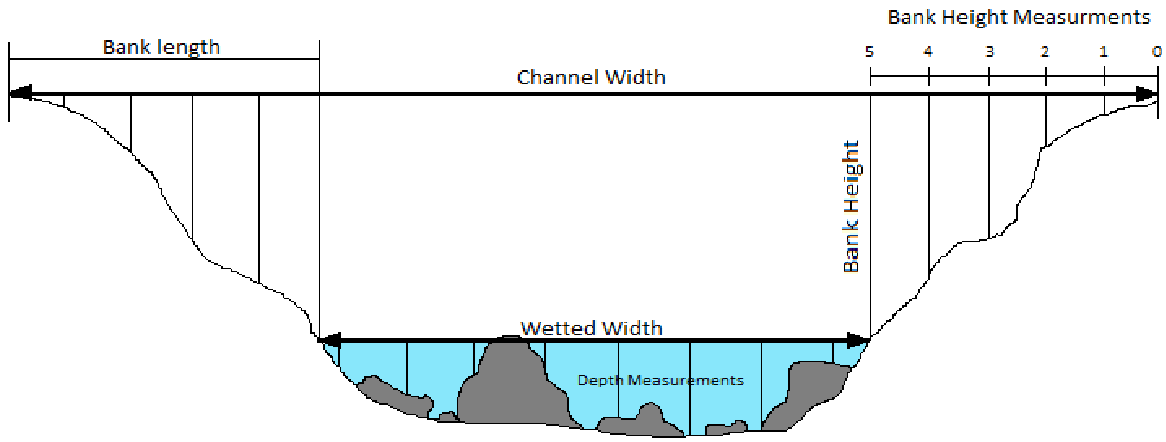
6.2.2 Transects

Record the GPS location (waypoint) of each transect surveyed. Identify each transect with a sequential number from upstream to downstream. A transect must be established for every 50 m of a particular habitat type (reach). If smaller habitat types (< 5 m in length) have been lumped together into a single reach, a transect must be established within each habitat type represented.

1. Record the habitat type being surveyed.
2. Begin measuring the channel cross-section from the left bank looking downstream. Pin the measuring tape into the banks or have a crew member hold the tape at the bankfull level and record the bankfull width on the field sheet. Keep the measuring tape in this position for the duration of cross-section measurements.
3. Measure and record wetted width.
4. Record bank height measurements from the both the left and right banks out to the wetted width of the stream (see diagram below – this is also provided on the field sheet). To do this, divide each bank into equidistant intervals (5 is typical for larger streams but this may be reduced for smaller streams, particularly when bankfull width and wetted width are similar). The distance to

be recorded refers to the distance from each bank as noted on the measuring tape (left bank would be '0', right bank would be the full bankfull width). Using a meter stick, measure the height of the bank (as inferred from the measuring tape across the stream) from the substrate. Note that if wetted width is equal to bankfull width, only one bank height measurement would be recorded for both the left and right bank (at '0' and at full bankfull width). Also note that left and right bank may vary in terms of distance to the wetted stream.

5. When wetted widths are > 1 m, perform a minimum of 10 depth and velocity measurements at equidistant intervals along the transect (see diagram below). If wetted width is < 1 m, record 3 depth and velocity measurements. Starting at the left bank, use the meter stick and a velocity meter to determine the depth of the water and water velocity at equal distances cross the wetted portion of the cross-section. Velocity measurements should be taken at 0.6 water depth. The distance to be recorded refers to the distance from the left bankfull width as recorded from the measuring tape (left bank would be '0'). Use the water level on the downstream side of the meter stick to determine depth as the level on the upstream side may be affected by stream velocity. An estimated negative depth, or height above the water level, should be taken if a measurement is located with no water depth in the adjacent area (an island or section of riffle with no significant depth or flow). A measurement of zero can also be taken if the river bottom is approximately the same height as the water level.



6. If substrate varies significantly at the transect location from that estimated for the entire reach (which may occur if smaller habitat types are lumped together), note it on the field sheet and record percent composition by substrate type.
7. Take representative photos at each transect of the following:
    a. Looking upstream
    b. Looking downstream
    c. Right bank (downstream orientation)
    d. Left bank (downstream orientation)
    e. Substrate

6.2.3 Between Transects

1. Once transect measurements are complete begin walking to the next transect location.
2. Note, waypoint, and photograph any unique habitat features or observations, including any information that will aid in producing a field sketch for the site:
    - Areas of upwelling or groundwater seeps
    - Gravel or point bars

- Ice scarring
- Beaver dams
- Back channels or off-channel habitats
- Islands
- Potential spawning areas (e.g. redds)
- Culverts

3. Note any potential barriers to fish passage/migration observed and mark and record their waypoints. Describe the permanency of the barrier – for example, barriers like waterfalls are permanent whereas a channel may be seasonally dry. Record any applicable measurements or observations of the barrier on the field sheet. Take photos and/or videos of each potential barrier. Refer to the Glossary (Section 8) for details on barriers to fish passage.
4. Once the next transect is reached, repeat procedures outlined in Section 6.2.2.

6.2.4 Reach Assessment

1. Once all transect cross-section measurements are taken within a reach, estimate the percent composition of streambed substrates according to the categories identified on the field sheet. Substrates categories are defined by the length of the intermediate axis (see Glossary for details).
2. Record the average degree of embeddedness of the substrate (see Glossary for details).
3. Conduct a pebble count whenever conditions are suitable. To conduct a pebble count, streams must be wadeable across the entire transect and the majority of the substrate must be of mineral origin. Pebble count tables are provided at the end of the field sheet:
   - Measure the intermediate axis of 100 randomly chosen rocks. One crew member will conduct the pebble count while the other crew member records the count measurement on the field sheet.
   - Beginning at one bank of the channel cross section, begin walking to the opposite bank, putting one foot directly in front of the other. Lean down and touch the substrate material that is nearest to the toes on your front foot without looking.
   - Pull out the material (if possible) that the tip of your finger is touching. Be careful not to bias the substrate to the largest pebble nearest to your finger rather than the one touching your finger. Do not bias the selection by avoiding larger boulder on the stream bed when walking across the stream.
   - Measure its intermediate axis in centimeters (cm). This is the diameter perpendicular to the longest axis (see Glossary for diagram). If the rock cannot be pulled out then measure it in the water. Relay the diameter (to the nearest 10th of a cm) to the other crew member. The recording crew member will record the measurement in the pebble count table on the field sheet.
   - Continue walking and measuring until 100 measurements are recorded. If the measuring crew member reaches the opposite bank before 100 measurements are taken, begin a zig-zag pattern through the stream, walking one foot in front of the other from bank to bank.
4. Estimate the amount of in-stream cover available within the entire reach. Record the percent area of the stream within the reach that each cover-type provides as potential refuge for fish. Note that overhanging vegetation must be within 1 m of the water's surface to count as cover. To assess whether pool depth provides cover, hold your boot above the bottom of the pool to what would be equivalent to residual depth of the pool. If you cannot see your boot, you can consider that area as instream cover. Add cover percentages of all cover types within the reach to obtain total instream cover.

5. For riparian areas, estimate the percentage of ground covered by trees, shrubs, grasses (includes sedges and ferns, and bare ground within 10 m from the bank's edge within the reach and record them on the field sheet. These values may add to more than 100%, as there can be different levels of vegetation covering the same area of ground.
6. Estimate the percentage of both left and right riverbanks within the reach with active erosion.
7. For the entire reach, estimate the percent stream shade and record it on the field sheet.
8. For the entire reach, identify the dominant riparian vegetation category on the field sheet (Grass, Shrub, Coniferous Forest, Deciduous Forest, Mixed Forest, Wetland, or None).
9. Finish the field sketch (aerial view) for the entire reach, using the Stream Habitat Mapping Legend as a guide. Note the locations of the transects used in the assessment. Indicate left and right banks, flow direction, orientation, significant landmarks and landscape features, barriers, channel shape and habitat types.

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8 GLOSSARY

Bankfull Level – the level of water flow in a river just before it spills over the banks into the floodplain. The bankfull level can be identified by changes in bank angle, vegetation, and soils.

Bankfull Width (i.e. channel width) - the width of the river channel at the bankfull level.

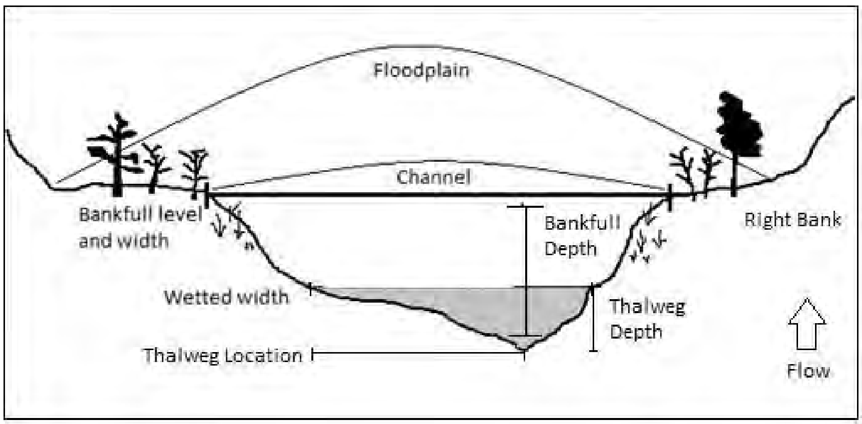


Image 1: Components of a channel cross-section

Barrier - areas or objects that may potentially be barriers to the movement of fish. Barriers can be natural (e.g. waterfalls), or man-made (e.g. culverts). Water velocity can also act as a barrier when the velocity (due to constriction or some other variable) is too great for fish to swim against. It is important to document all barriers or obstructions for each section of stream that is assessed. Record the following information for all barriers observed, when applicable:

- type of barrier
- location of barrier (waypoint)
- barrier permanency
- vertical height of the barrier (measured or estimated)
- length and width of the barrier
- slope of the barrier
- additional observations that help to describe the obstruction

Embeddedness - refers to the degree larger substrate is surrounded by finer sand and silt material that fills in spaces between the individual rocks. Highly embedded substrate limits spawning and rearing success of fish, reduces habitat for benthic macroinvertebrates, and impairs a river's ability to form a thalweg and transport material. A stain line on the rock may indicate the level of burial and aid in the estimation. Note: Bedrock would be recorded as unembedded. Sandy or organic substrate is recorded as completely embedded because it is embedded within itself.

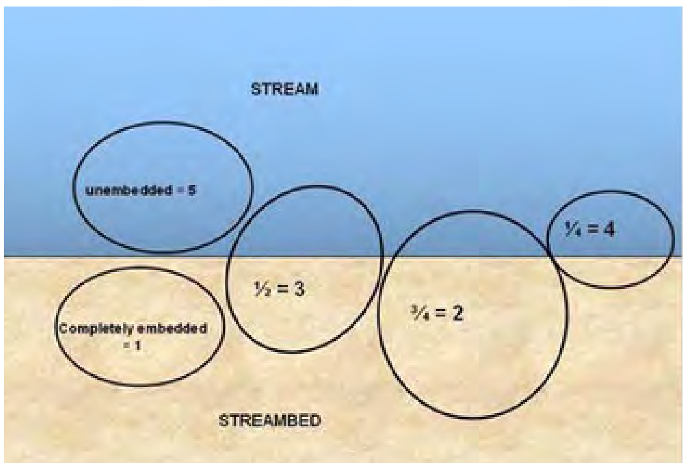


Image 2: Varying substrate embeddedness (Source: EC, 2012)

Entrenchment - the vertical containment of a stream, or the disconnection of the channel from a floodplain. A stream may also be entrenched by the use man-made berms. In streams that are highly entrenched, overbank flooding occurs less frequently than less entrenched streams. For the purposes of this SOP, entrenchment is qualitatively described in the field through a visual assessment, and is categorized as one of the following: Highly Entrenched (HE), Moderately Entrenched (ME), Slightly Entrenched (SE), or Not Entrenched (NE). "Not Entrenched" streams are typically associated with streams areas that have no defined channel (see "Habitat Types" for description).

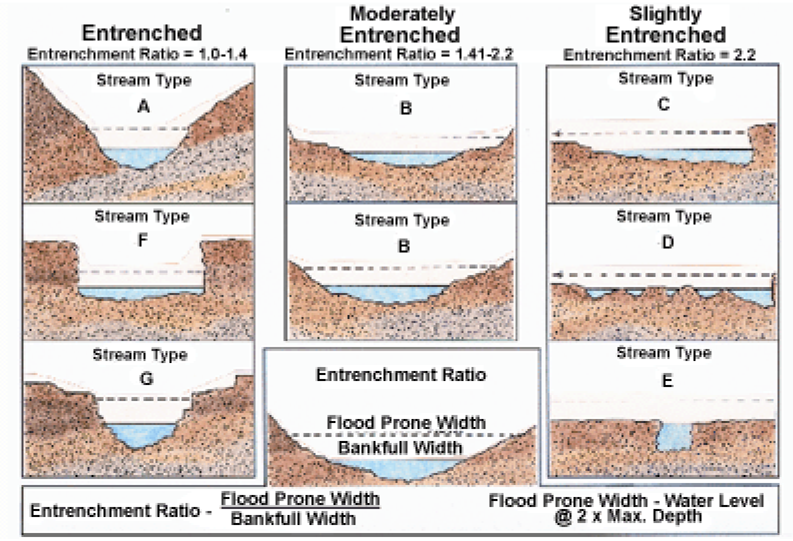


Image 3: Degrees of entrenchment (the term "entrenched" equates to "highly entrenched" for the purposes of this SOP. Source: https://cfpub.epa.gov/watertrain/moduleFrame.cfm?parent_object_id=1259)

Erosion - an area of slumping displaying a loss of bank material. Do not confuse an eroded band with undercut bank. While eroding forces create undercut banks these banks tend to remain stable due to an established root system.

Flow Type – refers to the presence of flowing water within a stream on a temporal scale. For the purposes of this SOP, streams are categorized into the following flow types (source: AT, 2009):

- **Perennial (P) -** A stream that flows continuously throughout the year.
- **Intermittent (I) -** Streams that go dry during protracted rainless periods when
- percolation depletes all flow.
- **Ephemeral (E) -** A watercourse that flows during snowmelt and rainfall runoff periods only.

Any watercourse or watercourse reach may have components of each flow type. For instance, perennial, with intermittent sections.

Gradient - The slope of the stream, or rate of vertical drop per unit of length of the channel bed (presented as a percentage). The following is a simple desktop method using Google Earth to determine stream gradient. This method will not be as precise as a direct field survey but should provide a good estimate of stream gradient:

Using Google Earth, determine the elevation at the upstream extent of the stream (the beginning) and the downstream extent (the end). If you are looking for the slope of a particular section (i.e. reach) instead of the entire stream, use the boundaries of the survey section for your endpoints.

Calculate **Rise** by subtracting the elevation at the downstream extent from the elevation at the upstream extent. Determine **Run** by measuring the length of the stream using the Google Earth ruler tool.
Use the following basic formula to calculate the stream's slope/gradient:

$$\text{SLOPE} = \frac{\text{RISE}}{\text{RUN}}$$

Habitat type - a categorical description of the types of aquatic environments within a stream. Habitat types that are commonly encountered include:

- **Riffle -** a shallow and fast section of stream with, often within a series of pools and runs. Water flow is agitated and surface is broken by rocky substrate, which appears turbulent. Substrate is coarse (gravel – cobble dominated).

Image 4: A riffle (Source: http://smallstreamreflections.blogspot.com/2017/05/in-riffles.html)

- **Pool** – a deep and slow section of river, generally occurring near the corners of meanders, or created by the vertical force of water falling down over logs or boulders. Pools have a rounded bottom and may comprise the full or partial width of the stream. For the purposes of this SOP, a pool is defined as having a minimum residual depth of 20 cm.
- **Run -** an area of stream characterized by moderate current, continuous, smooth surface and depths greater than riffles. Runs are stretches of the stream, typically downstream of pools and riffles, where stream flow and current are moderate.

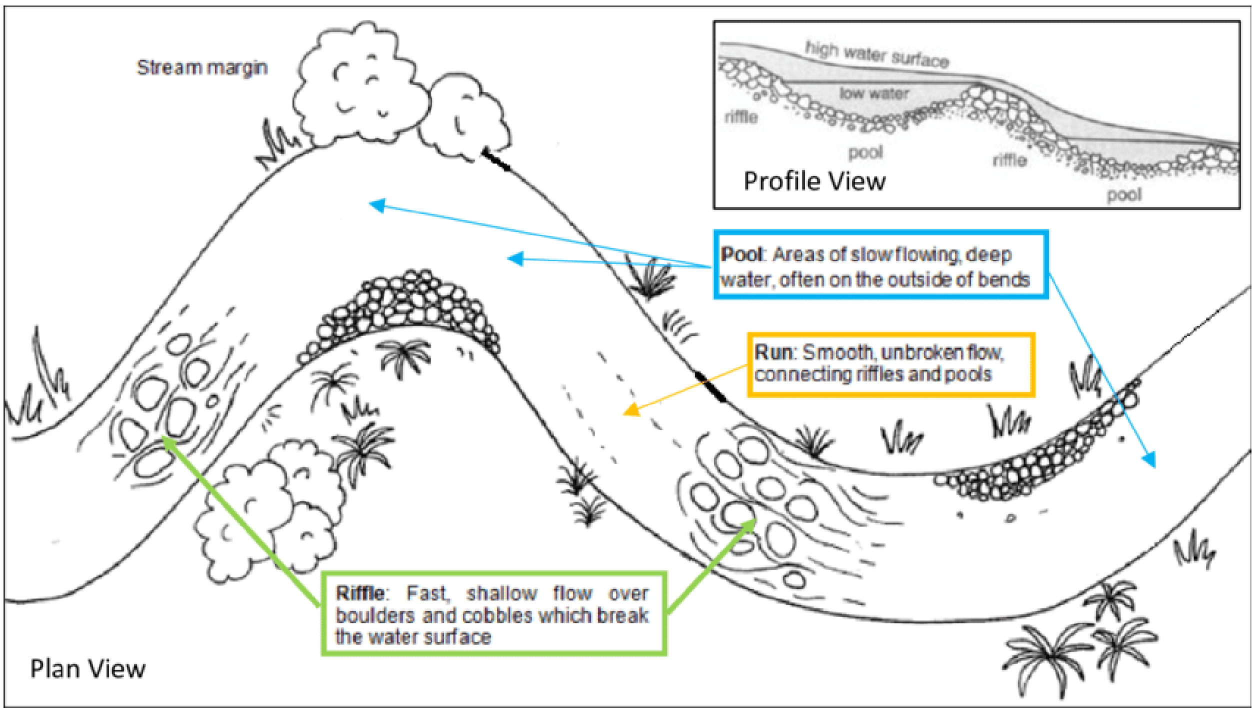


Image 5: A typically riffle-run-pool sequence within a stream (Source: https://www.researchgate.net/figure/Elements-of-a-river-reach-pool-riffle-and-run_fig13_322765638)

- **Rapids** – area of steeper gradient with irregular and rapid flows, often with turbulent white waters. Deeper than riffles, with substrate being extremely coarse (large cobble – boulder).

- **Chute/Falls/Cascade –** Significant white water present. Can be an area of channel constriction, usually due to bedrock instructions. Associated with a rapid change in stream gradient with most water free-falling over a vertical drop or series of drops.

Image 6: A cascade

- **Step-pool** – a series of staircase like pools which occur in steeper channel sections. Each pool has a defined step made of larger substrate, followed by a drop into a pool.

Image 7: Step-pool habitat (Source: https://www.researchgate.net/figure/Artificial-step-pool-sequence-in-the-Mala-Raztoka-Brook_fig6_277075982)

- **Flat –** associated with low gradient streams, water is very smooth (flow is not obvious), and substrate often comprises organic matter, mud, and sand. Area characterized by low velocity and near-uniform flow; differentiated from pool habitat by high channel uniformity.

Image 8: A flat

- **Boulder-bed –** area characterized by a significant occurrence of large boulders as a result of glacial till deposits. Water may be visible between boulders or heard flowing subsurface

Image 9: A boulder-bed

depending on the time of year of the survey. Channel dimensions may be obscured. Boulders may be bare or have vegetation cover (typically mosses or alders).

- **No defined channel (NDC)–** typically occurring in small headwater streams, these areas are more accurately characterized as general drainage, with poorly or no defined channel banks and substrates largely comprised of organic forest soils. Water flow is diffusely spread out (i.e. sheet flow). Often associated with wetland habitat. NDCs may have diffused standing water during higher seasonal flow periods, or may be completely dry and lacking surface water of any kind, but may act as a connection between defined channels upstream and downstream.

Image 12: An area of a stream with NDC during high flow

Image 11: An area of a stream with NDC during low flow

The following table provides additional detail to aid in identificaiton of habitat types (McCarthy, Grant, and Scruton, 2006).

Habitat Type	Habitat Parameter	Description
Fast Water	**Mean Water Velocity**	**> 0.5m/s**
	Stream Gradient	**Generally > 4%.**
Rapid	General Description	Considerable white water[1] present.
	Mean Water Velocity	> 0.5 m/s
	Mean Water Depth	< 0.6 m
	Substrate	Usually dominated by boulder (Coarse[2]) and rubble (Medium[2]) with finer substrates (Medium and Fine[2]) possibly present in smaller amounts. Larger boulders typically break the surface.
	Stream Gradient	Generally 4-7%
Falls/ Chute/ Cascade	General Description	Mainly white water present. The dominating feature is a rapid change in stream gradient with most water free-falling over a vertical drop or series of drops.
	Mean Water Velocity	> 0.5 m/s
	Mean Water Depth	Variable and will depend on degree of constriction of stream banks.
	Substrate	Dominated by bedrock and/or large boulders (Coarse).
	Stream Gradient	> 7% and can be as high as 100%.
Run	General Description	Relatively swift flowing, laminar[3] and non-turbulent.
	Mean Water Velocity	> 0.5 m/s
	Mean Water Depth	> 0.3 m
	Substrate	Predominantly gravel, cobble and rubble (Medium) with some boulder (Coarse) and sand (Fine) in smaller amounts.
	Stream Gradient	Typically < 4% (exception to gradient rule of thumb)
Moderate Water	**Mean Water Velocity**	**0.2-0.5m/s**
	Stream Gradient	**>1 and < 4%**
Riffle	General Description	Relatively shallow and characterized by a turbulent surface[4] with little or no white water.
	Mean Water Velocity	0.2 – 0.5 m/s
	Mean Water Depth	< 0.3 m
	Substrate	Typically dominated by gravel and cobble (Medium) with some finer substrates present, such as sand (Fine). A small amount of larger substrates (Coarse) may be present, which may break the surface.[5]
	Stream Gradient	Generally >1 and < 4%
Steady/ Flat	General Description	Relatively slow-flowing, width is usually wider than stream average and generally has a flat bottom.
	Mean Water Velocity	0.2 - 0.5 m/s
	Mean Water Depth	>0.2 m
	Substrate	Predominantly sand and finer substrates (Fine) with some gravel and cobble (Medium).
	Stream Gradient	> 1 and < 4%
Slow Water	**Mean Water Velocity**	**Generally < 0.2m/s (some eddies can be up to 0.4m/s).**
	Stream Gradient	**< 1%.**
Plunge / Trench / Debris Pools	General Description	Generally caused by increased erosion near or around a larger, embedded object in the stream such as a rock or log or created by upstream water impoundment resulting from a complete, or near complete, channel blockage. These pool types may be classified as an entire reach (e.g., pools greater than 60% of the stream width) or as sub-divisions of a fast water habitat.
	Mean Water Velocity	< 0.2 m/s
	Mean Water Depth	> 0.5 m depending on stream size (e.g., may be shallower in smaller systems).
	Substrate	Highly variable (i.e., coarse, medium or fine substrates)
	Stream Gradient	Generally < 1%
Eddy	General Description	Relatively small pools caused by a combination of damming and scour: however scour is the dominant forming action. Formation is due to a partial obstruction to stream flow from boulders, roots and/or logs. Partial blockage of flow creates erosion near obstruction. It is typically < 60% of the stream width and hence will be a sub-division of a faster-water habitat type (e.g., Run with 20% eddies).
	Mean Water Velocity	Typically < 0.4 m/s, but can be variable.
	Mean Water Depth	> 0.3 m. May vary depending on obstruction type, orientation, streambed and bank material and flows experienced.
	Substrate	Predominantly sand, silt and organics (Fine) with some gravels (Medium) in smaller amounts.
	Stream Gradient	Variable

1 White water is present when hydraulic jumps are sufficient to entrain air bubbles which disturb the water surface and reduces visibility of objects in the water.

2 Coarse, Medium and Fine substrate types are classified according to the Standard Methods Guide for the Classification/Quantification of Lacustrine Habitat in Newfoundland and Labrador (Bradbury *et al*. 2001).

3 Laminar describes the surface of the water as smooth and glass-like with no reduced visibility of objects in the water.

4 Turbulence is present if there are local patches of white water or if water movement disturbs a portion of the surface.

5 Pocket water often constitutes an important component of riffles in Newfoundland and Labrador and is characterized by a predominance of larger substrates (e.g., boulders) breaking the surface. The result is a riffle with many eddies around the boulders.

Intermediate Axis - the axis on which the pebble will roll down the stream.

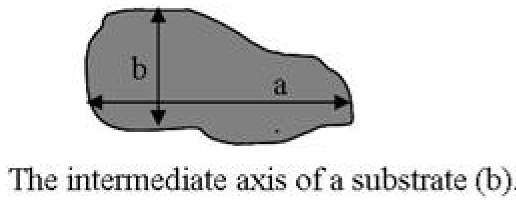


Image 13: (Source: EC, 2012)

Instream Cover - includes large woody debris, undercut banks, unembedded large substrate, aquatic vegetation, deep pools, and overhanging vegetation within 1 m of the water's surface. These features provide valuable refuge and resting areas for fish. As the instream features become embedded by fine silt and sand, cover for fish is reduced. To be considered viable instream cover for this assessment, areas must be obscured from the surface by the cover element itself (boulder, LWD, vegetation, bank).

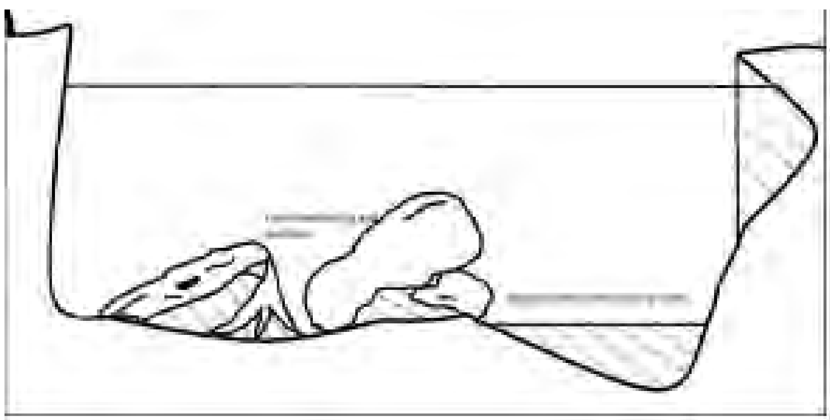


Image 14: Example of cover types within a transect (Source: NSHSI, 2018)

The following terms may be used to guide the description and identification of cover. Bolded cells indicate categories of in-stream cover, specifically.

Large Woody Debris	Fallen trees, logs and stumps, root wads, and piles of branches within or along the edges of streams.
Boulders	Large substrate under which fish can hide. Refuge for fish must be provided between the boulder and the channel bottom (i.e. a boulder that is complete embedded does not provide in-stream cover).
Undercut Banks	An undercut bank occurs when the river cuts into the bank, removing rocks and soil while leaving some portion of the bank overhanging the river. Undercut banks generally are stabilized by the presence of vegetation and roots that hold the topsoil intact.
Deep Pools	To assess whether pool depth provides cover, hold your boot above the bottom of the pool to what would be equivalent to residual depth of the pool. If you cannot see your boot, you can consider that area as instream cover.

Overhanging vegetation	Riparian cover overhanging the stream. Note: overhanging over must be within 1 m of the water's surface to count towards in-stream cover.
Emergent vegetation	Aquatic plants growing above or extending above the water surface (e.g. cattails, sedges, grasses, rushes)
Submergent vegetation	Aquatic plants that grow entirely below the water surface (e.g., elodea, bladderwort, pipewort, potamogeton), and includes numerous mosses and macroalgae)

Riparian Area – strip of land adjacent to watercourses which plays an important role in stream productivity and overall function. For the purposes of this SOP, the riparian area is considered all ground within 10 m from the bank's edge.

Redd – salmonid spawning nests. Characterized as circular to oblong patches of recently cleaned, gravel-cobble-sized substrate that contrasts the surrounding substrate. Redds typically have a depression from the surrounding substrate and may have a 'mound' on the downstream end of the disturbance. If identified, redds would be measured, photographed and their location recorded on GPS.

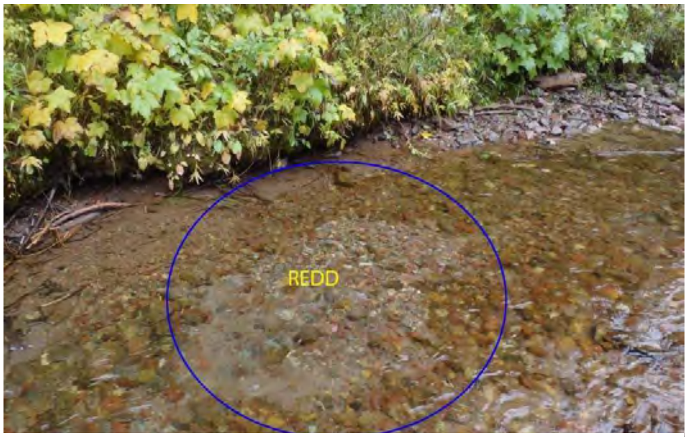


Image 15: A salmonid redd (Source: https://www.tu.org/blog/redd-surveys-shaping-priorities-in-michigans-pere-marquette/)

Stream Order - the hierarchical ordering of streams based on the degree of branching. It is a simple quantitative method to categorize stream segments based on their relative position within the drainage basin. Stream order provides a general indication of stream size, stream function and energy sources. Determine the stream order by labeling the first stream at the head of the watershed as 1 and increasing the order by 1 each time two streams of the same order join until you reach the watercourse/watercourse reach being assessed.

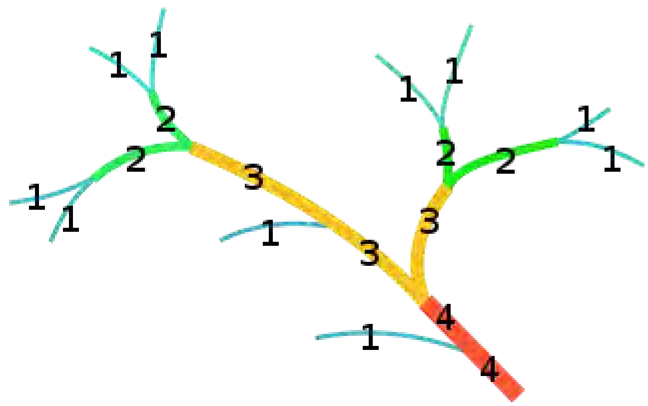


Image 16: Example of stream order classifications (based on Strahler, 1957).

Stream Shade – this is the canopy cover created by riparian vegetation above the stream. Midday sun is the most direct and influential on stream temperatures, so shade estimates should be made between 10:00 am and 2:00 pm, when possible.

Substrate Types – The following table may be used to aid in identification of substrate types (from DFO 2012).

Bedrock	Continuous solid rock exposed by the scouring forces of the river/stream
Boulder	Rocks ranging from 25cm to >1 m in diameter
Rubble	Rocks ranging from 14-25 cm in diameter
Cobble	Rocks ranging from 3-13 cm in diameter
Gravel	Small stones ranging from 2mm to 3 cm in diameter
Sand	Grains ranging from 0.06 to 2 mm in diameter, frequently found along stream margins or between rocks and stones.
Silt	Very fine sediment particles, usually <0.06 mm in diameter
Muck/detritus	Organic material from dead organisms (plant and/or animal)
Clay/mud	Find deposits between rocks and covering other substrates

Transect - A line across a stream perpendicular to the flow and along which measurements are taken, so that morphological and flow characteristics along the line are described from bank to bank. For the purposes of this SOP, "transect" and "cross section" are used interchangeably.

Watercourse - Any provincially regulated watercourse as defined by NSE guidance (2015).

Watercourse Name - The official name of the stream being surveyed as referenced on provincial topographic maps. If no official name exists, enter "unnamed".

Watercourse Reach - A length of stream characterized by a single habitat type (e.g. a run). Complex streams will comprise many reaches. In smaller, first-order streams, major habitat types may be so short as to not warrant the continuous establishment of very small reaches. When individual habitat types are small in overall length (<5 m), they may be lumped together into one reach.

Wetted Width – the width of the stream that contains water at the time of the assessment.

Turbidity - The concentration of suspended sediments and particulate matter in the water. Measure of the relative clarity of a liquid. If not measured, turbidity is to be visually assessed and recorded based on the following codes:

- T (Turbid) - very turbid or muddy appearance, objects visible to 15 cm depth
- M (Moderately Turbid) - cloudy, objects visible to 45 cm depth
- L (Lightly Turbid) - occasionally cloudy, objects visible to 1 m
- C (Clear)

McCallum Environmental Ltd.

APPENDIX A

Detailed Fish Habitat Assessment – Streams

Detailed Fish Habitat Assessment - Streams

General Survey Data			
Project:	Project #:	Date:	Surveyors:
Watercourse Name:	Watercourse #:	Reach #:	Stream Order:
Weather (℃, cloud %, precipitation):			
Reach Boundary Coordinates: U/S____________________________ D/S____________________________			
Photos: Transects ☐ Barriers ☐ Other Features (____)			

Reach Characteristics		
Reach Length (m):	Gradient* (%):	Entrenchment: HE ☐ ME ☐ SE ☐ NE ☐
Flow Type*: P ☐ I ☐ E ☐	Does reach include other habitat types (< 5 m in length)? ☐	
Habitat Type:	If applicable, check all habitat types included in reach: Riffle ☐ Run ☐ Flat ☐ Pool ☐ Cascade ☐ Step ☐ Other ☐ (_______________)	

Water Quality		
Temperature (℃):	pH:	Dissolved Oxygen (mg/L):
Conductivity:	TDS:	Turbidity (T, M, L, C, or NTU):

Substrate	
% Bedrock	
% Boulder (>25 cm)	
% Rubble (14-25 cm)	
% Cobble (3-13 cm)	
% Gravel (0.2-3 cm)	
% Sand (0.06-2 mm)	
% Silt (<0.006 mm)	
% Muck/Detritus	
% Clay/Mud	
Embeddedness (%)	
Pebble Count?	☐

Cover	
% Large Woody Debris	
% Boulders	
% Undercut Banks	
% Deep Pools	
% Overhanging Veg	
% Emergent Veg	
% Submergent Veg	
Total Cover (%)	

*P: perennial, I: Intermittent, E: Ephemeral
*Note methodology (clinometer, estimate, desktop). Categories for estimates: <1% (flat), 1-4% (riffle/run), 4-7% (rapids), >7% (step-pool, cascade, falls)

Banks and Riparian Area (Right and Left Banks are looking downstream)

Bank	**% Trees**	**% Shrubs**	**% Grass**	**% Bare**	**% Eroding**	**% Shade**	**Dominant Riparian Veg.**
Left Bank							Grass ☐ Shrub ☐ Coniferous Forest ☐ Deciduous Forest ☐ Mixed-wood Forest ☐ Wetland ☐ None ☐
Right Bank							

Barriers		
Types (circle all present): No visible channel Underground flow Velocity Beaver Dam Dry Falls Culvert Other (___________)	**Locations and Comments** (waypoint, height, width, slope of barrier and depth of plunge pool. Note any hydrological indicators if no visible channel or underground flow are circled):	**Permanency:** Permanent ☐ Temporary/Seasonal ☐ Undetermined ☐ Manmade ☐ **Date Observed:**

Date: Location: Assessor:

Detailed Fish Habitat Assessment - Streams

Note: Transect measurements are to be taken every **50 m** of a single habitat type (i.e. reach). If minor habitat types (<5 m) have been lumped into the overall reach, take representative transect measurements at each habitat type present. See diagram under “field sketch” for reference.

Transect Information		
Transect #:	Easting:	Northing:
Habitat Type:	Wetted Width (m):	Bankfull Width (m):

Cross-Section Measurements (all measurements in m, taken in increments from max bank out to wetted edge)							
Left Bank	Distance:						
	Height:						
Right Bank	Distance:						
	Height:						

Velocities (taken from left bank to right bank – left and right banks are looking downstream)										
Distance (m):										
Depth (m):										
Velocity (m/s):										
Substrate Obs:										

Photos: Downstream ☐ Upstream ☐ Left Bank ☐ Right Bank ☐ Substrate

Transect Information		
Transect #:	Easting:	Northing:
Habitat Type:	Wetted Width (m):	Bankfull Width (m):

Cross-Section Measurements (all measurements in m, taken in increments from max bank out to wetted edge)							
Left Bank	Distance:						
	Height:						
Right Bank	Distance:						
	Height:						

Velocities (taken from left bank to right bank – left and right banks are looking downstream)										
Distance (m):										
Depth (m):										
Velocity (m/s):										
Substrate Obs:										

Photos: Downstream ☐ Upstream ☐ Left Bank ☐ Right Bank ☐ Substrate

Transect Information		
Transect #:	Easting:	Northing:
Habitat Type:	Wetted Width (m):	Bankfull Width (m):

Cross-Section Measurements (all measurements in m, taken in increments from max bank out to wetted edge)							
Left Bank	Distance:						
	Height:						
Right Bank	Distance:						
	Height:						

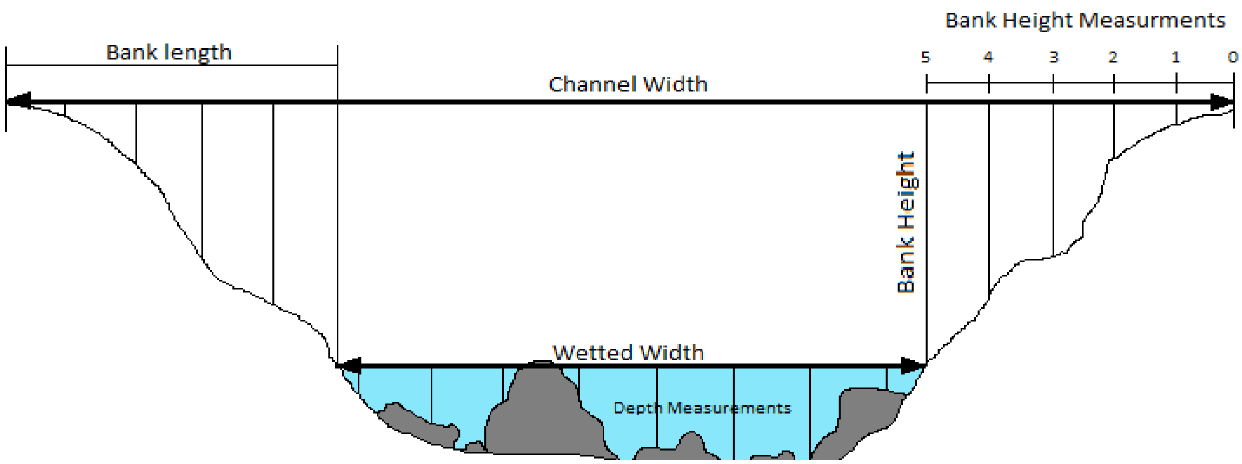
Velocities (taken from left bank to right bank – left and right banks are looking downstream)										
Distance (m):										
Depth (m):										
Velocity (m/s):										
Substrate Obs:										

Photos: Downstream ☐ Upstream ☐ Left Bank ☐ Right Bank ☐ Substrate

Date: Location: Assessor:

Detailed Fish Habitat Assessment - Streams

Field Sketch



Date:

Location:

Assessor:

Detailed Fish Habitat Assessment - Streams

Pebble Count: Transect #___. Record intermediate axis in cm.

Pebble Count: Transect # ___. Record intermediate axis in cm.

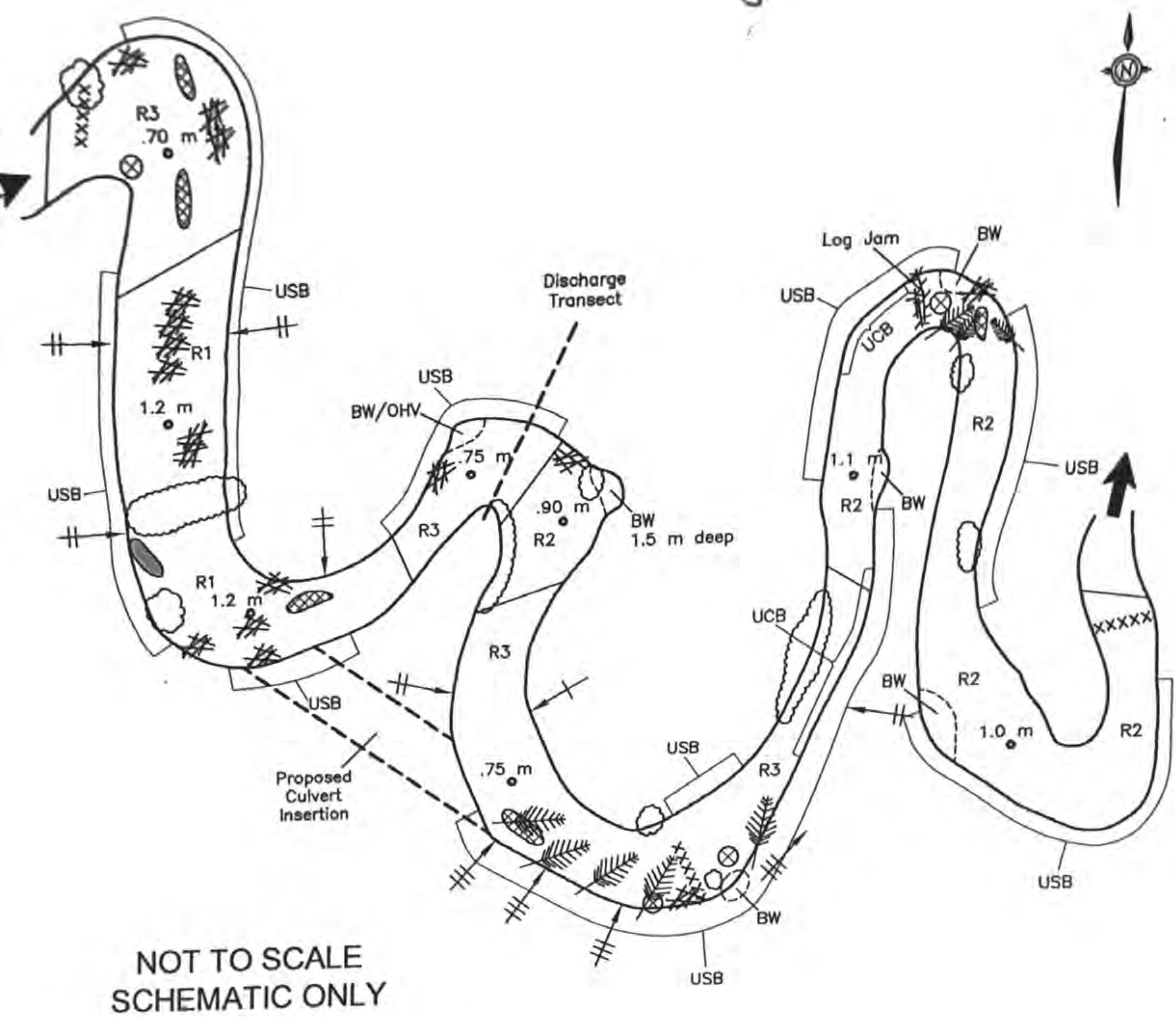
Pebble Count: Transect # ___. Record intermediate axis in cm.

Pebble Count: Transect # ___. Record intermediate axis in cm.

Date: Location: Assessor:

APPENDIX B

Example Stream Habitat Mapping Legend



LEGEND - STREAM HABITAT MAPPING SYSTEM

Channel Unit/Habitat Type:

- FA Falls; Very Swift, Vertical Drop; Impassable to Fish
- CA Cascade; Very Swift, Turbulent; Passable to Fish
- CH Chute; Channel Restricted, Swift, Moderate Depth
- RA Rapids; Very Swift, Deep, With Cover
- RF Riffle; Swift, Shallow, Turbulent
- R1 Class 1 Run; Moderately Swift, Deep With Cover
- R2 Class 2 Run; Moderately Swift, Moderate Depth and Cover
- R3 Class 3 Run; Moderately Swift, Shallow, Limited Cover
- FL Flat, Slow, Laminar Flow, Depositional

- P1 Class 1 Pool; Slow, Deep
- P2 Class 2 Pool; Slow, Moderate Depth
- P3 Class 3 Pool; Slow, Shallow
- IP Impoundment Pool; Pool Formed by Dam

- BW Backwater; Slow, Reverse Flow
- BG Boulder Garden
- SN Snye; Isolated Area of Zero Velocity
- • 1.5 m Indicates Channel Unit Depth
- | Channel Unit Divider

Substrate Particle Size:

- Si Silt (<0.06mm)
- Sa Sand (0.06 –2mm)
- Gr Gravel (2–64mm)
- Co Cobble (64–256mm)
- Bo Boulder (>256mm)
- Bd Bedrock

Shore and Bottom Slope:

- Flat (Shallow slope)
- Repose (moderate, stable slope)
- Steep Slope
- Vertical

Habitat Feature:

- Sand/Mud Bar
- Gravel Bar
- Island
- Woody Debris Pile
- Root Wad
- UCB Undercut Bank (fish cover)
- USB Unstable Bank (slumping or eroding)
- OHC High Quality Overhead Cover
- ISC High Quality Instream Cover
- LE Ledge; Bedrock Intrusion, Vertical Drop
- Overhanging Vegetation (Tree)
- Overhanging Vegetation (Shrub)
- Overhanging Vegetation (Grass)
- Inundated Vegetation
- SV Submergent Vegetation
- EV Emergent Vegetation
- TV Terrestrial Vegetation
- BA Bare–no vegetation
- SH Shrubs
- GF Grass/Forbs
- DF Deciduous Forest
- CF Coniferous Forest
- MW Mixed Wood Forest
- MT Minnow Trap
- BL Beaver Lodge
- XX Beaver Dam
- Direction of Flow
- Benchmark

STANDARD OPERATING PROCEDURE: FISH COLLECTION

1 PURPOSE

The purpose of this document is to provide standard methods for fish collection techniques performed by McCallum Environmental Ltd. (MEL) employees and subconsultants in freshwater habitats.

2 SCOPE

This document provides standards for data collection and measurements, and gives details on a limited range of fish collection methodologies/gear for linear watercourses and littoral habitats of open water areas (i.e. ponds, lakes), including:

- Electrofishing
- Minnow traps
- Eel pots
- Fyke nets
- Seine nets

Subject to study design, these sampling techniques can provide both qualitative information (i.e. species presence, community composition, and relative abundance) and quantitative information (i.e. population estimates) on fish species within freshwater habitats. A clear understanding of the purpose of the sampling program will help define the fish trapping methodology that is needed.

It is important to note that all gear types have certain limitations, including but not limited to catch selectivity and sampling efficacy. The best fish collection studies will employ variety of gear types to sample as many habitat types as possible, thus ensuring the widest possible range of fish species and sizes are collected. A summary of gear types (i.e. sampling methodologies) presented within this document and their limitations are provided in Section 5. There are several resources that provide greater detail and a wider range of procedures for fish collection - see Portt et al. (2006) for a comprehensive review of fish sampling methods in freshwater habitats.

It is also important that all field staff understand the habitat preferences of fish expected to be encountered within the study area. All field staff should have a general understanding of the biology and habitat preferences of anticipated fish species and age groups. This knowledge can greatly improve the sampling efficiency of the field crew and provides important information for gear selection. Detailed information on the biology of fishes in Nova Scotia can be found in Scott and Crossman (1973), McPhail and Lindsey (1970), and the Nova Scotia Adopt A Stream Manual (2005). Fact sheets for common freshwater fish species have been provided in Appendix C.

3 PERMITTING

Before engaging in any fish collection survey, MEL must apply for, and obtain a Licence to Fish Finfish for Scientific Purposes, issued by Fisheries and Oceans Canada (DFO). This is required under the provisions of the Fisheries Act, and any fishing completed without a permit can be subject to criminal charges under the Act. Project managers must ensure proper notification is provided to DFO as outlined in the licence, and must confirm that there are no variation orders in effect which may limit fish sampling methods.

All field staff must read and understand the conditions of the fishing licence and are required to have a hard copy of the licence on hand during all fish collection surveys.

4 SAFETY

The following documents provide important safety considerations and Personal Protective Equipment (PPE) for this type of work, and should be consulted before proceeding with any fish collection survey:

- MEL HSE Policy;
- MEL Remote Work Policy; and,
- Fisheries and Oceans Canada's Interim Policy for the Use of Backpack Electrofishing Units (2003)

The following sections provide important information pertaining to the prevention and avoidance of injury to personnel and fish during fish collection surveys. Unique safety considerations that apply to each fishing method are outlined in Sections 5.1 through 5.5, and procedures outlined in Section 6.0 contain safety checks and emergency response protocols to be followed by all field crew members.

5 FISH COLLECTION METHODS - THEORY

Gear types used for sampling can be divided into two categories: active and passive. Active gear includes those that are moved through the water either by machine or with human power (e.g. electrofishing). Passive gear is usually set and left stationary for a period of time (e.g. minnow traps).

Although gear will be selected prior to the field survey, the surveyors will exercise their judgment in using any combination of gear types to ensure that all habitat types are surveyed within the watercourse reaches or waterbodies of interest.

Certain criteria assist in selection of appropriate gear types. These criteria can include, for example, the overall objective of the fish collection survey, anticipated fish species to be encountered, and in-field limitations such as the physical characteristics of the watercourse/waterbody being surveyed. Fish mortality is also an issue that must be considered, with preference for non-lethal or low-mortality methods wherever possible. Gear types known to have high mortality rates (e.g. gill nets) are not proposed for use as part of MEL fish collection efforts at this time.

Certain limitations may restrict the use of a particular gear type to a lake, a stream, or a particular habitat type. For example, electrofishing is effective in shallow areas of with higher velocity but cannot be used efficiently in deep open waters. Site accessibility, substrate, vegetation, time constraints, size, and accessibility of the habitat of the lake or stream may further affect deployment of each gear type. The best results are obtained by using a variety of gear types to sample as many habitat types as possible, thus ensuring the widest possible range of fish species and sizes are collected.

Many factors affect fish sampling. These include water depth, conductivity, water clarity, water temperature, water velocity, fish size and behavior. The effects these factors have on sampling efficiency vary, and many of the factors are interrelated. Efficacy and limitations of specific gear types are summarized in Table 1.

5.1 Electrofishing

Electrofishing is the technique of passing electric current through the water to attract and stun fish, thus facilitating their capture. This SOP pertains to backpack electrofishing only. It is most useful in streams and rivers, but can also be used to sample shallow littoral areas of lakes. The deeper and wider a sampling area, the more likely fish will be able to avoid capture.

The electrofishing unit is essentially a portable transformer carried on the back of the operator (like a backpack), with probes, controls, and gauges. An electrical current is produced by the unit and is passed through the water from the cathode (negatively (-) charged probe) to the anode (positively (+) charged probe). This current produces an electric field in the water that will affect any fish in a variety of ways depending on where the fish is situated in relation to the electrical field (flight, attraction, or stun). It is also influenced by environmental conditions such as flow rate and conductivity, and the size of the fish present.

Electrofishing is the preferred MEL method for fish collection. Ideally, electrofishing reaches will be free of safety or navigation hazards such as abundant woody debris, deep pools, unstable substrate, or high flow. Although larger fish are typically more easily stunned, electrofishing can be effective at capturing all species and sizes of fish.

Photo 1: Example of an electrofishing crew in action

Electrofishing can be used to determine both qualitative metrics (i.e. determining species presence, diversity, or relative abundance) and quantitative metrics (i.e. estimating population size, absolute abundance), depending on the characteristics of the habitat and the overall objective of the survey. Electrofishing procedures presented in Section 7.2 outline techniques for both qualitative and quantitative surveys. Quantitative surveys (i.e. the depletion method) is the preferred procedure and should be completed whenever site conditions allow.

The depletion method (also known as the "Zippin" method, see Zippin, 1958) is a suitable method for population estimates when the stream is very small, it is expedient to collect all data within a short time period such as one day, and the population being estimated is relatively small (roughly less than 2,000 individuals). This type of freshwater habitat is typical of what MEL biologists encounter throughout Nova Scotia's landscape, especially within headwater inland systems.

The depletion method requires that an adequate number of fish be removed on each sampling pass so that measurably fewer fish are available for capture and removal on a subsequent pass. The number of passes required generally depends on the capture result of each pass; however, a minimum of three passes is generally recommended. Two passes may be sufficient if the second catch is < 10% of the first, and if catches have not declined in the first three sweeps then additional passes are required until catches are < 25% of that in the initial pass.

The following conditions must be met for accurate depletion method estimates:

1. Emigration and immigration by fish during the sampling period must be negligible. This is accomplished by installing barrier nets at both upstream and downstream ends of the electrofishing reach.
2. All fish within a specified sample group must be equally vulnerable to capture during a pass.
3. Vulnerability to capture of fish in a specified sample group must remain constant for each pass (e.g. fish do not become more wary of capture).
4. Collection effort and conditions which affect collection efficiency, such as water clarity, must remain constant. To minimize error, the amount of effort used on each pass should be as constant as possible.

The depletion method is ineffective when more individuals are caught in the second or third passes than were caught in previous passes. This may be particularly problematic for streams containing low numbers of fish. In addition, the depletion method can only be used when barrier nets can be effectively deployed to reduce fish movement. When sampling reaches where blocking nets are not practical (i.e. large rivers), a qualitative survey (single pass without the use of barrier nets) should be performed, which will allow an estimate of relative abundance (Catch Per Unit Effort, known as CPUE).

Electrofishing must be done with a minimum crew size of two people: a "crew leader" and the other "crew members". The crew leader must be a qualified person and be certified to conduct backpack electrofishing surveys. The crew leader is responsible for the instruction of all other crew members. At least one crew member must have up-to-date Standard First Aid and CPR training.

Unsafe working conditions that may cause one to halt electrofishing operations (this list is not exhaustive and the final decision is generally left to the crew leader):

- Temperature
  - Electrofishing cannot be conducted in water temperatures >22℃
- Weather conditions
  - Moderate rain (enough to soak through clothing)
  - thunder and lightening
  - extreme heat (above 30℃)
- Dark water, deep water, fast flowing waters
  - unsure footing
  - inability to properly see substrate and/or fish
  - difficult to net fish efficiently and safely

- Stream conditions
  - thick, hidden, difficult vegetation and other debris in site
  - in-stream or overhanging vegetation

If any of these situations arise, the team must stop to evaluate conditions, and determine whether it is safe to proceed with electrofishing surveys. All crew members will work as a group to discuss and evaluate options to proceed with the survey. The final decision to proceed, delay, or forego the survey will be left to the crew leader. The crew leader must contact the Project Manager within 24 hours if a survey is delayed or skipped due to safety concerns.

5.2 Minnow Traps

Minnow traps are small, wire or plastic enclosures used to trap live fish. They are typically circular and slightly tapered towards the ends, with inward facing funnels at each end. The opening size for most minnow traps is 3 – 5 cm in diameter, with a standard mesh size of 6 - 8 mm, giving it an effective catch range of body depths approximately 6 - 50 mm. Small fish can swim inside through funnels that guide them from the large opening near the outside of the trap to the narrow opening close to the centre of the trap. Once inside it is difficult for the animal to locate the opening and escape.

Minnow traps consist of two wire baskets held together by a clip. The baskets are interlocked and the clip is inserted to hold the two halves together. The trap is attached with rope to a fixed object to it can be retrieved, and is positioned either on the bottom or suspended at a particular depth. Minnow traps are set with bait, which is discussed further in Procedures (Section 7).

Photo 2: Typical metal minnow trap (Source: https://dynamicaquasupply.com/products/minnow-trap-gee-style-1-8-mesh)

Minnow traps are also size selective and are best suited for sampling juvenile fish or adults of small species. They are most commonly used in littoral habitat and low velocity streams, especially within areas that may be difficult to sample with nets or electrofishing, such as deep areas, or habitats with abundant aquatic vegetation or woody debris. Water depth must be sufficient to submerge the trap entrances. As for all trap and net types, the length of set time for minnow traps should account for activity levels of fish at various times of the day (daylight, dusk, overnight, and dawn). Generally, traps should be set for approximately 24 hours (set on the first day and retrieved the following day). Traps may be re-deployed on successive days, provided they are checked once per 24 hours. If minnow trapping is completed to supplement electrofishing efforts, shorter set times may be suitable (to be determined on a project-by-project basis).

Minnow traps provide a qualitative metric of abundance (i.e. relative abundance), with effort expressed in terms of catch per trap per length of time set (CPUE).

5.3 Eel Pots

Eel pots are similar to minnow traps in that they allow fish into an opening in a rigid metal trap. MEL's eel pots are rectangular and are available in a variety of lengths (2-5 ft). A single, inward facing funnel (6.5 - 8 cm opening) is located at one end of the trap, through which small and medium sized fish can swim inside through. This longer funnel guides the fish from the large opening near the outside of the trap to the narrow opening situated closer to the opposite end of the trap. This end of the trap acts like a door which can be opened to retrieve trapped fish and to install bait. A bungee cord and hook keep this door closed when the trap is set. With a wire mesh size of 1-2 cm, the effective catch range of eel pots are fish with body depths of 10 - 80 mm. The trap is attached with rope to a fixed object to it can be retrieved, and is positioned on the bottom substrate.

Photo 3: Typical metal eel pot (Source: https://ketchamsupply.com/product/eel-trap/)

This sample method is selective towards small-medium sized fishes, and can be deployed wherever water depth allows the opening of the eel pot to be submerged. Eel pots target slightly larger fish which may be excluded from the minnow trap; however as a larger trap, it is typically deployed in larger, deeper pools or littoral zones without many obstructions, whereas minnow traps can be selected to sample small watercourses where other methods cannot be used. Pots should be set for approximately 24 hours (set on the first day and retrieved the following day). Traps may be re-deployed on successive days, provided they are checked once per 24 hours. If trapping is completed to supplement electrofishing efforts, shorter set times may be suitable (to be determined on a project-by-project basis). Eel pots can provide a qualitative metric of abundance (i.e. relative abundance), with effort expressed in terms of catch per trap per length of time set (CPUE).

5.4 Fyke Nets

A fyke net is a type of hoop net which traps fish inside mesh enclosures. The mesh is supported by a series of rigid hoops, which become smaller towards the back of the net. The opening of the trap contains a D-shaped hoop, and all subsequent hoops are round. The fyke net is characterized by “wings” which lead fish to the fyke net opening. The wings are short lengths of mesh with float (on the top, with buoys) and lead (on the bottom, weighted) lines that are attached to the lateral margins of the first hoop and extended at a 45º angle to the opening of the trap.

Fish that enter the fyke net pass through constrictions called tunnels. The tunnels are cones of mesh that are attached to the hoops, so that when the net is set and the hoops are separated the narrow end of the tunnel points to the rear. Usually there are multiple tunnels per net which get smaller towards the back of the net. Fyke nets are normally not baited, relying instead on the wings to guide fish into them. Fyke nets are accessed at the posterior end, where the mesh that extends beyond the last hoop is closed by a drawstring.

Fyke nets can be set in littoral and stream habitats in water that is deeper or shallower than the height of the hoops, as long as the tunnels are submerged. These nets are difficult to set where the bottom is

Photo 4: Example of a fyke net installation in an open waterbody

uneven, such as among boulders, and where there is dense vegetation or an abundance of other obstructions such as logs or stumps. In littoral habitats, fyke nets should be installed perpendicular to the shoreline, with the posterior end of the net positioned farthest offshore. In stream setting, the net is normally set with the opening facing upstream. One of the main drawbacks of a fyke net in stream environments is that debris can collect in or damage the net, reducing catch efficiency.

Fyke nets are size and species selected – they tend to target larger bodied fish as smaller fish like juvenile salmonids and forage fish may escape through the mesh (2 cm openings), and are more likely to capture roaming species than sedentary species. When deployed, fyke nets should remain in place for approximately 24 hours (set on the first day and retrieved the following day). Fyke nets may be re-deployed on successive days, provided they are checked once per 24 hours. If netting is completed to supplement electrofishing efforts, shorter set times may be suitable (to be determined on a project-by-project basis). Nets can provide a qualitative metric of abundance (i.e. relative abundance), with effort expressed in terms of catch per trap per length of time set (CPUE).

5.5 Seines

Seine nets (which also double as barrier nets for use during electrofishing surveys) consist of a length of fine mesh strung between a positively buoyant line (the float line) and a negatively buoyant line (the lead line) that is pulled through the water to encircle fish. Typical seines used in research are made of a woven (also called knotless) nylon mesh with small (in our case, 1/8th inch) openings. This SOP pertains only to seines used through wading, though they may also be deployed from a boat.

Seines can be used in both littoral habitat and slackwater areas of larger rivers, but generally cannot be used in moderate-fast currents. Seines are normally only used in water depths that are less than two thirds the depth of the seine, so that the lead line remains on the bottom and the float line remains at the surface as the net is pulled forward. Seining is easiest over smooth bottoms with no debris or obstructions, which may cause the net to lift off the bottom substrate, causing a loss of fish.

The simplest deployment technique involves two people, one on each end of the seine. One person stays fixed at the shore, while the second person wades through the water with the seine in a smooth arc. The seine haul ends by bringing the two ends of the seine together and pulling the net forward so that the encircled fish end up in the mesh that is between the lead and float lines.

Photo 5. Example of seining within riverine habitat

(Source: https://commons.wikimedia.org/wiki/File:Seining_for_wild_fish.jpg)

Efficiency varies widely among species, with benthic species being less susceptible to capture than mid-water species. Smaller individuals are more susceptible than large individuals, which may avoid capture by swimming out of the path of the seine. Qualitative abundance estimates can be expressed in terms of catch per haul if all hauls are similar, whereas more quantitative abundance estimates can be expressed as catch per unit area seined (e,g, catch per m^2).

Table 1. Efficacy and limitations of gear types (adapted from Portt el al. 2006)

Gear	Limitations			Survey Objective			Units
	Depth	Habitat	Selectivity	Presence	Relative Abundance	Absolute Abundance	
Electrofishing	Limited to safe wading depths for backpack; <2 m for boat. Only requires enough water to submerge the anode ring and tail.	Cannot conduct in water >22°C, or in the rain. Currents must be low enough to safely wade. High turbidity, vegetation, woody debris, soft substrate, and low conductivity decreases efficiency. Efficiency lower in large streams than in small streams.	Capture efficiency greater for large individuals. Benthic species are easy to overlook.	✓	✓	✓	CPUE (effort = electrofishing seconds) or catch per square m
Minnow Traps	Requires depths sufficient to submerge trap (>15cm). Not suitable for extremely shallow water.	Limited to low velocity habitat.	Limited to small-bodied fish (6 - 50 mm).	✓	✓		CPUE (effort = trap time in hours)
Eel Pots	Requires depths sufficient to submerge interior funnel (>20cm) along the entire length of the trap. Not suitable for extremely shallow water.	Limited to low velocity habitat.	Limited to small/moderate bodied-fish (10 - 80 mm).	✓	✓		CPUE (effort = trap time in hours)

Gear	Limitations			Survey Objective			Units
	Depth	Habitat	Selectivity	Presence	Relative Abundance	Absolute Abundance	
Fyke Nets	Requires depths sufficient to submerge interior funnel (>20 cm). Not suitable for extremely shallow water.	Limited to low-moderate velocity habitats with limited amounts of debris.	High selectivity for roaming species (vs. sedentary). Good for intercepting fish during migration. Effective catch range 20 mm + body depth.	✓	✓		CPUE (effort = net time in hours)
Seines	Limited to safe wading depths. Ideal water depths are less than 1/2 – 2/3 depth of the seine, so that the lead line can rest on the substrate, while the float line remains above water.	Limited to stream or littoral habitat with small, rocky substrate and limited obstructions.	Benthic species less catchable than mid-water species. Smaller individuals more susceptible than large individuals.	✓	✓	✓	CPUE (effort = number of hauls) or catch per square m

6 MATERIALS

The materials and equipment required to safely perform fish capture surveys in the field are listed below. The list is inclusive of all materials required to perform any fish capture survey (electrofishing, trapping, and netting).

- Electrofishing Kit
  - backpack electrofisher in Pelican case
  - anode pole and ring
  - cathode tail
  - batteries and battery charger
  - gloves (long-armed, lineman's gloves)
  - polarized sunglasses
  - long-handled landing net
  - wader repair kit
- Traps and nets
  - minnow traps
  - eel pots
  - fyke nets
  - seine nets (i.e. barrier nets)
  - rope
  - rebar or stakes to aid in setup
- Fish Processing Kit
  - clear tupperware with ruler
  - plexiglass fish viewer
  - electronic balance scale (including calibration weights and extra batteries)
  - spring scale (and extra batteries)
  - live-well buckets (plastic, 5-gallon)
  - small dip net
- Additional Equipment
  - standard MEL PPE
  - Required PPE for electrofishing:
    - Leak-free chest waders with wading belt
    - Wide brimmed hat
    - Polarized sunglasses
    - Long-armed gloves/linesman gloves
  - first aid kit
  - personal flotation device if deemed necessary based on site characteristics
  - field sheets on write-in-the-rain paper ("Fish Collection Tracking Sheet", Appendix D)
  - fish ID books, identification key
  - pencils
  - multi-parameter water quality instrument (YSI or equivalent)
  - GPS
  - hand sanitizer
  - flagging tape
  - measuring tape

- meter stick
- phone or digital camera
- **hard copy of DFO fishing licence**

7 FISH COLLECTION METHODS – PROCEDURES

7.1 Planning: Before You Leave

1. Review detailed written scope provided to you by the Project Manager. This will identify priority deliverables, timelines, and budget allowed for each task. Detailed methods will be provided in this scope (i.e. # of traps required, set time required, etc).
2. Identify the crew supervisor/operator and crew members. The crew supervisor must have an Electrofishing Crew Leader Certification and proper training for the use of the electrofisher and safety procedures. The primary responsibility of the crew supervisor is to ensure the safety of all crew members. Their secondary responsibility is to direct the survey. A field team must consist of a minimum of 2 people, and all crew members are responsible for working in a safe manner, bearing mind that any action can affect the safety of other crew members.
3. Determine the location(s) of the survey, size of area to be surveyed and easiest access to the site based on the work scope provided by the Project Manager. Sample design should be verified by the Project Manager.
4. Prepare site maps and GPS units as required.
5. Ensure that all personal safety equipment and field gear are in good working order. Check the electrofisher unit and traps for any obvious signs of damage. Ensure all traps and nets have clear markings on them identifying the licence number, a contact person, and an emergency contact number.
6. Fill out a field tracking sheet. Have all crew members review and sign off on the field tracking sheet.

7.2 Electrofishing

7.2.1 Site Setup

1. Ensure that all personal safety equipment is in good working order and remove all jewelry including watches, necklaces or rings before commencing electrofishing.
2. Assign roles for the following:
   - electrofisher operator
   - primary netter
   - secondary netter (if third crew member is available)
3. Prepare the workstation for the survey by laying out the first aid kit(s) and other equipment to ensure fast and easy access. Set-up any equipment to be used for processing fish.
4. Measure a 100 m survey reach along the contours of the stream channel, marking the beginning and end of the survey reach with flagging tape and take GPS waypoints. For “closed” sites, install the barrier nets at the downstream extent, and then upstream extent of the reach, ensuring that the lead line is placed firmly against the bottom substrate and that the nets cover the entire channel width. This is not required for larger streams greater than the width of the barrier nets (on average > 7 m across); however, whenever possible, adjust the downstream and upstream extent locations of reaches to allow for use of barrier nets (try to find a narrow channel section). For

larger streams, a qualitative, single-pass survey using an open-site methodology should be employed.

5. Take representative photos of the following:
    - Looking upstream
    - Looking downstream
    - Right bank (downstream orientation)
    - Left bank (downstream orientation)
    - Substrate
    - Any distinct physical features
6. Sketch a rough drawing of the site on the Fish Collection Tracking Sheet, noting any distinct physical features of the site (barriers, pools, braiding etc.), and discuss any potential safety hazards with all crew members. Discuss how to proceed through the survey reach.
7. Record the site identifier information, general site conditions (air temperature, weather, previous precipitation), and physical characteristics of the reach (widths, depths, substrate, habitat types, etc) on the Fish Collection Tracking Sheet.
8. Measure and record temperature, conductivity (SPC, CON), total dissolved solids (TDS), pH, dissolved oxygen (DO), and salinity (SAL) on the Fish Collection Tracking Sheet.

    Note: If performing multi-pass surveys, water temperature must be recorded at the beginning of each pass. ***Electrofishing cannot be conducted in water >22°C.***

9. Assemble the electrofishing unit.
    - With the main power switch in the OFF position, and emergency shut off switch pressed down, plug the anode and cathode into their proper connectors located on the bottom of the Pelican case and install the battery
    - Ensure the tilt switch is turned on
    - Reset the 'elapsed time' counter
    - Check that emergency releases are in good working order
    - Set a low output voltage (100 or 150V) and frequency (40 or 60Hz) to start
    - Ensure that the audible safety tone and light are working
    - Keep the emergency shut off switch pressed down when entering the stream
10. Outside of the closed survey reach, test the voltage and frequency settings and adjust if necessary. Voltage and frequency may need to be changed to get a desired response. In general, lower frequencies are safer for larger fish than higher frequencies. If the unit is not producing satisfactory results, try increasing the frequency a few levels before increasing the output voltage. Only increase the output voltage one-step at a time, releasing the anode pole switch to change the electrofisher output frequency and/or voltage levels.

    Note: Observe fish closely. In general, if it takes more than 5 seconds for a fish to recover it may have been shocked too much. If it takes more than 15 seconds for a fish to recover it was definitely shocked too much; therefore reduce the frequency or output voltage. Another common indication of an excessive voltage setting is "burn marks" on fish caused by the triggering of pigment cells in the flesh and visible as dark discolorations. Burn marks are temporary, but when observed the voltage should be decreased. The voltage should only be increased if fish are consistently in the fright zone and are not completely stunned.

7.2.2 Surveying

1. The survey should be completed in an upstream direction. Start at the most downstream point of the sampling site and work your way upstream. Once in the reach, the backpack operator will release the emergency shut off switch on the electrofishing unit. The operator must always give a verbal indication to, and receive a verbal acknowledgement from, all crew before commencing each sweep.
2. The electrofisher operator must say aloud "Power On" each time they begin electrofishing. Begin the first sweep by shocking water at the designated starting point.
3. The netter should be positioned downstream of the operator, approximately 2-3 m apart. The netter should set the pole net flush with the bed of the stream and perpendicular to flow.
4. Continue sweeping the anode ring wading from one bank to the other, always in line with the pole net, thus sampling a "lane" of the stream. When fishing undercut banks or log jams, fish can be drawn out by inserting the uncharged anode, switching it on and then pulling the anode out and away. Creating currents using the anode ring or dip-nets can often assist with pulling stunned fish out of complex structure when using this technique. When the opposite bank is reached, both the machine operator and pole netter move upstream 2–3 m and begin fishing again. Continue fishing until the entire sample reach has been fished.
   *Note: If you get water in waders or gloves, or it begins to rain hard enough to saturate clothing, **STOP WORK** immediately and get dry clothing. Never reach into the water in vicinity of an electrode, even if rubber gloves are being worn. To further prevent electrical shock, never touch an electrode while the circuit is energized, even while wearing rubber gloves and waders.*

5. Transfer captured fish to live wells where they can be held until the completion of the electrofishing pass. Keep the live well in a shaded area. When fish are held for a longer period of time, particularly during warm conditions, regularly change the water maintain water quality.
6. Record pass details (seconds of electrofishing, voltage, and frequency) on the Fish Collection Tracking Sheet. Reset the elapsed time counter for each pass.
7. Process the captured fish (refer to Section 8). Once processed, return captured fish to watercourse/ waterbody, outside of the barricaded reach (if using barrier nets).
8. Repeat steps 1-8 until the required number of passes have been completed. The number of passes required will depend on the type of survey (qualitative or quantitative) being employed.
   a. For a **qualitative, open-site survey,** one pass should be sufficient, unless crew members note a high number of fish that evaded capture. In that case, perform a second or third pass to obtain greater species representation. For all qualitative electrofishing surveys, crews should aim for at least 300 seconds of effort (i.e. minimum effort).
   b. In **quantitative, closed-site surveys,** a minimum of three passes should be performed. The requirement for additional passes is determined by the total catch on the last run. If the catch on the last run is <20% of the catch on the first pass and <50% of the catch of the previous pass, no additional passes are required. If no fish are captured or observed on the first two passes, the third pass is not necessary.
9. At the conclusion of all electrofishing surveys, inspect all equipment and note any problems requiring correction. Disconnect the battery and all attachments. Batteries must be charged at the

end of each day's use to maintain the life expectancy and all equipment must be thoroughly dried and stored in the appropriate manner.

7.3 Trapping and Netting

As previously stated, fish collection surveys are most effective when using a variety of gear types to sample as many habitat types as possible. Efforts should be made to supplement electrofishing surveys with other fishing techniques (trapping and netting) when the watercourse reach or portions of the reach being surveyed are not suitable for electrofishing (i.e. non-wadeable, deeper pools, high concentration of woody debris). Trapping and netting are also the preferred method for the open water habitats (e.g. ponded wetlands) and littoral habitats of lakes, where electrofishing tends to be inefficient. The types of traps and nets suitable for each survey depends largely on physical habitat characteristics of the watercourse or waterbody and the fish species anticipated to inhabit them. However, the main objective for netting and trapping should be to set the most diverse combination of traps and nets possible. The habitat limitations and selectivity of each trap type are summarized in Table 1.

7.3.1 Site Setup

Note: if trapping/nettings occurs within the same survey reach as electrofishing, combine all data onto one Fish Collection Tracking Form. Trapping/netting completed within a watercourse/waterbody without electrofishing requires its own tracking form.

1. Ensure that all traps and nets are in good working order (no tears and holes). Ensure all passive traps that are to be left unattended have an identification tag (licence number, contact name and emergency contact number) attached.
2. Select suitable locations within the watercourse/waterbody for deployment that are accessible by wading. Consider the physical characteristics of the habitat being surveyed, the fish species anticipated to be present, and the likelihood of fish to congregate in certain areas based on the species and time of year. Plan to distribute traps so they will be independent of each other. Target in-stream habitats such as:
    - Areas with suitable water depths for trap deployment
    - Slack-water areas (particularly in rivers)
    - Potential refuge/cover areas, including snags, deep pools, highly vegetated areas, and undercut banks
    - Off-channel habitats, side channels, and backwaters
3. If considering seining, identify any possible snags, large substrate, deep areas, or other safety hazards which may impede the survey. Discuss and mitigate with all crew members. Only seine if it is safe and appropriate to do so.
4. When trap/net locations are confirmed, take a GPS waypoint and a water depth reading of each location. Record the UTM coordinates and water depth for each trap/net on the Fish Collection Tracking Sheet.
5. Sketch a rough drawing of the site on the Fish Collection Tracking Sheet, noting any distinct physical features of the site (barriers, pools, braiding etc.), and discuss any potential safety hazards with all crew members.

6. Record the site identifier information, general site conditions (air temperature, weather, previous precipitation), and physical characteristics of the watercourse/waterbody (when applicable) on the Fish Collection Tracking Sheet.
7. Measure and record temperature, conductivity (SPC, CON), total dissolved solids (TDS), pH, dissolved oxygen (DO), and salinity (SAL).
8. Proceed with trap/net deployment or seining (if conditions allow).

Note: As standard practice, all passive traps and nets (minnow traps, eel pots, and fyke nets) should be set for approximately 24 hours. The involves setting traps/nets on one day, and retrieving traps the following day them the following day. Traps may be re-deployed on successive days, provided they are checked once per 24 hours. If trapping is completed to supplement electrofishing efforts, shorter set times may be suitable (to be determined on a project-by-project basis).

7.3.2 Trap/Net Deployment (Day 1)

1. If deploying minnow traps or eel pots, place bait in inner compartment, bearing in mind various mesh sizes so the bait stays inside the traps. Possible bait includes dry or wet cat/dog food, or Cheetos. Ensure rope is attached to each minnow trap/eel pot and tie the other end to a stationary object. Identify the stationary object with flagging tape. This will assist in locating the traps and will also prevent the trap from floating away.
2. If deploying fyke nets, face the opening upstream if in riverine habitat, or perpendicular to the shoreline if in an open waterbody with the opening facing the shore. Fix the wings in place using stakes driven into the substrate, or rope attached to stationary objects to achieve a 45º angle to the opening of the trap. Ensure that the lead line lays flat on the bottom substrate – this can be ensured by placing rocks along the bottom edge of the wings. Ensure that each funnel is open and not twisted to allow for the passage of fish to the back of the net. Tie off the posterior drawstring and extend the traps back so that each segment is fully extended and the hoops are upright. To maintain this position, the posterior end of the trap may need to be fixed in place – this can be achieved with a stake, stick, rope, rock or other heavy object.
3. Ensure all entries into the traps and nets are submerged.
4. Record deployment time on the Fish Collection Tracking Sheet.
5. Take photos of each trap setup.

7.3.3 Trap/Net Retrieval (Day 2)

1. If multiple traps are used, retrieve in the order they are deployed, one at a time. Record retrieval time for each trap/net on the Fish Collection Tracking Sheet. Set times and retrieval times can be rounded to the closest 5-minute interval.
2. Deposit fish captured into a live well.
3. Process captured fish (refer to Section 8).
4. Rinse the traps/nets clean after all of the fish have been released. Allow the traps/nets to dry once the field survey is complete.
5. If re-deploying traps, follow outlines in Section 7.3.2.

7.3.4 Seining

1. Attach a pole (stake, rebar, etc.) to each end of the seine and used as a handle. The lead line should be attached to the bottom of the pole, which is kept on or at the substrate. An alternate method is to tie a loop in each end of the lead line and place it over the operators' feet that are

closest to the net, and to hold the float line in the hand closest to the net. The bottom line is pulled forward by the operator's leg.

2. With one crew member staying stationary on the shore/bank holding one end of the seine, the other crew member drags the other end of the net into the water by wading in a perpendicular line to the shore, keeping the lead line on the bottom substrate and the float line at the water's surface.
3. Once almost all of the net has been pulled into the water, the wading crew member arcs back to the shoreline/bank, creating an arc shape with the net. The wading operator then pulls their end of the net back to the shoreline, lining up parallel to the stationary operator.
4. To retrieve the net, pull the net to shore with one person on each end of the net. The float and lead lines should be pulled in together at a slow, even pace. Do not pull too quickly, as this could cause the float line to become submerged and possibly allow fish to escape over the net. If the float line is pulled in ahead of the lead line, the flow of water will be downward causing the lead line to lift off the bottom, allowing fish to escape underneath the net.
5. As the net approaches shore, the lead line should be kept on the bottom and the float line should be lifted slightly to stop fish from jumping out of the net. The entire net should be pulled onto the shore and the catch quickly transferred into live wells and processed.

8 FISH PROCESSING

Fish should be handled as little as possible and processed quickly. The water quality of the live wells should be maintained as close as possible to the fish's natural habitat, and should be kept out of direct sunlight. Monitor condition of fish on a regular basis to ensure the temperature and oxygen levels in the well are adequate, and replace water if fish show signs of stress (i.e. gasping at surface, frantic swimming, lethargy, rapid gill movements, etc.). Note that these processing procedures do not include anesthetic. Gentle pressure should be used to immobilize fish on the measuring board - ensure that this pressure remains slight and is not focused on the eye area or the operculum.

1. Prepare the onshore workstation to commence the processing of captured fish. Layout/assemble all equipment from the Fish Processing Kit. Level the electronic balance scale and calibrate prior to use.
2. If fish have been captured through multiple gear types, process fish from each gear type one at a time. This is necessary to infer qualitative abundance data for each method of fish collection.
3. Any crew member involved in fish handling procedures will ensure that hands are free of chemical contaminants (i.e. insect repellent, sunscreen) prior to any handling of fish. If additional surveys are to take place in the same day, crew members must sanitize hands prior to handling fish from different areas in order to minimize the risk of disease transfer.
4. Prepare the live well (fish captured during electrofishing should be actively placed in a live well during sampling), ensuring that water is refreshed regularly, especially on warm days. Prepare multiple live wells and separate fish species if predation within the well is likely to occur (i.e. American eel captured with other fish species).
5. On the Fish Collection Tracking Sheet under Individual Fish Measurements (Appendix D), assign each fish captured with a number starting from 1, and continue numbering for each fish (1, 2, 3…) captured within a particular survey site. Photograph each individual fish with the fish number in the photograph (or photograph the fish number prior to photographing the fish). Record the collection method - if electrofishing with multiple passes, record what pass the fish was captured during (e.g. Pass 1), or if captured with a trap or net, record the gear type and ID if using multiples of the same type (e.g. MT1). Gear type codes are presented on the Fish Collection

Tracking Sheet. Record the fish species using the 3-letter codes provided in Appendix B. If species is unknown, record with a "U".

6. Measure and record the total length (TL, mm), fork length (FL, mm), weight (in grams), and life stage (if known). See Appendix B for terms and definitions:
   - Small fish (<500g) are to be weighed with the electronic balance scale, measuring to with +/- 0.01g.
   - Large fish (>500g) are to be weighed on a spring scale using a tared mesh net.
7. Note whether or not the adipose fin is clipped, as this will indicate that the fish is from a hatchery. Watch for burn marks and note any other pertinent observations. Note any mortalities, and overall condition. Appendix A provides anatomical features and morphological definitions for fish.
8. Return captured fish to the habitat area. In the case of multi-pass electrofishing surveys, captured fish may should be returned outside and downstream of the barrier nets so as to avoid being double counted.

9 REPORTING

Reporting and data management requirements will be communicated to the field crew by the Project Manager. At a minimum, the following parameters must be communicated to the Project Manager for submission to DFO under Appendix A of the License to Fish for Scientific Purposes:

- Dates of the fishing activity
- Fishing location (waterbody, county and province)
- Gear type used
- Number of fish caught by species
- Life stage of fish caught by species
- Number of fish sampled/tagged by species if applicable
- Fate of fish by species:
  - Number released alive
  - Number of incidental mortalities
  - Number retained alive
  - Number of retained mortalities.

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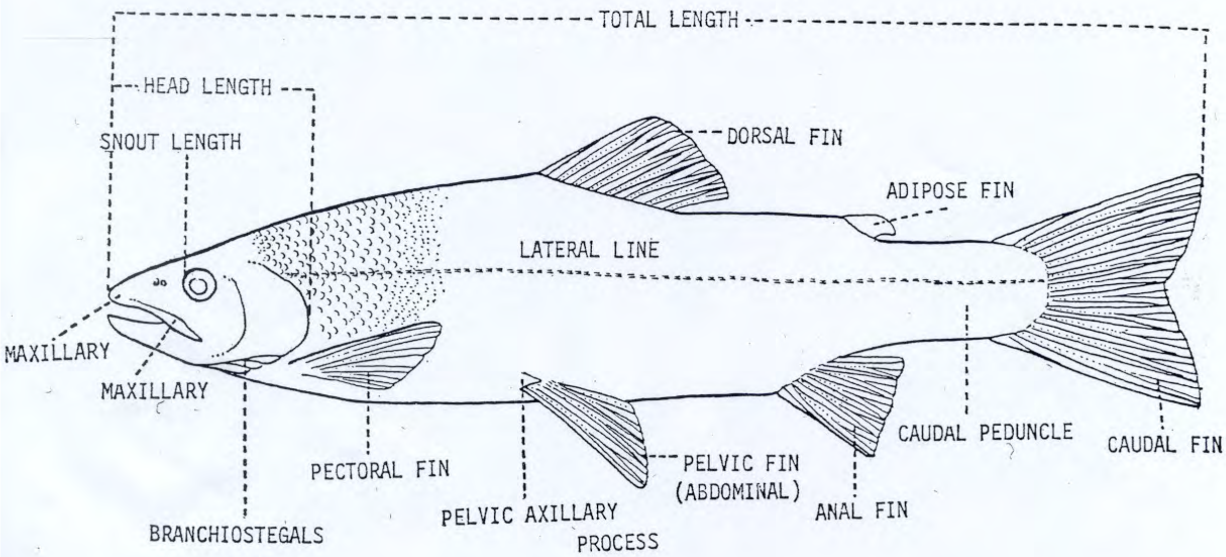
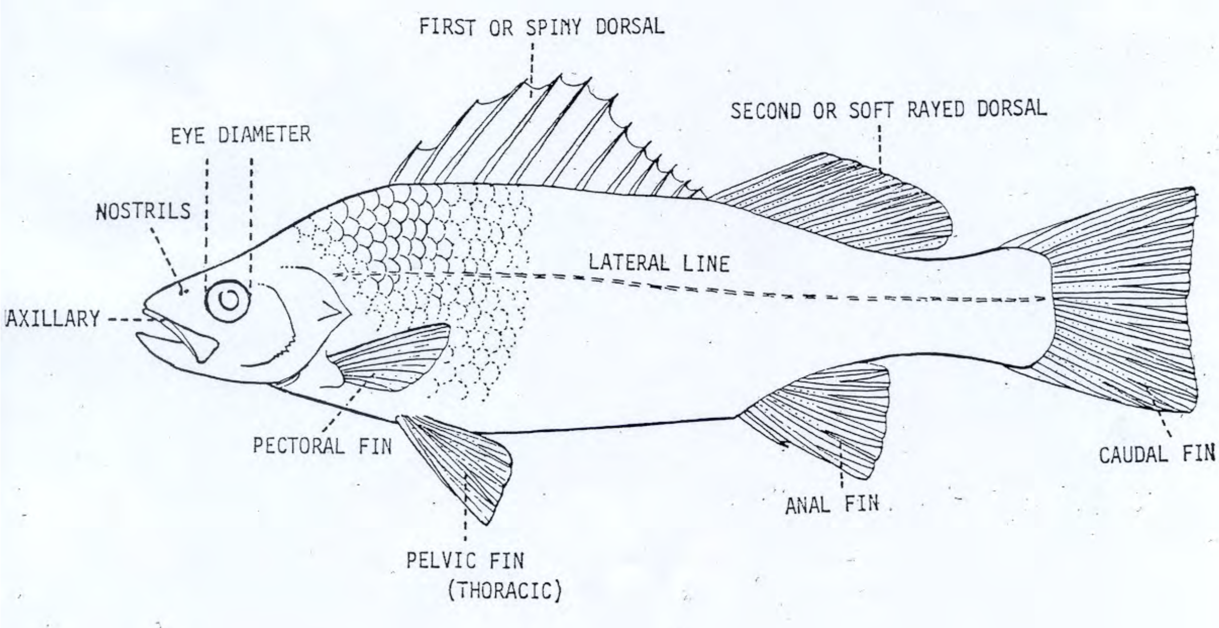
Appendix A: Anatomical Features of Fish


TOTAL LENGTH
HEAD LENGTH
SNOUT LENGTH
DORSAL FIN
ADIPOSE FIN
LATERAL LINE
MAXILLARY
MAXILLARY
CAUDAL PEDUNCLE
CAUDAL FIN
PECTORAL FIN
PELVIC FIN
(ABDOMINAL)
ANAL FIN
PELVIC AXILLARY
PROCESS
BRANCHIOSTEGALS


FIRST OR SPINY DORSAL
SECOND OR SOFT RAYED DORSAL
EYE DIAMETER
NOSTRILS
LATERAL LINE
AXILLARY
PECTORAL FIN
CAUDAL FIN
ANAL FIN
PELVIC FIN
(THORACIC)

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Appendix B: Fish Species Codes & Definitions

Code	Species Name	Code	Species Name
ALE	Alewife (*Alosa pseudoharengus*)	LKC	Lake chub (*Couesius plumbeus*)
EEL	American eel (*Anguilla rostrata*)	LKT	Lake trout (*Salvelinus namaycush*)
AMS	American shad (*Alosa sapidissima*)	LWF	Lake whitefish (*Coregonus clupeaformis*)
ARC	Arctic char (*Salvelinus alpinus*)	LLS	Landlocked salmon (*Salmo salar*)
ATS	Atlantic salmon (*Salmo salar*)	LNS	Longnose sucker (*Catostomus catostomus*)
AST	Atlantic sturgeon (*Acipenser oxyrhynchus*)	MUM	Mummichog (*Fundulus heteroclitus*)
ATC	Atlantic tomcod (*Microgadus tomcod*)	MUS	Muskellunge (*Esox masquinongy*)
BKF	Banded killifish (*Fundulus diaphanus*)	9SB	Ninespine stickleback (*Pungitius pungitius*)
BND	Blacknose dace (*Rhinichthys atratulus*)	NRD	Northern redbelly dace (*Chrosomus eos*)
BNS	Blacknose shiner (*Notropis heterolepis*)	PLD	Pearl dace (*Semotilus margarita*)
BSS	Blackspotted stickleback (*Gasterosteus wheatlandi*)	PSF	Pumpkinseed Sunfish (*Lepomis gibbosus*)
BLH	Blueback herring (*Alosa aestivalis*)	RBS	Rainbow smelt (*Osmerus mordax*)
BKS	Brook stickleback (*Culaea inconstans*)	RBT	Rainbow trout (*Salmo gairdneri*)
BKT	Brook trout (*Salvelinus fontinalis*)	RSF	Redbreast sunfish (*Lepomis auritus*)
BBH	Brown bullhead (*Ictalurus nebulosus*)	RWF	Round whitefish (*Prosopium cylindraceum*)
BNT	Brown trout (*Salmo trutta*)	SLP	Sea lamprey (*Petromyzon marinus*)
BUR	Burbot (*Lota lota*)	SST	Shortnose sturgeon (*Acipenser brevirostrum*)
CHP	Chain pickerel (*Esox niger*)	SLS	Slimy sculpin (*Cottus cognatus*)
CSH	Common shiner (*Notropis cornutus*)	SMB	Smallmouth bass (*Micropterus dolomieui*)
CRC	Creek chub (*Semotilus atromaculatus*)	SPL	Splake (*S. namaycush x S. fontinalis*)
FLF	Fallfish (*Semotilus corporalis*)	STB	Striped bass (*Morone saxatilis*)
FHM	Fathead minnow (*Pimephales promelas*)	3SB	Threespine stickleback (*Gasterosteus aculeatus*)
FSD	Finescale dace (*Chrosomus neogaeus*)	WHP	White perch (*Morone americana*)
4SB	Fourspine stickleback (*Apeltes quadracus*)	WHS	White sucker (*Catostomus commersoni*)
GSH	Golden shiner (*Notemigonus crysoleucas*)	YLP	Yellow perch (*Perca flavescens*)
GLF	Goldfish (*Carassius auratus*)		

Total Length: the distance from the most anterior part of the head to the tip of the tail when the fin lobes of the tail are pressed together. This is the only length measurement collected for fish without forked tails such as banded killifish.

Fork length: measured from the most anterior part of the head to the median caudal fin rays (fork of tail). This measurement is only appropriate for fork tailed fish such as trout and salmon.

CPUE: Catch per unit effort = catch (fish) / survey effort (time).

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Appendix C: Fish Fact Sheets for Common Freshwater Species (Source: NSSA, 2005)

SECTION 6.0. FISH FACTS

THIS SECTION CONTAINS:

- Some notes on fish anatomy
- Habitat requirements of salmon and trout
- Fish facts on many Nova Scotia fish species

6.1. Understanding Fish

This first section contains information on the anatomy of fish. Although different species of fish vary, what is described here is a general description of a trout or salmon.

```
A woman wrote the very first
published fishing manual
nearly 500 years ago. Dame
Juliana Berners, prioress of
the Benedictine convent near
St. Albans, England hand
wrote the treatise f Fishing
with an Angle in 1496. The
boll included advice on how
to construct a two-section
rod and where the best places
were to fish
```

Eyes and Sight

As with the eyes of mammals, fish eyes serve a number of purposes: to find food, to watch for enemies and other dangers, and to navigate perhaps even during ocean migrations. The pupil bulges outward to take in a wider field of vision, and although the eyes are set on the side of the head, they have all-around vision, giving the fish stereoscopic vision in a forward direction. The lens of the fish eye can move in and out like a camera lens. Trout and salmon appear to have the ability to see well into air and have good vision in semi-darkness. They respond strongly to sudden changes in light intensity (which would usually indicate danger), especially if they are within a closed environment from which they are unable to escape.

Gills

Fish gills are composed of two basic parts: the gill covers and the gill filaments. The gill covers protect very delicate threads or **filaments** that are located in cavities on either side of the head. A special pump called the **brachial pump** maintains a flow of water over the gills. When the mouth closes, water passes through the gills and out through the gill covers which open. The gill filaments are richly supplied with blood vessels that pick up oxygen out of the water. Carbon dioxide is released as a waste product. More activity increases the need for oxygen and this results in a corresponding increase in the opening and closing of the mouth and gills.

Nostrils and Smell

Trout and salmon have a well-developed sense of smell. It is believed that they use this ability to seek out and recognize the chemical characteristics of their home streams for spawning. This sense is sometimes helpful in avoiding predators. Fish breathe through their gills and mouth, not their nose.

Lateral Line (line along the side of the body)

There is a row of special scales with small holes along each side of the fish's body called the **lateral line**. The system is connected to a series of nerve endings can detect changes in pressure, sound, and movement. The lateral line helps to warn the fish of the approach of predators and search for prey.

Mouth

The mouth is used to catch and hold food of various types; but food is not chewed before being swallowed. The mouth is also important for breathing or respiration. Water is constantly taken in through the mouth and forced out over the gill filaments through the gills. This fish receives its oxygen by moving water over its gills.

Fins

Most fish have two sets of paired fins: the pelvic and pectoral fins, and four single fins: dorsal, caudal, anal and adipose. Some fins are spiny (although not on salmon or trout). Spines can be used for protection or for sexual display.

- The dorsal and anal fins are used for maintaining vertical balance and achieving quick changes in direction.

- The pelvic and pectoral fins are used for horizontal or lateral balance and resting.

- The adipose fin is small and fleshy on trout, salmon and whitefish and we don't know its purpose. Fishery managers, to identify certain stocks of fish or indicate that a fish is tagged, often clip it off.

- The caudal or tail fin is the most important fin as it is used to propel the fish through water by the flexing of strong muscles along the sides of the body. The caudal fin is also used by the female salmonids and male smallmouth bass to move gravel and scoop out the nests (redds) in which eggs are deposited.

Scales

The body surface skin of the fish, except for the head and fins, is protected by overlapping scales that grow in regular patterns and by an outer coating of mucus, which protects the fish from disease. Growth of the scales is continuous and takes place around the perimeter of each scale. Growth is more rapid in summer than in winter, thus, growth rings (looking somewhat similar to those of trees) of summer are farther apart than those of winter, and indicate the age and life history of the fish. When fish are sick or stressed, the rings are closer together. Rings spaced more apart indicate healthy growth and environmental conditions.

Ears

Fish do not have external ears but they can detect sound with an inner ear and labyrinth that function as organs of balance as well as hearing. Low frequency sounds can also be detected in the water by the lateral line system.

6.2. Habitat Requirements

If you know what a fish needs in a stream in order to survive, it is a natural progression to determine where and what is in need of protection or rehabilitation. This section will concentrate primarily on the needs of trout and salmon (referred to as **salmonids** by biologists). These fish can be found in many different habitats in our part of the world. Because they often have to cope with severe and varying conditions they can be remarkably resilient in habitat use, in feeding, growth and reproduction. Despite the fact that these fish adapt to change well they can be highly sensitive, environmentally "fussy" fishes; particularly in the "egg" and "young" stages.

The habitat requirements for fish are the things they need to live. As we learned in the first section, this is a combination of water, food, space, and cover. In this next section we'll look at the important habitat requirements of fish. Even within one species different habitat combinations are required for nursery areas, feeding and spawning. Understanding habitat will help you to better determine the health of the stream, its potential for trout and salmon and other fish, and the locations most likely to benefit from rehabilitation and enhancement.

Trout and salmon require very special conditions for:

- Successful **spawning** (the production of eggs)
- The development and hatching of eggs
- Growth and survival for their young
- Feeding

In general, salmonids require streams that have:

- **Temperatures** that are fairly cool
- **Shade**; there should be trees and shrubs along the bank of the stream
- Water with lots of **oxygen**
- Clean **gravel** of different sizes on the stream bottom
- Sufficient **flow of water**
- No major **physical obstructions** which will stop them from moving up or downstream
- **Cover** or places to hide when it gets too hot and to hide from predators
- **Clear water** so they can see insects to feed on
- **The right combination of habitats** for different parts of their life cycle
- Lots of small insects and animals for **food**

Let's look at each one of these in turn.

Temperature

Salmonids need much cooler water than other fish such as perch, bass, gaspereau or suckers. For example, if water temperature rises much above 20 - 25·C, for very long, most salmonids, especially in early stages, will become seriously stressed or will die. On the other hand, many species of bass, suckers and perch for example, thrive in much higher temperatures. Young trout and salmon prefer a water temperature between 15 and 18·C. Brook trout will die if the water temperature rises above 22 C. (72 degrees F.) for more than several consecutive days; rainbow and brown trout will die if it's hotter than 24·C. (75 degrees F.). Fish can adapt to a gradual change in temperature, but sudden drastic changes can shock and kill them.

Also, fish are cold blooded which means that their body temperature varies according to the temperature of the surrounding water. The warmer it gets, the faster their metabolism gets so they need more oxygen. The problem is that warmer water holds less oxygen.

Temperature also affects the growth and reproduction of fish. Fish lay eggs only at certain temperatures. Most salmonids prefer cooler temperatures: salmon, brown trout, brook trout and lake trout spawn during the late autumn and early winter; rainbow trout prefer the warmer temperatures from mid-April to late June. Temperature is also a major factor in the timing of fish migrations.

The temperature of a stream is regulated by springs, shade, and the stream width to depth ratio. Most streams begin as springs bubbling out of the ground. The spring water comes from snow melt and rain water that percolated into the soils of the surrounding hillsides the previous week, day, month, or year. Sometimes because of human activity the amount of rainwater that goes deep down into the soil is reduced, not allowing the water table to be replenished. This can cause springs to dry up, so that water levels in rivers decrease and water temperatures increase. Many streams come from lakes and their water is warmer when it enters the stream. In these streams even more care must be taken to make sure that the water doesn't get too hot.

Shade

The amount of shade along a stream is very important. Too much shading in a stream reduces the growth of instream plants (algae). This will mean less food for insects, and in turn less food for fish. In some places it can also make spring-fed streams too cool for salmonids, which prefer 16-17 C. temperatures for growth.

Too little shading encourages heating of the stream and raised temperatures. The percent of shading needed varies from stream to stream and depends upon the amount of spring water available to cool the stream, the stream's width and depth, and human land use activity in the area. There is a balance in all these and the optimum appears to be about 60% shade during the peak of the day. In general, most streams don't have enough shade. A narrow, deep river channel also maintains cooler water temperatures by having less surface exposed to the air. Where width greatly increases, the shallow water is then highly susceptible to heating by direct contact with the air. Even in well-shaded streams, the water temperature follows the air temperature very closely if pools are poorly developed and the channel is wide and shallow. Direct sunlight warms things up even more, as everyone knows; it's cooler in the shade.

Oxygen

Trout and salmon that live in streams require high levels of **dissolved oxygen** (the amount of oxygen contained in the water). Fish are extremely sensitive to any decrease in the available supply of oxygen and can suffocate very quickly if they are forced to endure a low level for even a short period of time. Young fish or breeding fish have even greater oxygen requirements. Eggs lying in the gravel take in oxygen through their shell. A lowered level of oxygen may result in a delay in the development of the embryo and the hatching. These low levels can be caused by increases in temperature, excessive nutrients and silt which all can deplete oxygen. Moving water adds oxygen to the stream. The faster the water moves, the more oxygen goes in.

Gravel and Stream Bottom

For successful egg-laying, salmonids require clean, stable gravel of 1-10 cm in diameter, depending on size of the adult fish. The gravel must be clean and loose, so that water can flow through the gravel to provide each egg with enough oxygen, and so that waste products emitted by the eggs (such as carbon dioxide and ammonia) will flow away from the egg. The gravel must contain different sized stones. Smaller gravel is used for egg laying, larger stones are needed for many of the insects which live in the water, and boulder sizes are needed to ensure spaces for fish to hide and over-winter.

The best bottom for a trout and salmon stream is a mixture of gravel, rubble, rock, and boulder with a liberal sprinkling of sunken logs and stumps. The rock/gravel bottom, especially in riffles and runs, offers the best habitat for insects that the fish eat. This mixture should have very little sand and silt in it. You should be able to pick up the surface stones without exposing sand or silt and see insects on them.

Stream flow

Nova Scotia is known for extreme changes in the amount of water that flows in streams. In the spring the water often flows high because of winter snow melt and spring rains. This is called the **spring freshet** or flood. In the hot weather of summer many streams experience droughts and have very little water flowing through them. This is extremely hard on salmon and trout. The best streams have flows without these extremes. It is especially important to have enough water flowing in the normal low flow period of late August and September to provide adequate nursery areas for young fish. It is also important during the winter, so that embryos and alvins do not freeze. Human activity in the watershed can result in higher freshets, lower summer and winter flows, and excessive ice formation.

Barriers to swimming up and downstream

During migrations between the ocean and the spawning and rearing sites in lakes and rivers, an unobstructed path is necessary for adults. Fry and juveniles also move to different habitats, as they grow older, so they require access up and down the stream and into side-channels and tributaries. Obstructions such as logjams, hydro power dams, and poorly installed culverts are especially damaging to the migrations of salmonids unless provisions for passage are made.

Clean Water

Clean, clear water is very important to trout and salmon. The water must be clear enough to permit the sunlight to reach the stream bottom where important plants and algae grow. These plants and algae are important food sources for many of the insects upon which trout and salmon feed. Also, high concentrations of solids such as silt in the water can damage the fragile breathing systems of insects and fish.

While some fish, such as suckers, locate food chiefly by smell or feel, trout and salmon need to see their food. Therefore, they feed and grow better in clear water. Water quality is critical during the spawning, incubation, and hatching periods. Heavy sedimentation can smother eggs in gravel and easily destroy them.

Cover/Shelter

Stream salmonids require cover such as undercut banks, logs, spaces under large rocks and boulders, overhanging trees and plants, and deep pools. This cover is used for feeding, hiding, resting, and over wintering. Additionally, overhanging plants shade the river to help control stream temperatures.

Fish spend a lot of time hiding from various predators, whether these predators be the web-footed, clawed, four-footed, or the two legged kind. Their hiding locations are commonly called areas of shelter. Shelter is critical to a fish's survival in a stream and various sizes of trout or salmon require different ranges of shelter. Ideally, most fish like to be protected or sheltered on three sides. This often means on the top, one side and bottom (e.g. an undercut bank). They also require a shelter that is a snug fit and not too roomy. Therefore, a fish will select a shelter that is close-fitting to its body size.

A shelter should break the water flow so that a "dead-space" or slow current area is created near it. A popular misconception is that salmonids like to swim against heavy currents. On the contrary, they prefer to rest where they don't have to exert themselves too much. As unlikely as it may seem, there are many "dead-spaces" among swift currents. Even the most torturous rapids will have holding areas as long as there is a structure that acts as a buffer to the current.

Fry not only prefer the shallow, slow margins of a stream, but also seek shelter that conceals them. In the shallows, woody debris such as branches, twigs, and small fallen tree limbs can provide many nooks and crannies for small fish. Where this material is absent, jumbles of large sticks and small boulders can also provide good shelter areas. Larger, older trout look for more substantial cover in the deeper areas of the stream. Undercut banks, log-jams, stumps, and boulders all offer hiding spaces for the larger fish.

Relatively shallow water can also be a holding location as long as the surface is riffled, which masks the presence of the fish. Weed beds composed of healthy aquatic plants provide additional cover for young and adult alike.

To add variety to the shelter equation, shelter can be species-specific to a certain degree. Brown trout and brook trout prefer areas with overhead cover and therefore select the margins and edges of the stream. Rainbow trout, however, are not as selective and often position themselves in mid-river if a suitable shelter or current break is available. Salmon parr prefer the cover of broken water surface (e.g. on riffles) and spaces under rocks in riffle areas.

There is an approach to assessing salmonid habitats presented in section 9 which provides additional information on the specific needs and when you need to undertake restoration.

6.3. FACTS ON FISH

The next section contains fact sheets on the following fish species found in Nova Scotia:

Atlantic Salmon
Brook Trout
Brown Trout
Rainbow Trout
Smallmouth Bass
Striped Bass
Alewife
American Eel
American Shad
Brown Bullhead
Rainbow Smelt
White Perch
Yellow Perch
White Sucker

Atlantic Salmon (Salmo salar)

One of the best-known members of the salmonid family is the Atlantic salmon which is also known as: grilse, grilt, fiddler; landlocked salmon, ouananiche and grayling (all for landlocked fish); black salmon, slink, kelt (all for post-spawning fish); smolt, parr, Kennebec salmon, and Sebago salmon.

Physical Characteristics

Salmon can vary in colour depending on the water they're in, their age, and sexual activity. In fact there are so many different physical looks in the life of a salmon that it can be confusing. What follows are some of the common colour characteristics:

Salmon in saltwater: blue, green or brown on the back and silvery on the sides and belly. On the upper body you can find several x-shaped black spots.

Salmon in freshwater: bronze-purple in colour and sometimes with reddish spots on the head and body.

Spawning males: these fish develop a hooked lower jaw (kype)

Salmon finished spawning (kelts): very dark in colour

Facts on Salmon

The name salar comes from the Latin "salio" whish means to leap. The Atlantic salmon can make leaps 3.7 m (12 ft) high and 5 m (16.3 ft) long!

Atlantic salmon are mentioned in the Magna Carta.

In the wild about 1 in 10 young salmon survive to become smolts and in many rivers fewer than 1 in 25 of those will return to spawn.

Most grilse are male.

Biologists can "read" the scales of salmon to determine how old they are, how many years they spent in fresh water, how many years they spent at sea and at what ages they spawned.

Young salmon (parr) in freshwater: 8 to 11 dark bars on the side with a red spot between each one.

Young salmon leaving fresh water for the sea (smolts): silvery in colour and usually about 12 to 20 cm (5-8 in) long.

Atlantic salmon can be easily confused with both brown trout and rainbow trout. However there are several characteristics that can help you distinguish the different species. Rainbow trout have a rows of spots on the tail (caudal) fin that is not found in salmon and brown trout have a reddish colouring on the adipose fin (the small fin in front of the tail on top of the body). Some of the different characteristics can be observed on the following pages in the line drawings.

Salmon Sizes

Sea-run salmon - can be as big as 1.5 m (59 in) and 36 kg (79 lb) but most are 9 kg (20 lb) or less.

Biggest known fish ever caught in Canada: a 25.1 kg (55 lb) fish caught in the Grand Cascapedia River, Quebec.

After two winters at sea: 2.7 to 6.8 kg (6-15 lb).

After one winter at sea (grilse): 1.4 to 2.7 kg (3-6 lb)

Landlocked Atlantic - 0.9 to 1.8 kg (2-4 lb). However a 16.1 kg (35.5 lb) specimen was taken in Sebago Lake, Maine over 50 years ago.

Distribution

Atlantic salmon are native to the North Atlantic Ocean and coastal rivers and can be found on both sides of the ocean including parts of Russia, Portugal, Iceland, and Greenland. In Canada and the U.S. they can be found from Northern Quebec and Labrador to the Connecticut River. Due to over fishing and the destruction of habitat, salmon no longer can be found in much of its original range and the numbers of fish have seriously declined. As an example, since the late 1800's, there has been no salmon in Lake Ontario. Landlocked populations of Atlantic salmon exist in some lakes of eastern North America, particularly in Newfoundland, Labrador and Quebec.

Natural History
Atlantic salmon spend part of their life feeding and growing during long migrations in the sea, and then return to reproduce in the fresh water stream where they hatched. This type of pattern, moving from the sea to freshwater, is described as being **anadromous**.

Atlantic salmon that are ready to spawn begin moving up rivers from spring through fall. These spawning runs are surprisingly consistent and occur at the same time each year for each river. Salmon populations are often spoken of as "early run" or "late run". Salmon travel long distances, as much as 500 km (312 mi) upstream and are known for their ability to leap small waterfalls and other obstacles. During this journey, the salmon does not eat, though it rises readily to an artificial fly. Landlocked salmon living in lakes move up into tributary streams to spawn.
Spawning occurs during October and November usually in gravel-bottom riffles at the head or tail of a pool. The female looks for places where the water is seeping down into clean gravel. Spawning occurs in the evening and at night. The female digs a nest **(redd)** 15-35 cm (6-14 in) deep in the gravel by turning on her side, flipping her tail upward and pulling the gravel up until a hole is excavated. She then usually moves upstream and repeats the whole process. After the female and male spawn in the redd the 5-7 mm eggs are buried with gravel by the female and the whole process is repeated several times until the female has shed all of her eggs. Females produce an average of 1500 eggs per kilogram of body weight (700 eggs/lb). After spawning the adults (now called kelts) usually drop downstream to rest in a pool. Contrary to some stories, adults do not die after spawning. Exhausted and thin, they often return to sea immediately before winter or remain in the stream until spring. Some will survive to spawn a second time but few survive to spawn 3 or more times.

Salmon eggs develop slowly (about 110 days) over the winter while water flowing through the nest keeps the eggs clean and oxygenated. In most of our rivers the eggs survive quite well and are protected from freezing or silt. The eggs hatch in the spring, usually April, and the young salmon (alvins) remain buried in the gravel for up to 5 weeks while they absorb the large yolk sac. It's at this stage that many young fish are lost. Over the winter silt and sand often move

Fishing Facts

The Atlantic salmon has been prized for centuries, both commercially and for sport. However, dam construction in rivers has blocked access to many spawning streams and siltation has destroyed many others.

In addition pollution, acid rain, over fishing and poaching have all contributed to a drastic decline in ·Canada's Atlantic salmon stocks.

Today, except for small fisheries in Quebec and Labrador, ·Canada's commercial fishery is closed. Recreational fisheries are very closely regulated, and "hook and release" angling is increasingly promoted.

Through salmon enhancement programs biologists and local community groups are working to restore the production potential of many salmon rivers.

into the nest and can trap the young fish. If they make it through this stage, the young salmon that emerge are about 2.5 cm (1 in) long in May or June.

During this freshwater stage before they migrate to sea they are known as parr. Salmon parr are territorial and feed during the day. They eat mainly water insects but will also eat other invertebrates when available. Young salmon usually live in shallow riffle areas 25 to 65 cm (10-26 in) deep that have gravel, rubble, rock, or boulder bottoms. Salmon parr may be eaten by many kinds of predators including trout, eels, other salmon, mergansers, kingfishers, mink and otter. During their first winter the parr stay under rocks on the bottom of the stream.

After two or three (but anywhere from 2 to 8) years in fresh water salmon parr turn into smolts and prepare for life in salt water. In the spring, these parr become slimmer and turn silvery. During the spring run-off, as water temperatures rise, smolts form schools and migrate downstream at night. It is during this downstream migration that smolts "learn" or become imprinted with the smell or other features of their particular river.

More Facts on Salmon

Salmon have been reared in hatcheries for decades to provide smolts for river stocking programs.

Today they are commercially farmed in large ocean pens, a rapidly growing industry in Atlantic Canada.

At sea salmon are known to travel long distances. Many salmon from Maritime rivers travel as far as the western coast of Greenland where the waters are rich in food. Here, salmon grow rapidly, feeding on crustaceans and other fishes such as smelt, alewives, herring, capelin, mackerel, and cod. Salmon will stay at sea for one or more years. The salmon will spend only one year at sea are smaller and called grilse when they return to freshwater to spawn. At sea, salmon are eaten by cod, pollack, swordfish, tunas and sharks but have been known to live to 11 years.

Brook trout (Salvelinus fontinalis)

This salmonid is also called speckled trout, brook charr, brookie, lake trout, square tail, sea-trout, Eastern brook trout, native trout, coaster, and breac.

Physical Characteristics

The brook trout is a handsome fish. Like salmon, their colour varies depending on the water they are in and their sexual activity. Here are some of the common characteristics:

Adult in freshwater: green to dark brown and black on the back and sides. Light-coloured wavy lines on upper back, dorsal fin and upper part of the caudal (tail) fin. Red spots surrounded by blue halos and many light spots are usually present on the sides. The belly is lighter, white to yellow in females, or reddish in males. The leading edges of the lower fins have a bright white border followed by a black border and reddish coloration.

Facts on Brook Trout

Larger brook trout that live in northern waters sometimes eat small mammals such as mice, shrews and voles.

A 61 cm (24 in.) sea-run trout that weighed 3.4 kg (7.5 lb) was caught in Halifax ·County Nova Scotia in 1871.

It can be seen today in the Nova Scotia Museum.

During spawning: colours intensify and males can become a deep orange-red on the belly.

Adult in saltwater: silvery on the sides and dark blue or green on the back. Pale red spots may be visible on the sides as well as the white leading edge on the fins. When returning from the sea these trout regain their freshwater colours.

Young brook trout or parr: 8 to 10 dark vertical bars (called parr marks) on the sides.

The largest "brookie" on record was taken in Ontario in 1915 weighing 14.5 lb (6.6 kg) and 34 in (86 cm) long. Brookies in Nova Scotia typically range from 15-35 cm (6-14 in) long.

Distribution

The brook trout is native to eastern North America from the Atlantic seaboard to Massachusetts, south along the Appalachian Mountains, west to Minnesota and north to Hudson Bay. It is found in a range of waters from tiny ponds to large rivers, lakes, and salt-water estuaries. Its popularity as a sport fish has resulted in brook trout introductions throughout the world. Widely distributed throughout the Maritimes, brook trout are our most sought-after freshwater fish.

Natural History

Brook trout prefer cool clear waters of 10 to 18·C with a lot of cover. Usually they live in spring-fed streams with many pools and riffles where they can use undercut banks, submerged objects such as large rocks and stumps, deep pools, and shelter from overhanging vegetation as hiding places. Brook trout are meat-eaters (carnivorous). They eat mostly water and land insects but will take anything they can swallow. Larger trout will eat leeches, small fish, mollusks, frogs, and salamanders.

Fishing facts

The brook trout is the most popular sport fish in the Atlantic Provinces. It is taken with spinning tackle, live bait or flies.

Unfortunately many natural populations of brook trout in Nova Scotia have declined. They are vulnerable to over fishing and human practices that affect their habitat. For example, siltation can smother developing eggs, dams can block access to spawning areas, or the loss of trees along a stream bank can reduce shade and cause summer water temperatures to get too high.

Brook trout have been reared in hatcheries for over a hundred years. Hatchery trout are widely stocked in natural waters to supplement "wild" populations or to introduce the brook trout to new areas. Sometimes trout are stocked in small ponds or lakes near urban areas to provide "put and take" sport fisheries.[8]

Brook trout in Nova Scotia spawn in October and November in shallow, gravelly areas of streams where there is a clean bottom and good water flows. Spring-fed headwaters are ideal but they'll also spawn in the gravel-bottomed areas of lakes where spring waters occur. The female digs a nest (redd) 10-15 cm (4-6 in) deep in the gravel with her body. After the eggs have been laid and fertilized, they are covered and left to develop slowly over the winter. A 25 cm (10 in) female trout can produce about 500 three to five mm eggs. Water flowing through the redds keeps the eggs clean and oxygenated. Hatching occurs in the spring and the larvae (alvins) remain still and undisturbed in the gravel while they absorb the large yolk-sac.

Young trout (fry) emerge from the gravel at a length of 2.5-3.5 cm and begin feeding on aquatic insects. They prefer shallow areas where the temperatures are 11-15·C and where rubble (rocks of 10-40 cm (4-16 in)) on the stream bottom provides cover. At the end of their first year, brook trout in Nova Scotia are 5-10 cm (2-4 in) long. Their growth depends very much on local conditions. Brook trout living in larger rivers and lakes would probably be 25 or 30 cm (10-12 in) at age 3, but those in small streams might only reach a length of 15 cm (6 in). Trout usually mature at three years old and rarely live past age 5.

Some populations of brook trout migrate to sea for short periods. They move downstream in the spring or early summer and remain in estuarine areas where there's lots of food. After about 2 months they return to freshwater. Brook trout probably migrate to sea in response to crowded conditions, low food supplies, or unfavourable temperatures in their home waters. Some over-winter in estuaries, and there are shore movements along our coast. Not all fish in a population migrate nor do they necessarily go every year. Sea-run brook trout live longer and grow larger than strictly freshwater trout. Brook trout predators include mergansers, herons, kingfishers, mink, owls, osprey, otter, perch, eels, and other trout.

Brown Trout (Salmo trutta)

The brown trout is also a salmonid and is known as German brown trout, German trout, Lochleven trout, European brown trout, or brownie.

Physical Characteristics

"Brownies" get their name from the brown or golden brown on their backs. Here are some of their other characteristics:

- their sides are silvery and bellies are white or yellowish • dark spots, sometimes encircled by a pale halo, are plentiful on the back and sides
- spotting also can be found on the head and the fins along the back
- rusty-red spots also occur on the sides
- the small top fin in front of the tail has a reddish hue
- sea-run brown trout have a more silvery coloration and the spotting is less visible.

Facts on Brown Trout

Apart from moving upstream to spawn, adults tend to stay at the same station in a river with very little movement to other areas of the stream areas. They can be found at these stations day after day, even year after year!

The closest relative of the brown trout is the Atlantic Salmon (Salmo salar). The brown trout's name (Salmo trutta) means salmon trout.

The largest brown trout ever taken was hooked recently in Arkansas, U.S weighing just over 40 pounds.

They closely resemble Atlantic salmon and rainbow trout but the salmon has no red coloration on the adipose fin and the rainbow trout has distinct lines of black spots on the tail. Young brown trout (parr) have 9-14 dark narrow parr marks along the sides and some red spotting along the lateral line.

Brown trout can grow to be quite large, especially sea-run fish. Brown trout weighing up to 31 kg (68 lb) have been recorded in Europe and a specimen weighing 13 kg (28.5 lb) was caught in Newfoundland. Typically they range from 2.3 to 3.2 kg (5-7 lb) but reach 5.9 kg (13 lb) in Guysborough Harbour.

Distribution

Brown trout naturally occur throughout Europe and western Asia. They range from Finland south to North Africa, west to Iceland and as far east as Afghanistan. Introduced throughout the world, they were first placed in Canadian waters in 1890. Today they are well established in rivers, lakes and coastal areas in much of North America and are found in all Canadian provinces except Manitoba, Prince Edward Island, and the Northwest Territories. Sea-run populations occur in Atlantic Canada and Quebec.

Brown trout are well established in several Nova Scotia watersheds. They are no longer being stocked in areas that they inhabit. Nova Scotia brown trout come from German and Lochleven (Scotland) ancestral stocks.

Fishing Facts

Brown trout prefer very similar habitats to our native brook trout except that they can tolerate slightly higher temperatures. They often use the lower reaches of rivers and streams where it is unsuitable for brook trout.

Biologists thought the brown trout out-competed and displaced the native brook trout and stocking programs were discontinued.
Brown trout do live longer and grow larger than brook trout. They have become quite popular with anglers and are caught in estuaries with lures and streamer-type flies. There is no commercial fishery.

Natural History

Brown trout prefer cool clear rivers and lakes with temperatures of 12-19·C. They are wary and elusive fish that look for cover more than any other salmonid. In running waters they hide in undercut banks, instream debris, surface turbulence, rocks, deep pools and shelter from overhanging vegetation. Brown trout are meat-eaters (carnivorous). They eat insects from water and land, and take larger prey such as worms, crustaceans, mollusks, fish, salamanders, and frogs as their size increases.

Brown trout spawn in the fall and early winter (October to February) at the same time or later than brook trout. They return to the stream where they were born, choosing spawning sites that are spring-fed headwaters, the head of a riffle or the tail of a pool. Selected sites have good water flows through the gravel bottom. The female uses her body to excavate a nest (redd) in the gravel. She and the male may spawn there several times. A 2.3 kg (5 lb) female produces about 3400 golden coloured eggs that are 4-5 mm in diameter. Females cover their eggs with gravel after spawning and the adults return downstream. The eggs develop slowly over the winter, hatching in the spring. A good flow of clean well-oxygenated water is necessary for successful egg development.

After hatching the young fish (alvins) remain buried in the gravel and take nourishment from their large yolk-sacs. By the time the yolk-sac is absorbed, water temperatures have warmed to 7-12·C. The fish (now known as fry) emerge from the gravel and begin taking natural food.

Brown trout fry are aggressive and establish territories soon after they emerge. They are found in quiet pools or shallow, slow flowing waters where older trout are absent. They grow rapidly and can reach a size of 165 mm (6.5 in) in their first year.

Yearling brown trout move into cobble and riffle areas. Adults are found in still deeper waters and are most active at night. They are difficult to catch and are best fished at dusk. Brown trout living in streams grow to about 1.8 kg (4 lb) but lake residents and sea-run fish grow larger. Most mature in their third to fifth year and many are repeat spawners.

In sea-run populations, brown trout spend 2-3 years in freshwater then migrate downstream to spend 1 or 2 growing seasons in coastal waters near the river mouth. There they feed on small fishes and crustaceans. Most return to their home streams to spawn but some straying occurs. Brown trout live up to 14 years and can spend as long as 9 years in the sea.

Rainbow Trout (Oncorhynchus mykiss)

This member of the salmonid family is also called Steelhead, Kamloops trout, steelhead trout, silver trout, or coast rainbow trout.

Physical Characteristics

Like most other members of the salmonid family, the appearance of rainbow trout varies.

Adults in freshwater: colour varies from metallic blue to green or yellow-green to brown on the back becoming silvery on the sides and light on the belly. Many small black spots cover the head, back, sides and fins, and spots on the tail are in obvious rows. The adipose fin (small fin in front of the tail on the back) has a black border. Mature fish have a distinctive rosy stripe along the side that extends from the gill cover to the caudal fin.

Facts on Rainbow Trout

The largest rainbow trout was caught in Alaska in 1970 and weighed 19.10 kg (42 lb).

The rainbow trout is commonly used as a laboratory animal for water quality testing.

Adults in saltwater: sea-run rainbow trout (steelheads) are more silvery in colour, may lack the rosy stripe, and show less spotting on the sides.

Young rainbow trout (parr): have 5-13 well-spaced dark parr marks on the sides and show less spotting on the body than adults.

Rainbow trout may look very similar to Atlantic salmon and brown trout, but can be distinguished by the regular rows of spots on the tail, the lack of any coloured spots and the absence of red in the adipose fin.

Rainbow trout can grow as big as 25.8 kg (57 lb) but in Nova Scotia usually grow up to 2.7 kg

(6 lb).

Distribution

Rainbow trout are actually native to the eastern Pacific Ocean and fresh waters of western North America. They naturally ranged from Mexico to Alaska and inland to the Rockies. However, they have been widely introduced throughout the world, and now occur across central North America to the eastern coast. Rainbow trout were first introduced to Atlantic Canada in the late 1800's. Today they are stocked in rivers and lakes throughout Nova Scotia and are known to reproduce in the Bras d'Or Lake watershed.

Natural History

Different populations of rainbow trout may have very different life history patterns. Rainbow trout may live in lakes or ponds, they may be stream dwellers or they may spend part of their lives at sea before returning to freshwater (anadromous) to reproduce.
They prefer water temperatures of 12-18·C and do well in clear, cool, deep lakes or cool, clear, moderately-flowing streams with abundant cover and deep pools. They spawn in the spring (usually from March to May in Atlantic Canada) in small tributaries of rivers, or in inlets or outlets of lakes. Rainbow trout usually home to the streams where they hatched.

Fishing Facts

A popular sport fish, rainbow trout are fished with wet and dry flies, lures or natural bait.

The flesh is tasty and may be prepared many ways.

Rainbow trout have been reared in hatcheries for decades to support stocking programs. They are also reared commercially in ponds for food and for sport, and more recently in salt water pens.

Spawning occurs in shallow riffles with gravel bottoms. The female uses her body to dig a nest (redd) in the gravel. One or two males will spawn with her in the nest, after which she buries the fertilized eggs. She repeats this process until all her eggs are used. Most female rainbow trout produce about 1,000-4,000 eggs. The eggs are 3-5 mm in diameter and hatch in 4-7 weeks depending on the temperature. In another 3-7 days the young absorb the yolk sac and emerge from the gravel.

The young of lake-dwelling fish may move into the lake by the end of their first summer. Some stay in a tributary up to 3 years before entering the lake. Young rainbow trout seek cover and prefer slow- moving shallow stream areas where rubble, rocks, instream debris and undercut banks provide shelter. Older trout move into faster and deeper stream waters. Rainbow trout that migrate to sea (steelheads) spend from 1-4 years in freshwater before they transform into smolts to prepare for life in salt water. Rainbow trout smolts lose their parr markings and become silvery. They migrate to sea in spring and remain there for a few months to several years before they return to fresh water.

Rainbow trout take a wide variety of foods, but in freshwater they eat mainly insects, crustaceans, snails, leeches, and other fish if available. At sea they eat mainly fish, crustaceans, and squid. Rainbow trout growth varies widely depending on their habitat, diet and life history pattern. Generally fish that go to sea or live in large productive lakes, grow largest and live longer. Rainbow trout usually mature at ages 3 to 5 at sizes that range from 15-40 cm (6-16 in) long. Many will spawn repeatedly. Rainbow trout can live to 11 years.

Smallmouth bass (Micropterus dolomieui)

This fish, a member of the sunfish family is also called northern smallmouth bass, smallmouth black bass, black bass, and brown bass.

Physical Characteristics

The smallmouth bass has the following characteristics:

- A robust, slightly laterally compressed fish
- Its colour varies from brown, golden brown, olive to green on the back becoming lighter to golden on the sides and white on the belly
- It has 8-15 narrow, vertical bars on the sides and dark bars on the head that radiate backwards from the eyes
- Its head is relatively large, with a large red, orange, or brown eye
- Its lower jaw protrudes
- Its two dorsal fins are joined; the front one is spiny and the second one has 1 spine followed by soft rays
- Its pelvic fins sit forward on the body below the pectoral fins
- Three spines border the front of the anal fin and a single spine is found on each pelvic fin
- Young fish have more distinct vertical bars or rows of spots on their sides and the caudal or tail fin is orange at the base followed by black and then white

Facts about Smallmouth Bass

Some male smallmouth bass return to the same nest year after year; over 85% of them build their nest within 138 m (150 yd) of where they nested in earlier years.

The world record smallmouth bass was caught in Kentucky, U.S.A. in 1955 and weighed 5.4 kg (11.9 lb). It measured 68.6 cm (27 in) long and 54.9 cm (21.7 in) in girth.

They have been seen "sunning" in pools with water temperatures of 26.7· C.

Smallmouth bass can reach over 4 kg (9 lb) in parts of central Canada but usually don't exceed 1.1 kg (2.5 lb) in Nova Scotia.

Distribution

The smallmouth bass is a freshwater fish originally found in lakes and rivers of eastern and central North America. As a result of widespread introductions, it now ranges from southern Nova Scotia and New Brunswick, south to Georgia, west to Oklahoma, north to Minnesota, west to North Dakota and east from southern Manitoba to Quebec. It also occurs in a few areas of western North America and has been introduced in Europe, Asia, and Africa.

Natural History

Smallmouth bass prefer clear, quiet waters with gravel, rubble, or rocky bottoms. They live in mid-sized, gentle streams that have deep pools and abundant shade, or in fairly deep, clear lakes and reservoirs with rocky shoals. Smallmouth bass tend to seek cover and avoid the light. They hide in deep water, behind rocks and boulders, and around underwater debris and crevices. Smallmouth bass prefer temperatures of 21-27· C. As temperatures fall, they become less active and seek cover in dark, rocky areas. In the winter they cease feeding, remain inactive on the bottom, staying near warm springs when possible.

Spawning takes place from late May to July in shallow (usually 0.3-0.9 m (1-3 ft) deep) protected areas of lakes and rivers, when the water temperature is 16 to 18· C. The male prepares a nest on a sandy, gravel or rocky bottom by cleaning an area 0.3 to 1.8 m (1-6 ft) in diameter. He defends the nest from other males and attracts a series of females into the nest to spawn. After spawning the female leaves and the male remains to guard the nest and fan the eggs. Females usually produce from 5,000 to 14,000 eggs, depending on their size. The eggs are from 1.2-2.5 mm in diameter and stick to stones in the bottom of the nest.

The young are about 5.8 mm long when they hatch in 4-10 days depending on the temperature. Hatching success can vary a lot. Sudden changes in temperature or water level can cause the eggs to die from shock or cause the male to abandon the nest, leaving it open for predators. After hatching, the male remains with the young for another 3-4 weeks while they absorb the yolk sac and begin to leave the nest.

Young fish tend to stay in quiet, shallow areas with rocks and vegetation. They begin feeding on plankton (tiny organisms suspended in the water), and switch to larger prey like water insects, amphibians, crayfish, and other fish as they grow. (Crayfish are native to New Brunswick but are not found in Nova Scotia). Two-year old bass are about 12.7 cm (5 in) long.

Older bass prefer rocky, shallow areas of lakes and rivers and retreat to deeper water at high water temperatures. Most bass do not travel great distances and those in streams spend all season in the same pool. Smallmouth bass mature at ages 3-6 when they are about 17 to 28 cm (6.7-11 in) long. Males usually mature a year earlier than females. They are known to live 15 years.

Some smallmouth bass predators are yellow perch, sunfishes, catfishes, white suckers and turtles.

Fishing Facts

Smallmouth bass are a fish of great sporting quality that have been popular with anglers since the early 1800's.

This popularity led to widespread introductions and the culture of smallmouth bass. It was harvested commercially until the 1930's but over-fishing led to its restriction as a sport fish.

Smallmouth bass can be taken with wet or dry flies, by trolling or casting with live bait or lures, or still fishing with crayfish, minnows or frogs.

Striped Bass (Morone saxatalis)

Other common names for this fish include: striper bass, striped sea bass, and striper.

Physical Characteristics

Striped bass have the following characteristics:

- A long, laterally compressed fish
- Its colour is olive green to blue or black on the back; the sides are pale to silvery (sometimes with brassy reflections); its belly is white
- It has 7-8 dark horizontal stripes on the sides
- Both eyes and mouth are relatively large and the lower jaw protrudes
- The pelvic fins sit forward on the body below the pectoral fins
- The first dorsal fin (on the back) is spiny and the second has one spine followed by several soft rays
- A single spine lies at the front of each pelvic fin and three short spines precede the anal fin
- Young often lack stripes and have 6-10 dusky bars on the sides

Striped bass have been recorded as large as

Facts about Striped Bass

A striped bass weighing 28.6 kg (62.9 lb) was caught near Reversing Falls in the Saint John River, New Brunswick in 1979.

The world record (angling) striped bass weighed 35.6 kg (78 lb) was caught at Atlantic City, New Jersey in 1982.

A striped bass tagged and released in the Saint John River, New Brunswick was recaptured 36 days later in Rhode Island, U.S.A. 805 km (503 mi) away! (22.4km/day 14 mi/day)

After fertilization striped bass eggs swell to about three times their original diameter to a size of 3.6 mm.

Surveys show the average striped bass angler on the Annapolis River, Nova Scotia spends about 50 hours on each fish caught.

56.7 kg (124.7 lb) North Carolina, 1891). However most striped bass caught are 13.6 kg (30 lb) or less.

The short (less than half the fin length) anal fin spines and body stripes distinguish striped bass from white perch, the other member of the temperate bass family found in Maritime waters. The white perch lacks stripes and 2 of its anal spines are longer than half the fin length.

Distribution

The striped bass is a coastal species found in rivers, estuaries, and inshore waters of eastern North America from the St. Lawrence River and southern Gulf of St. Lawrence to northern Florida, as well as the northern coast of the Gulf of Mexico. It was introduced on the Pacific coast of North America over 100 years ago, where it now ranges from California to southern British Columbia. Striped bass have been introduced and become established in some landlocked lakes in the southern and central U.S.

Striped bass have been introduced to parts of Europe and Asia.

Fishing Facts

Historically valued both for food and for sport, stocks of striped bass have been declining since the 1970's. This is probably due to a combination of over fishing, habitat destruction, pollution and natural population cycles.

The striped bass is becoming a popular sport fish in ·Canadian waters and can be caught by casting, trolling, jigging, and fly fishing. They are fished in the surf or along shorelines and estuaries wherever schools of small food fishes are found and best fishing is often in the evening at high tide. Striped bass can be fished with live bait, lures (bucktails, Rapalas), plugs and poppers (skipping bugs). Bait success depends on the location and feeding habits of bass at the time but gaspereau, eels and worms are popular.

It is not fished commercially in Nova Scotia.

Natural History

Striped bass is a schooling fish, living in the sea and returning to fresh water to spawn (anadromous). It is most common in steady-flowing, turbid rivers that have low slopes and large estuaries. During their saltwater life many striped bass make long sea migrations. However not all fish migrate and some populations do not migrate at all. Some fish remain in the estuary of their home rivers.

Striped bass spawn in May and June after moving upriver the previous fall, usually at water temperatures of 14 to 22· C. The length of this journey can vary from a long journey inland to just above the head of tide. Striped bass sometimes spawn in brackish water.

Striped bass produce many eggs. In fact, more than three million have been recorded for a 22.7 kg (50 lb) female! About 100,000 eggs is more typical of bass in our rivers. Striped bass spawn near the water surface in water 0.3-6.1 m (1-20 ft) deep. The eggs have a large oil globule and are semi-buoyant. Ideally the current that prevents them from getting silted over and smothered on the bottom carries them along. The eggs hatch in 2-3 days depending on the temperature (15-18.6·C).

Newly hatched fish are about 5 mm long. After absorbing yolk-sac, they feed on zooplankton (tiny invertebrates suspended in the water).

Striped bass are carnivores and take progressively larger prey as they grow. They eat a variety of invertebrates such as insect larvae, marine worms, and crustaceans as well as many kinds of schooling fishes, especially herring and gaspereau.
Adults feed most actively just after sunset and just before dawn and can be seen moving in with the tide, rolling and flashing as they feed on smaller fish. Canadian striped bass grow fairly rapidly and can be 14.5 cm (5.7 in) at age 1. They usually mature at age 3-6 years when they are about 34-53 cm (13.4-21.7 in) long. Males usually mature a year earlier than females, but do not live as long. Striped bass can live to 31 years.

Other fish such as Atlantic tomcod, Atlantic cod, silver hake and larger striped bass eat small striped bass. Adult striped bass have few predators except humans.

Young striped bass form schools and spend their first two or three years in the lower reaches of rivers and in estuaries, preferably where there is a sand and gravel bottom and some current. After this period, many leave their home waters and make long sea migrations along the Atlantic coast. Striped bass populations from North Carolina to the Bay of Fundy are typically migratory and travel in large schools moving north in the summer and south in the winter. They probably return to their home rivers when they reach sexual maturity and are ready to spawn, however mature fish do not necessarily return every year to spawn. In general, most migrating striped bass are female. Some of the large striped bass caught along the Maritime coasts probably originate from U.S. rivers.

Striped bass populations go through cycles. Every so many years the young-of-the-year offspring survive in particularly high numbers and become what is called a dominant year class in the population. Year class success is probably determined in the first two months of life and may be related to environmental conditions during this period.

Alewife (Alosa pseudoharengus)

Common names for the alewife are gaspereau, river herring, sawbelly, or kiack.

Physical Characteristics

The alewife is a member of the herring family. Here are some things to look for:

• A slender, laterally compressed fish coloured greyish-green on the back, and silvery on the sides and belly

• Gasperaux entering freshwater are often copper-tinged

• A single black spot is present on each side, just behind the head

• The eye is relatively large and has an obvious eyelid

• A row of scales, known as scutes, form a sharp edge along the mid-line of the belly which is how the alewife came to be called "sawbelly".

The alewife in Nova Scotia is usually 25-30 cm (10-12 in) long and weighs up to 340 gr (12 oz). There is no lateral line.

Facts on Alewife

Alewife eggs, or roe, are canned and sold as a delicacy.

Despite the many thousands of eggs laid by spawning alewife very few offspring actually survive. In some populations as few as three young-of-the-year fish migrate downstream for each female that spawned.

Another species known as the blueback herring is very difficult to distinguish from the alewife. They inhabit the same watersheds and have similar natural histories. Many reports of alewife probably include the blueback herring as well.

Distribution

The alewife is found in rivers and lakes along the eastern coast of North America from Newfoundland to North Carolina and the adults live in coastal marine waters 56-110 m (180-350 ft) deep. Landlocked populations exist in several Ontario and New York lakes. Since the Welland Canal was built in 1824, the alewife has spread throughout the Great Lakes.

Fishing Facts

During the spawning runs commercial fishermen set large trap nets or enclosures called weirs in coastal rivers and estuaries to catch migrating alewives. Major Canadian fisheries are on the Shubenacadie, Miramichi, and Saint John Rivers.

The catch is used for fishmeal, lobster bait, pet food or it is smoked, canned, salted or pickled. Although tasty, alewives are not favoured locally for human consumption due to their large number of bones.

Natural History

In the Maritimes the alewife spends most of its life growing in salt water feeding mainly on zooplankton, tiny invertebrates, that live in the water column. Each spring from April to July large runs of adult alewives migrate up coastal rivers to spawn in freshwater lakes, ponds and streams (this movement from sea to freshwater makes the alewife an anadromous fish).

Alewives also spawn in brackish water. Like trout and salmon, alewives use their sense of smell to return to the streams and lakes where they hatched or near by watersheds. Female alewives usually begin spawning at age 4, repeat spawn each following year and may live to be 10. Male alewives often mature a year earlier than females. About 75% of alewives entering Nova Scotia rivers are repeat spawners. Alewives can move into coastal areas in late winter but will not migrate into fresh water until river temperatures begin to warm. Males enter the river first. Alewives only migrate into freshwater during daylight hours. However spawning occurs at night and can occur in standing, slow moving or fast mid-river water. A single female can lay as many as 200,000 eggs.

After spawning the adults begin the downstream migration to the sea within a few days.

Alewife eggs are about 1mm in diameter and are left to lie on the bottom or float with the current. Depending on the water temperature, the eggs hatch in about a week. After the yolk-sac is absorbed the tiny, larval fish stay near the spawning grounds preferring shallow, warm and sandy areas. They feed on tiny species of zooplankton. From August to October young-of-the-year, (sizes from 32-152 mm (1.25-6 in) migrate downstream in large groups or schools to live in estuaries and coastal areas. Adults over winter at sea in the George's Bank, Gulf of Maine or Nantucket Shoals and as far south a Florida. Alewives can live at least 10 years.

Alewives are eaten by many species of fish and birds including striped bass, salmonids, smallmouth bass, eels, perch, bluefish, weakfish, terns and gulls.

American Eel (Anguilla rostrata)

Physical Characteristics

The American eel has a long snake-shaped body. It has no pelvic fins and the fins along the top of the body are continuous. The body is covered with mucus, which is where the expression "slippery as an eel" comes from. Their colour changes as they grow up and there are different names for eels at these different stages.

"Glass eels" are young eels approaching the shore at sea. Their bodies are transparent with a distinct black eye.

"Elvers" are eels that are just adapting to fresh water and are greyish-green in colour.

"Yellow eels" are adults in freshwater. Their colour varies from yellowish to greenish to olive-brown, being darker on the back and lighter on the belly.

Fishing Facts

Commercial fishermen harvest silver and yellow eels with many kinds of gear including weirs, traps, otter trawls, nets, handlines, eel pots and spears.

Eels are sold for human consumption and as bait for other fisheries. Many are shipped fresh or frozen to Europe where they are considered a delicacy and served smoked or jellied.

Elvers have been harvested for use in pond culture and grow-out operations. The American eel is caught by recreational fishermen.

"Silver, bronze, or black eels" are sexually mature eels which darken to a bronze-black hue on the back with silver underneath.

American eels can grow to a size of 1270 mm (50 in) and weigh up to 4.5 kg (10 lb).

Distribution

American eels are found in freshwater streams and rivers, brackish coastal waters and the Atlantic Ocean of eastern North America from southern Greenland and Labrador to the Gulf of Mexico and northern South America. It is the only member of the freshwater eel family found in North America and is wide spread in the Maritime Provinces.

Natural History

The American eel goes on long oceanic migrations to reproduce. Unlike fish such as Atlantic salmon and alewife that return to freshwater to spawn, eels are catadromous, which means they spend most of their lives in freshwater lakes and streams, returning to sea to spawn. No one has ever seen American eels spawn but it is believed to occur in the Sargasso Sea, east of the Bahamas.
Spawning occurs from February through April and hatching probably occurs within a few days. The tiny transparent eel larvae (known as leptocephali), only a few millimetres long, drift with ocean currents to the coastal areas of North America. They grow rapidly until the fall.

Once they are between 8-12 months old and about 55-65 mm (2.1- 2.6 in) long they transform into glass eels. At this stage, eels actively migrate toward freshwater. As they enter brackish and freshwater they begin to develop colour and are known as elvers. Elvers and glass eels reach the Maritime coasts in April and May. At first the elvers are active at night and rest near the bottom during the day. They may stay in estuaries for some time moving up and downstream with the tide as they physiologically prepare to live in fresh water. When elvers begin to migrate upstream they become active during the day and are thought to use the current and the odour of brook water to find their way. This upstream migration can take several years with distances as far as 1000 km (600 mi) involved.

Elvers eat aquatic insects, small crustaceans and fish parts. After a year in freshwater elvers are about 127 mm long (5 in). Following this stage, eels enter a growth phase lasting many years in which they are known as yellow eels. Some eels do not migrate upstream as elvers but

Facts about Eels

Eels do not become definitely male or female until they are 20-25 cm (8-10 in) long!

What sex an eel becomes is thought to be partly determined by environmental conditions such as crowding and food abundance.

In areas (southern U.S.) where food abundance and water temperatures favour rapid growth rates, a higher percentage of male eels are found. In cooler areas, such as Nova Scotia, where eels grow more slowly but reach an overall larger size, there tends to be more females. This is an advantage since larger females produce more eggs and can contribute more offspring.

Eels can absorb oxygen through their skin and can travel overland particularly in damp, rainy weather.

remain instead to live in estuaries. Yellow eels are most active at night and spend the day concealed in vegetation or burrowed in the bottom. Their diet includes insect larvae, fish, crabs, worms, clams, and frogs. They also feed on carrion and are able to tear pieces off food items too large to be swallowed whole.

In late summer and fall some adult American eels in eastern Canada begin their spawning migration to the Sargasso Sea. During this time they change to the "silver eel" stage and become sexually mature. Males can mature at age 3 but females mature later usually at ages 4-7. However eels can spend up to 40 years in fresh water. Female eels produce from 0.5 to 4.0 million eggs. It appears that all eels die after spawning. Adult eels are eaten by larger fish such as sharks, haddock, and swordfish and also by gulls and bald eagles.

Facts on Fishing

American shad were much more abundant in the past. During the 1800's a thriving fishery for shad existed along the Atlantic coast supporting an annual catch as high as 23,000 tons (50 million pounds). Today small commercial fisheries exist but numbers have greatly declined due to over-fishing and changes in our rivers. Dams often block access to vast areas of spawning habitat. Even where fishways provide access, many young shad may not survive the downstream migration.

Shad are fished commercially in rivers during the spawning runs. The eggs (roe) are most desirable so large numbers of mature females are taken. The flesh is sold fresh and salted. Shad are angled and considered a fine game fish.

American Shad (Alosa sapidissima)

Physical Characteristics

The American shad, like the alewife (gasperau), is a member of the herring family and has the following characteristics:

- Slender and silvery-coloured with a blue-green metallic hue on the back
- Has a black spot, similar to the alewife, located on the side, just behind the head - on the shad, this spot is followed by several smaller dark spots
- The eye has an obvious eyelid
- A row of scales known as scutes form a sharp "sawbelly" edge along the midline of the belly
- There is no lateral line

American shad can grow to 76 cm (30 in) and weigh 6.8 kg (15 lb). However, adults found in Canadian rivers are usually 45 to 50 cm (18-20 in) long and weigh from 1.4 to 2.7 kg (3-6 lb).

Distribution

American shad are anadromous (moving from the sea to freshwater) fish found along the Atlantic coast of North America from Newfoundland to Florida. Large spawning runs used to occur in the Shubenacadie and Annapolis rivers (also Saint John, Petitcodiac and Miramichi) but they are found in many Maritime coastal rivers. They have been introduced along the Pacific coast and now range from Alaska to California.

Natural History

The American shad lives for several years at sea before returning to spawn in the stream where it hatched. Shad avoid cold temperatures and prefer to stay in water 8·C or warmer. Water temperature and currents determine much of their migration and behaviour.

Each spring, schools of shad, using their sense of smell, begin to migrate up coastal rivers and tributaries when water temperatures reach 12·C.

Spawning in the Maritimes occurs during June and July in water temperatures of 13-20·C. Migration stops in temperatures over 20·C. American shad do not usually travel as far upstream as the alewife. They spawn in rivers at night in mid-water in streams with a wide range of bottom types. The eggs are about 3 mm across and drift along with the current to hatch in 8-12 days depending on the temperature.

A female can produce anywhere from 60,000-600,000 eggs but shad in Canadian rivers usually produce about 130,000 eggs. Many shad in the Maritimes are repeat spawners, however shad in southern populations die after spawning.

Young shad spend their first summer in the river feeding on insects and crustaceans. They swim near the bottom in water as deep as 3.7 to 4.9 m (12-16 ft) but at night they are found near the surface. When they migrate to sea in the fall, they have grown to a size of 7.5 to 12.5 cm (3-5 in). They migrate to the sea as temperatures in the river drop.

At sea, shad live in schools and move according to the bottom temperatures, seeking areas that are 7-13· C. They stay near the bottom during the day, dispersing at night to all depths. Immature and spawned-out adults remain offshore in areas like the Bay of Fundy until winter, when they move farther out to sea in order to stay in preferred water temperatures. At sea they eat zooplankton (tiny invertebrates that live in the water), small bottom crustaceans, and occasionally small fish. Most shad mature at age 4 or 5 when they are about 48-53 cm (19-21 in) long. Shad can live up to 13 years.

Although not a major food source for other animals, shad are eaten at sea by seals, sharks, blue-fin tuna, kingfish, and porpoises. Young shad in freshwater are eaten by bass, American eels, and birds.

Brown bullhead (Ictalurus nebulosus)

Physical Characteristics

Nova Scotia's only member of the freshwater catfish family is easy to identify with its distinctive sets of whisker-like formations around the mouth. These are called barbels and the bullhead has four pairs.

The following can also identify the bullhead:

• A thick rounded body, heaviest toward the front

• A broad, large, somewhat flattened head

• Sharp, saw-toothed, spines at the base of the dorsal and pectoral fins. These spines can be "locked" in an erect position.

• The tail or caudal fin is square and there is an adipose fin (small fin on the back in front of the tail)

Facts about Bullheads

The spines at the base of the dorsal and pectoral fins can be "locked" into an erect position. This is thought to help protect the bullhead against predators, making it much harder to swallow.

Brown bullheads take many kinds of bait and can be easily caught by anglers. They are best fished with worms at dusk.

The flesh of the brown bullhead is very tasty. They are reared commercially in the southern U.S.

Brown bullheads are extremely resistant to pollution. In areas of heavy pollution they can be the only fish species present.

• Its colour is dark brown to olive green on the back ; its sides are sometimes mottled with dark blotches and the belly is cream coloured

• There are no scales but the skin has many taste glands

In Nova Scotia it seldom grows more than 30 cm (1 ft) long and 0.5 kg (1 lb) in weight. Bullheads weighing as much as 2.7-3.6 kg (6-8 lb) have been caught in Ontario.

Distribution

The brown bullhead is found in the fresh waters of eastern and central North America, from the Maritime Provinces to Florida, and westward to southern Saskatchewan, Missouri, and Texas. It occurs across southern Canada from Saskatchewan to the Maritimes. The brown bullhead has been introduced to western North America and Europe.

In Atlantic Canada the brown bullhead exists only in New Brunswick and mainland Nova Scotia.

Natural History

Brown bullheads usually live on the bottom in the shallow, weedy, mud-bottomed areas of lakes or large slow-moving streams. They tolerate higher water temperatures and lower oxygen levels than many other fish species.

They feed on the bottom at night, using their barbels to search for food. They eat a variety of foods including insects, fish eggs, leeches, mollusks, crayfish, worms, algae, plants, and small fishes. Young bullheads feed mainly on insects and plankton (tiny organisms suspended in the water).

Bullheads spawn in the late spring when water temperatures approach 21·C. One or both parents excavate a shallow nest in a protected area of mud or sandy bottom. Spawning occurs in the daytime and several thousand cream coloured eggs are deposited in the nest. The parents care for the eggs by fanning them with their fins and physically stirring them up. After hatching, the young catfish are jet black and resemble tadpoles. They swim in a "school" and are protected by their parents for several weeks until they are about two inches long.

The brown bullhead usually matures at age 3 and lives for 6-8 years. The chain pickerel and other members of the pike and perch families eat them.

Rainbow smelt (Osmerus mordax)

Other common names are Atlantic rainbow smelt, smelt, American smelt, freshwater smelt, Atlantic smelt, leefish, and frost fish.
This fish is one of two members of the smelt family found in Atlantic Canada. The other member found here is capelin.

Facts about Smelt Freshly caught smelt smell very much like cucumber! No doubt this feature is responsible for the common name "smelt". This odour disappears after preservation or freezing.

Males smelt are more abundant on the spawning grounds than females. This is probably because they can spawn up to 8 consecutive nights but females may spawn only 3 or 4 nights.

Physical Characteristics

The rainbow smelt is a small slender fish that grows to about 25 cm (10 in). It has the following characteristics:

- Olive-green on the back, becoming lighter on the sides
- Sides have a purple, pink and blue iridescence especially when freshly caught
- The belly is silvery
- Relatively large mouth with fang-like teeth and a protruding lower jaw
- The caudal (or tail) fin is deeply forked
- An adipose fin (small fin in front of the caudal fin on the top) is present
- The lateral line is incomplete
- Spawning males are covered on the head, body and fins with tiny bumps (nuptial tubercles)
- Smelt in freshwater are darker becoming almost black on the back

Distribution

The rainbow smelt is found in rivers and coastal areas of eastern North America from Labrador to New Jersey and on the west coast from Vancouver Island around Alaska to the Arctic Ocean. Landlocked populations also occur in lakes and ponds throughout the Atlantic region. They have been introduced in the Great Lakes and have increased their range to other Ontario drainages through unauthorized introductions.

Fishing Facts

Smelt are fished commercially and for sport. Winter fishing for smelt is a popular sport. Anglers take them on lines through the ice, using worms as bait. In spring, anglers dipnet or seine them in the spawning tributaries.

Commercial fisherman catch them in box nets, bag nets, gillnets or by trawling.

The largest Maritime fishery occurs in the Miramichi estuary. Smelt are sold fresh or frozen and are very tasty.

Natural History

The rainbow smelt is a schooling fish, which grows and matures in shallow coastal waters and migrates up freshwater streams to spawn (anadromous). Smelt move into estuaries in the fall and begin to move up the streams after the spring thaw.

Spawning occurs from February-June usually at water temperatures from 4-10·C). Smelt do not necessarily return to the stream of their birth to spawn, especially if there are other nearby streams. Smelt in landlocked lakes swim up tributary streams or in some cases spawn along the shoreline. Spawning occurs at night in fast moving water. Several males spawn with one female. The fertilized eggs become sticky and attach to the bottom, sometimes forming a thick layer. One female can produce as many as 93,000 eggs. After spawning the adults return to the estuary during the day but may return upstream to spawn again on subsequent nights. Some fish die after spawning. The rest leave freshwater after spawning to spend the summer in coastal waters.

Smelt eggs are about 1mm in diameter and take anywhere from 11-29 days to hatch, depending on the temperature. Smelt fry are 5 to 6 mm long when they hatch and drift downstream to brackish water. They use water depth for cover and feed near the surface at night. Young smelt feed on plankton (tiny organisms suspended in the water), and may grow to 5 cm (2in) by August.

Older fish eat larger invertebrates and other fish. Smelt grow most rapidly in their first year and can tolerate increasing amounts of saltwater, as they get older. They prefer temperatures of 6-14· C and stay close to shore, seeking cover in eelgrass beds or below the water.

Smelts in the Miramichi average 13.9 cm (5.3 in) at age 2, and 20.6 cm (8.1 in) by age 5, southern populations grow faster. Smelt in small landlocked lakes may only reach a length of 10.2 cm (4 in). Smelt usually mature at age 2 in the Maritimes and can live to age 17. Females live longer and grow larger than males.

Smelt are eaten by bluefish, striped bass, salmonids as well as birds, and harbour seals.

White Perch (Morone americana)

Oddly enough, the white perch is actually a member of the bass family and is not a true perch. Other common names for the white perch are silver perch, sea perch, silver bass, narrow-mouthed bass, and bass perch.

Facts about White Perch

The oldest known white perch lived 17 years.

The world angling record for white perch is a 2.15 kg (4.7 lb) fish taken in Messalonskee Lake, Maine in 1949.

Physical Characteristics

The white perch has the following characteristics:

- A deep, thin body that slopes up steeply from the eye to the beginning of the dorsal fin
- Colours which can be olive, grey-green, silvery-grey, dark brown or black on the back becoming a lighter green on the sides and silvery-white on the belly
- The pelvic and anal fins (both on the belly) are sometimes rosy coloured
- Like all members of the bass family it has two dorsal fins on the back and the pelvic fins sit forward on the body below the pectoral fins
- The first dorsal fin has nine spines but the second one is soft rayed • there are three spines at the front of the anal fin, and a single spine precedes the second dorsal fin and each pelvic fin
- It has many small sharp teeth
- Its scales are relatively large and the lateral line is complete

It can grow to 48.3cm (19 in) and 2.72 kg (6 lb).

It is very similar in shape to the striped bass, also found in our waters. The white perch has a deeper, less rounded body than the striped bass. The anal fin spines of the striped bass are less than one-half the fin length, but the second and third anal spines in the white perch are greater than this.

Distribution

White perch are found in fresh and brackish waters along the Atlantic coast from the southern Gulf of St. Lawrence to North Carolina and inland along the upper St. Lawrence River to the lower Great Lakes. It is present in all three Maritime Provinces.

Fishing Facts

The white perch has very tasty flesh and where it grows large enough can be a popular sport fish. They are caught on bait (worms, small minnows) lures, or streamer-type flies.

White perch are fished commercially in Chesapeake Bay, U.S. and the lower Great Lakes.

Natural History

White perch is a fish that can live in fresh or salt water and does best when summer water temperatures reach 24·C. In the Maritimes, it occurs mostly in freshwater lakes and ponds. Sea-run populations are found in some coastal rivers and estuaries.

Spring spawning takes place when water temperatures are 11-16·C, late May-late July in shallow water over many kinds of bottom. Males and females each spawn several times and the tiny 0.9 mm eggs become sticky after fertilization and attach to vegetation and bottom materials. White perch are quite prolific; a 25 cm (10 in) female can produce 247,700 eggs.

The length of time for hatching depends on the water temperature. When the water is cooler, hatching takes longer (4-4.5 days at 15·C versus about 30 hours at 20·C). Newly hatched white perch are 2.3 mm long and feed on plankton (tiny organisms in the water). They grow rapidly and can reach 65 mm (2.5 in) by late summer.

Growth rates of white perch vary among regions and populations. Few studies have been done on Maritime populations. Most perch in our waters are less than 15 cm (6 in). Larger pan-sized white perch that weigh 225 to 450 g (0.5-1 lb) are taken in some Nova Scotia lakes. Lake Ontario fish can reach 33.5 cm (13.2 in) and 780 g (1.72 lb). Even larger sizes have been reported in some U.S. waters.

White perch in lakes are known to feed both during the day and at night. Fresh and saltwater populations move to surface (or inshore) waters at night, retreating to deeper water during the day. They perch eat mostly aquatic insect larvae when they are small. As they grow, many kinds of fish such as smelt, yellow perch, killifish, and other white perch are eaten. They usually mature at 3 years and live 5-7 years.

White perch are thought to compete with some game fishes for food. In some places a lack of harvesting, either by anglers or other species of fish, can lead to large populations of stunted, small white perch. Smallmouth bass, chain pickerel, and large trout will eat white perch.

Yellow perch (Perca flavescens)

This, the only true member of the perch family in Nova Scotia, is also called perch, lake perch, and American perch.

Physical Characteristics

The yellow perch has the following characteristics:

- Its colour is black-green, to olive, to golden brown on the back and extending down the sides in tapered bars
- The rest of the sides are yellowish becoming grey to white on the belly
- It has two dorsal fins (on the back), the first one has 13-15 sharp spines, the second has only one spine followed by soft rays
- The pelvic fins with one spine sit forward on the belly almost directly below the pectoral fins
- The pectoral fins are amber-coloured and transparent whereas the pelvics are yellow to white and opaque
- Eyes are yellow to green
- The scales feel rough to the touch
- The colour of a spawning male fish intensifies; its lower fins can become orange to bright red.
- Young yellow perch are first transparent, then silvery or pale green

Facts about Yellow Perch

Occasionally yellow perch are found with the unusual colouring of grey-blue or red and the absence of dark bars on the side.

The yellow perch has been called "a good bold-biting fish" "the most extravagantly handsome of fishes" "a ravager of all smaller fish" and "bait-stealing little devils".

Students studying the anatomy of bony fishes most often use the yellow perch.

The yellow perch can grow to 1.9 kg (4.2 lb) but in Nova Scotia it does not exceed 30 cm (12 in) and 450 g (1 lb).

Distribution

Yellow perch can be found in freshwater of North America from Nova Scotia south along the Atlantic coast to Florida, west from Pennsylvania to Missouri, northwest to Montana, north to Great Slave Lake, southwest to James Bay and east to New Brunswick and Nova Scotia. It has been introduced widely in the south and western U.S.and has spread to southern British Columbia. Yellow perch cannot be found in Prince Edward Island, Cape Breton Island or Newfoundland. It is occasionally found in brackish water along the Atlantic coast.

Facts about Yellow Perch

The yellow perch is fished both for sport and for food. Anglers can catch them in summer and winter with fish or worms as bait. Yellow perch have been fished commercially in Canada for over a hundred years and are sold both fresh and frozen. The flesh is white and tasty.

Yellow perch are sometimes infected with the broad tapeworm (Diphyllobothrium latum) that can be transmitted to humans if the flesh is improperly cooked.

Natural History

The yellow perch is a schooling, shallow water fish that can adapt to a wide variety of warm or cool habitats. They are found in large lakes, small ponds, or gentle rivers but is most abundant in clear, weedy lakes that have muck, sand, or gravel bottoms. They prefer summer temperatures of 21-24· C. Yellow perch feed on aquatic insects, crustaceans, and a variety of fishes and their eggs.

Spawning occurs from April through July, but usually during May in Nova Scotia, at water temperatures of 9-12·C. The adults move into shallow areas of lakes or up into tributary streams. Males are first to arrive and the last to leave. Yellow perch spawn at night or in early morning, most often in areas where there is debris or vegetation on the bottom.

The female perch sheds her eggs in a long jelly-like spiral or accordion-folded strand. Several males fertilize the eggs during spawning. The egg mass can be as much as 2.1 m (7 ft) long, 51-102 mm (2-4 in) wide and weigh 0.9 kg (2 lb)!

Females produce an average of 23,000 eggs but have been known to shed up to 109,000 eggs. The egg masses are semi-buoyant and attach to the vegetation or bottom material. They receive no parental care and can be cast ashore during storms or eaten by predators. Yellow perch eggs are 3.5 mm in diameter and hatch in 8-21 days, depending on the temperature. Newly hatched perch are about 5 mm long.

Young perch grow quickly and remain near the shore during their first summer, swimming in large schools that often include other species. Perch in Nova Scotia waters do not grow as large as those living in the warmer, larger, or more productive habitats of central Canada. In general northern populations grow more slowly but live longer, and females grow faster than males.

Adults move in schools farther offshore than the young. They move between deeper and shallow water in response to changing food supplies, seasons, and temperatures. Perch feed in the morning and evening, taking food in open water or off the bottom. At night they rest on the bottom. Yellow perch remain active and feed during the winter.
Yellow perch can outbreed and out-feed speckled trout or other fish in a lake. This can sometimes lead to an overpopulation of small, stunted fish (less than 15 cm (6 in).

Other fish such as smallmouth bass, chain pickerel, and lake trout eats yellow perch. Birds like mergansers, loons, kingfishers and gulls also take them.

White Sucker (Catostomus commersoni)

This fish, the only member of the sucker family found in Nova Scotia, is also called the common sucker, common white sucker, eastern sucker, sucker, black sucker, mud sucker, mookie and muckie.

Fishing Facts
The flesh of the white sucker is bony but can be very tasty, particularly when hot-smoked.

Young suckers are sold as bait but there is little other commercial interest in the species. Suckers should not be used as bait in lakes that do not already contain suckers.

White suckers are not a popular sport fish but they can be caught on wet flies, small spinners and small hooks baited with dough balls or worms.

Physical Characteristics

The white sucker has the following characteristics:

- A torpedo-shaped fish distinguished by its sucker-like mouth located on the underside of its blunt, rounded snout
- Its mouth has thick lips covered with little fleshy bumps (papillae)
- Its colour varies from grey to coppery brown to almost black on the back and upper sides, becoming lighter on the lower sides to white on the belly
- During spawning, the darkness on the back intensifies and the body becomes more golden in colour
- Spawning males develop coarse bumps (nuptial tubercles)on the anal fin and lower tail (caudal) fin
- It has relatively large scales, one dorsal fin, no adipose fin and the lateral line is complete
- Young white suckers from 5 to 15 cm (2-6 in) in length usually have three large dark

spots on the sides

They can grow to 63 cm (25 in) and more than 3.2 kg (7 lb) but reach about 46 cm (18 in) in Nova Scotia.

Distribution

The white sucker is a North American species found in freshwater lakes and streams from Labrador south to Georgia, west to Colorado and north through Alberta and British Columbia to the Mackenzie River delta. In Canada, it is absent from Newfoundland, eastern Labrador, Prince Edward Island, south-western British Columbia and much of the far north.

Facts about Suckers

Spawning migrations of white suckers can be numerous and very dense - 500 have been known to swim upstream past a single point in 5 minutes.

Although examining the growth rings on their scales ages most fish, this method is not always reliable for suckers older than 5 years. They are best aged using sections of their pectoral fin rays.

Natural History

The white sucker can adapt to a wide range of environmental conditions but generally lives in the warm, shallow waters of lakes and quiet rivers. They prefer summer temperatures of 24·C. In streams they are most abundant in pool areas with ample underwater debris, streamside vegetation, and water depth to provide cover.

In lakes they are usually found in the upper 6.2-9.2 m (20-30 ft) of water, moving to shallows to feed. They are bottom feeders that browse the bottom, sucking in aquatic insects, small clams, and snails, and then spitting out the inedible sand and gravel. They feed mostly at dawn and dusk, and are active year round.

White suckers spawn in the spring (May and June), migrating upstream to spawning areas (small streams and tributaries) when water temperatures are 10-18·C. Suckers typically spawn in shallow gravel riffles where the water is up to 30 cm (1 ft) deep and where the speed is moderate. Lake populations of white suckers with limited access to streams will occasionally spawn on gravel shoals where there are waves. Although some spawning occurs in daytime, most takes place at sunrise and sunset. One female spawns with several males. Females usually produce 20,000-50,000 eggs, but can produce up to 139,000 eggs. Suckers do not build a nest, but scatter their eggs, which stick to the bottom, or drift downstream and attach elsewhere.

The eggs hatch in 8 to 11 days, depending on the temperature (10-15· C). The young remain in the gravel for 1or 2 weeks and then migrate downstream at a size of 12 to 17 mm. Sometimes only 3% of white sucker eggs survive to this stage. Young suckers in lakes are found along shorelines with sand or gravel bottoms. In streams they prefer sand and gravel shallow areas with moderate currents.

At first white suckers do not feed on the bottom. Their mouth is at the end of their snout, and they feed near the surface of the water on plankton (tiny organisms suspended in the water). When they grow to about 16-18 mm (0.6-0.7 in), their mouths shift to the underside of the head and they begin taking food from the bottom. White suckers grow most rapidly during their first year and can reach a length of 17.9 cm (7 in) by age 1. Growth rates vary considerably in different areas, but in all populations females grow more rapidly than males, reach larger sizes, and live longer. They usually mature at ages 5 to 8, and males mature a year earlier than females. Suckers can live up to 17 years.

Although there is evidence that suggests that the white sucker can compete for food with other sport fish, they can be a major food item in the diet of other fish such as Atlantic salmon, brook trout, pike and bass. Birds and mammals also eat them.

Appendix D: Fish Collection Tracking Sheet

Fish Collection Tracking Sheet

McCallum Environmental Ltd.

Pre-Job General Information		
Project:	Project Number:	Task:
Date:	Personnel:	WC/WB ID:
Weather:	Precipitation (past 24 hours):	Reach ID:

Site Characteristics **Photos taken of the site?** ☐ **Yes (US, DS, LB, RB, Substrate)**

Stream Type (% Surface Area)		Water Quality Measurements	
Riffle		pH	
Run		SAL (ppt)	
Pool		CON (µS/cm)	
Other (specify)		SPC (µS/cm)	
Substrate (% Surface Area)		TDS (mg/L)	
Bedrock		DO (%, mg/L)	
Boulder (>25 cm)		* Temp measurements are recorded below	
Rubble (14-25 cm)			
Cobble (3-13 cm)		**Physical Measurements (average over reach)**	
Gravel (0.2-3 cm)		Bankfull width (cm)	
Sand (0.06-2 mm)		Wetted Width (cm)	
Silt (<0.006 mm)		Depth (cm)	
Muck/Detritus		Length of Reach (m)	
Clay/Mud		Velocity (estimate)	

Fish Caught? (if so, list species)
Add any commentary or observations from survey effort.

Revisions to Electrofisher settings required?

Sketch of Site: Include flow direction, locations of habitat features/cover ex. Large boulders, large woody debris, overhanging vegetation, and undercut banks

ELECTROFISHING (Electrofishing must proceed in an upstream direction)

		Pass 1	Pass 2	Pass 3
Method Used: ☐ Depletion ☐ CPUE				
Site Set-up: ☐ Open ☐ Closed	**Effort (seconds)**			
Upstream Waypoint:	**Voltage**			
Downstream Waypoint:	**Frequency**			
Water visibility: ☐ Good ☐ Fair ☐ Poor	**Water temp (℃)**			
***Measure Temperature at Beginning of each pass**	**Air Temp (℃)**			
*****DO NOT Electrofish if water temp is greater than22ºC *****	**# of Fish Caught**			
*** Do NOT Electrofish if temperature is greater than 22ºC**				

TRAPPING & NETTING

Gear Used: ☐ Fyke Nets (#__) ☐ Minnow Traps (#__) ☐ Eel Pots (#__) ☐ Seine		**Bait:**
Locations and Depths (UTM, cm):		**Time In (hr):**
		Time Out (hr):

Fish Collection Tracking Sheet

McCallum Environmental Ltd.

Individual Fish Measurements

Pre-Job General Information		
Project:	Project Number:	Task:
Date:	WC/WB ID:	Reach ID:

Individual Fish Measurements – Photograph EACH individual – with enough detail to confirm ID if required								
Capture Method*	Fish ID #	Species Code	Fork Length (mm)	Total Length (mm)	Weight (g)	Age/Age Class	Mark observed? State type and tag # if poss.	Comments (e.g. parasites, lesions, net marks, dead, etc)

*PASS(#) = Electrofishing, MT = Minnow Trap, EP = Eel Pot, FN = Fyke Net, SN = Seine

APPENDIX C. PHOTOGRAPH LOG

Photo 1: Cameron Flowage trapping location.

Photo 2: Crusher Lake trapping location.

Photo 3: Killag electrofishing reach.

Photo 4: Mud Lake and Outlet trapping location.

Photo 5: WC5A electrofishing reach.

Photo 6: WC5B electrofishing reach.

Photo 7: WC12 electrofishing reach (too dry).

Photo 8: WC13 electrofishing reach.


Photo 9: WC14 electrofishing reach.


Photo 10: WC20/WC22 electrofishing reach.


Photo 11: WC21/WL220 electrofishing reach.


Photo 12: WC23 electrofishing reach.


Photo 13: WC26 electrofishing reach.


Photo 14: WL59 trapping location.


Photo 15: American Eel.


Photo 16: Atlantic Salmon.


Photo 17: Banded Killifish.


Photo 18: Brook Trout.

Photo 19: Brown Bullhead.

Photo 20: Creek Chub.

Photo 21: Golden Shiner.

Photo 22: Lake Chub.

Photo 23: Ninespine Stickleback.

Photo 24: White Sucker.

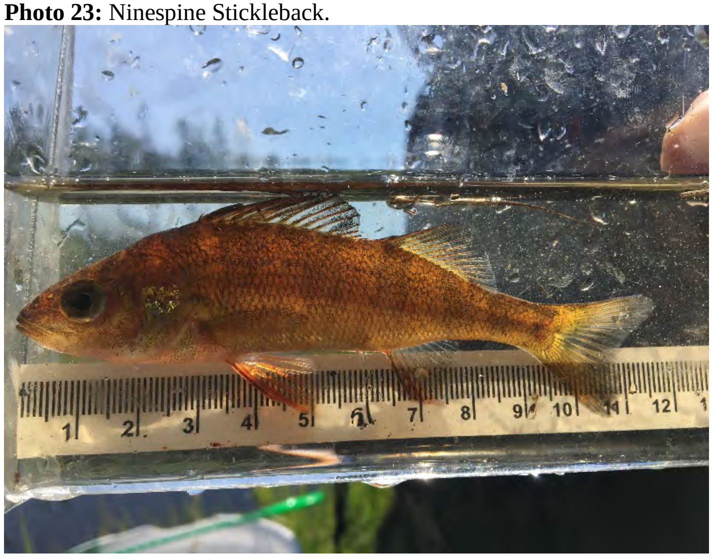

Photo 25: Yellow Perch.

Photo 26: WC5 Reach 1.

Photo 27: WC5 Reach 2.

Photo 28: WC5 Reach 3.

Photo 29: WC5 Reach 4.


Photo 30: WC5 Reach 5.


Photo 31: WC5 Reach 7.


Photo 32: WC5 Reach 8.


Photo 33: WC13 Reach 1.

McCallum Environmental Ltd.

Photo 34: WC13 Reach 2.

Photo 35: WC13 Reach 3.

Photo 36: WC13 Reach 4.

Photo 37: WC13 Reach 5.

Photo 38: WC14 Reach 1A.

Photo 39: WC14 Reach 1B.

Photo 40: WC14 Reach 2.

Photo 41: WC20 Reach 1.


Photo 42: WC21 Reach 1.


Photo 43: WC21 Reach 2.


Photo 44: WC22 Reach 1.


Photo 45: WC23 Reach 1.


Photo 46: WC23 Reach 2.


Photo 47: WC23 Reach 3.


Photo 48: WC25 Reach 1.


Photo 49: WC25 Reach 1.

Photo 50: WC26 Reach 1.

Photo 51: WC26 Reach 2.

Photo 52: WC27 Reach 1.

Photo 53: WL59.

Photo 54: WL61.

Photo 55: WL56.

Photo 56: Downstream end of WC20 within WL205. 9 Sept 2019, following Hurricane Dorian. No evidence of surface water.

Photo 57: Typical substrate and vegetation along most obvious flow path at downstream extent of WC20 within WL205. 17 Sept 2019. No evidence of surface water.

Photo 58: Typical substrate and vegetation at downstream end of WC20. 6 Nov 2019. No evidence of surface water.

Photo 59: Typical substrate and vegetation at upstream extent of WC23. 6 Nov 2019. No evidence of surface water.

Photo 60: Typical substrate and vegetation in upland forest between WC20 and WC23. 22 Nov 2019. No evidence of surface water.

Photo 61: Typical substrate and vegetation in upland forest between WC20 and WC23. 22 Nov 2019. No evidence of surface water.

Photo 62: Typical substrate and vegetation showing pools along the most obvious flow path at the upstream extent of WC23. 16 Dec 2019. Surface water confined to isolated pools.

Photo 63: Typical substrate and vegetation showing pools along the most obvious flow path within the upstream extent of WC23. 8 April 2020. Surface water confined to isolated pools.

Photo 64: Downstream extent of WC20, looking north. 8 April 2020.

Photo 65: Typical substrate and vegetation at upstream extent of subterranean barrier. Looking south from downstream extent of WC20. 8 April 2020. No evidence of surface water.

Photo 66: Typical substrate and vegetation within the upland forest between WC20 and WC23.8 April 2020. No evidence of surface water.

Photo 67: Typical substrate and vegetation within the upland forest between WC20 and WC23. 8 April 2020. No evidence of surface water.

Photo 68: Typical substrate and vegetation within the upland forest between WC20 and WC23. Looking south from downstream extent of WC20. 23 April 2020. No evidence of surface water.

Photo 69: Typical substrate and vegetation within the upland forest between WC20 and WC23. 23 April 2020. No evidence of surface water.

APPENDIX D. LABORATORY RESULTS

RE: Brook trout gDNA sample

Ali MIRABZADEH <<email address removed>>
To Melanie MacDonald
Cc Heather Allen; Aron Weir; eDNA

Reply | Reply All | Forward | ...

Fri 2020-07-17 10:23 AM

You forwarded this message on 2020-07-17 11:43 AM.

Brook trout gDNA test.jpg
52 KB

Hi Melanie,

Good news! I was able to detect Brook trout gDNA using eFish assay. Please see the attached picture.

Red line - Negative control
Green line - Positive control
Blue line - Brook trout gDNA

Please let me know if you have any question.

Regards,
Ali

Ali Mirabzadeh, M.Sc.
Senior Analyst, Animal DNA
Bureau Veritas Laboratories
2-335 Laird Road, Guelph, ON, N1G 4P7
Phone: <personal information removed> Fax: 519 836 4218
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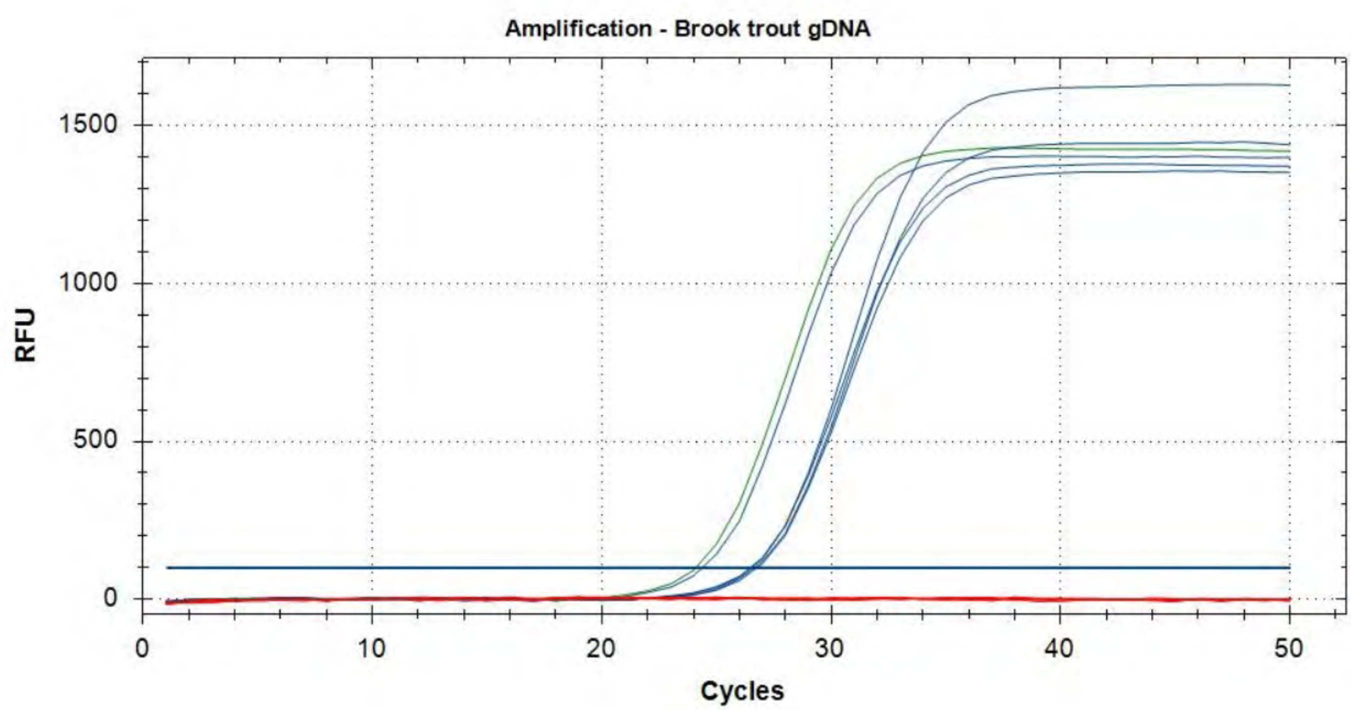

Attention: Melanie MacDonald
McCallum Environmental Ltd
2 Bluewater Road, Suite 115
Halifax, NS
Canada B4B 1G7

Client Project #: 17-175
Site Location: Beaver Dam
C.O.C. #: 20200717
Quote #: N/A
PO#: N/A

Report Date: 2020/07/23
Report #: ME20200723
Version: 1

ENVIRONMENTAL DNA - CERTIFICATE OF ANALYSIS

BV JOB #: E20200717
Received: 2020/07/17, 11:24 AM

Sample Type: Cellulose Nitrate (CN) filter, preserved in silica
\# Samples Received: 19

Analyses (eDNA Isolation - Species)	Test Requested	Test Performed	Date eDNA Extracted	Date Analyzed IntegritE-DNA^{TM}	Date Analyzed Target Species	Laboratory Method	Analytical Method (qPCR Primer/Probe set)
eDNA Isolation and IntegritE-DNA^{TM}	19	19	2020/07/20	2020/07/21 2020/07/22	N/A	GUE SOP-00056	ePlant5
General Fish assay (eFish)	19	19	N/A	N/A	2020/07/22	GUE SOP-00056	eFish1

Remarks:

Bureau Veritas Laboratories (Animal DNA Department, DNA Services) is accredited to ISO17025:2017 for eDNA testing.

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by industry professionals using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and Bureau Veritas Laboratories in writing). All data has met quality control and method performance criteria unless otherwise noted.

Bureau Veritas Laboratories' liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. Bureau Veritas Laboratories has been retained to provide analysis of samples provided by the Client using the testing methodology referenced in this report. Interpretation and use of test results are the sole responsibility of the Client and are not within the scope of services provided by Bureau Veritas Laboratories unless otherwise agreed in writing. Bureau Veritas Laboratories is not responsible for the accuracy or any data impacts that result from the information provided by the customer or their agent.

Results relate to supplied samples tested. This Certificate should not be reproduced except in full, without the written approval of the laboratory.

eDNA tests are used to confirm presence of eDNA in samples for the targeted species / species groups.

Collected eDNA samples will contain eDNA at various stages of degradation, being subject to environmental forces that breakdown DNA, including microbial activity, ultraviolet radiation, heat, hydrolysis, and enzymatic activity. eDNA is first evaluated for eDNA quality and presence of qPCR assay inhibitors using the IntegritE-DNA^{TM} assay before testing for target species or genera to confirm that the eDNA is of sufficient quality for testing and to identify and address qPCR inhibition (if present) to avoid false negatives.

SAMPLE RETENTION: Samples and DNA extracts generated from the samples will be retained by Bureau Veritas Laboratories for a period of 90 days after which time they will be discarded unless prearrangement has been made by client with Bureau Veritas Laboratories for longer storage.

Unit 2 - 335 Laird Road
Guelph, ON N1G 4P7

Phone: (519) 836-2400
Toll Free: (877) 706-7678
Fax: (519) 836-4218
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Attention: Melanie MacDonald
McCallum Environmental Ltd
2 Bluewater Road, Suite 115
Halifax, NS
Canada B4B 1G7

Client Project #: 17-175
Site Location: Beaver Dam
C.O.C. #: 20200717
Quote #: N/A
PO#: N/A

Report Date: 2020/07/23
Report #: ME20200723
Version: 1

ENVIRONMENTAL DNA - CERTIFICATE OF ANALYSIS

BV JOB #: E20200717
Received: 2020/07/17, 11:24 AM

Methodology for Sample Analysis

Samples received to the laboratory are entered into the Laboratory Information Management System (LIMS) upon receipt. Samples were inspected and assessed for amount of silica beads, silica bead saturation level, coin envelope condition and number of coin envelopes in each bag. Samples were frozen at -20°C until processing in the laboratory. Sample analysis is completed within 10 or 15 business days (as indicated by the client on the COC) following receipt of samples by the testing laboratory.

eDNA isolation is completed using the DNeasy Blood & Tissue Kit™ (QIAGEN). A negative control is included as a blank filter sample with each batch of eDNA isolation to monitor for potential laboratory contamination during the eDNA isolation process.

Following eDNA isolation from the filter, the IntegritE-DNA™ assay[1] is used to avoid the potential of a false negative (Type II error) during target species or genera testing. The IntegritE-DNA™ assay evaluates the integrity of eDNA for suitability for qPCR and for presence of qPCR inhibitors which may reduce the effectiveness of the qPCR assay for target species or genera. This assay evaluates the quality of eDNA to assess whether it is amplifiable using a qPCR assay that targets the chloroplast genome derived from plants/algae that are ubiquitously found in fresh water systems. Four technical replicates per eDNA sample, four technical replicates of negative control (Ultrapure water), and two technical replicates of positive control are used for the IntegritE-DNA™ assay. The cut-off Ct (qPCR cycle threshold) value for the IntegritE-DNA™ assay is 30. If the IntegritE-DNA™ assay produces a positive detection frequency of ≥ 2 of the 4 technical replicates, this indicates that the eDNA for the target taxa is likely to be of sufficient quality to be detected (if present) with the target assay. If the IntegritE-DNA™ assay produces a positive detection frequency < 2 of the 4 technical replicates (eDNA is degraded or qPCR inhibitors are present), then sample cleanup is completed using the OneStep PCR Inhibitor Removal Kit™ (ZYMO Research) to remove potential qPCR assay inhibitors from the isolated eDNA. Subsequent to inhibitor removal, the IntegritE-DNA™ assay is repeated to re-assess whether the eDNA is of sufficient quality for qPCR. If a sample fails at the IntegritE-DNA™ assay for the second time the client will be informed that the quality of the sample is insufficient for the qPCR assay. eDNA indicator (IntegritE-DNA™) in the sample suggests that degradation has taken place and therefore the target species assay may be ineffective. Once a sample passes the IntegritE-DNA™ assay, then the target species or genera assay is performed. Eight technical replicates per eDNA sample, eight technical replicates of the negative control (Ultrapure water), and two technical replicates of positive control (total DNA or synthetic DNA) are used for the target species or genera assay to assess the detection or non-detection of DNA of the target species or genera. The cut-off Ct value for target species assay is 50.

[1] Hobbs J, Round JM, Allison MJ, Helbing CC (2019) Expansion of the known distribution of the coastal tailed frog, *Ascaphus truei* , in British Columbia, Canada, using robust eDNA detection methods. PLOS ONE 14(3): e0213849.

<Original signed by>

BECKY HENDERSON
Senior Customer Service Representative, Bureau Veritas Laboratories, DNA Services
Email: <email address removed>
Phone #: <personal information removed>

Please direct all questions regarding this Certificate of Analysis to your Customer Service Representative above.
==
For Service Group specific validation please refer to the Validation Signature Page.

Total Cover Pages: 2

RESULTS - General Fish assay (eFish)

Client Sample ID	BV Case ID	Sampling Date	Preservation Type	COC Number	IntegritE-DNA™ Positive detection (Ct≤30)[1]	QC Batch	Cleanup required	IntegritE-DNA™ Positive detection (Ct≤30) after cleanup	QC Batch	Analytical Method (qPCR Primer/Probe set)	Target Species eDNA Positive detection (Ct≤50)[2]	QC Batch
1-A	ME20200042	2020/07/09	Silica	20200717	4/4	200721Q1	No	N/A	N/A	eFish1[4]	0/8	200722Q2
1-B	ME20200043	2020/07/09	Silica	20200717	4/4	200721Q1	No	N/A	N/A	eFish1	0/8	200722Q2
1-C	ME20200044	2020/07/09	Silica	20200717	4/4	200721Q1	No	N/A	N/A	eFish1	0/8	200722Q2
2-A	ME20200045	2020/07/09	Silica	20200717	4/4	200721Q1	No	N/A	N/A	eFish1	0/8	200722Q2
2-B	ME20200046	2020/07/09	Silica	20200717	4/4	200721Q1	No	N/A	N/A	eFish1	0/8	200722Q2
2-C	ME20200047	2020/07/09	Silica	20200717	4/4	200721Q1	No	N/A	N/A	eFish1	0/8	200722Q2
3-A	ME20200048	2020/07/09	Silica	20200717	4/4	200721Q1	No	N/A	N/A	eFish1	1/8	200722Q2
3-B	ME20200049	2020/07/09	Silica	20200717	4/4	200721Q1	No	N/A	N/A	eFish1	1/8	200722Q2
3-C	ME20200050	2020/07/09	Silica	20200717	4/4	200721Q1	No	N/A	N/A	eFish1	2/8	200722Q2
4-A	ME20200051	2020/07/09	Silica	20200717	4/4	200721Q1	No	N/A	N/A	eFish1	2/8	200722Q2
4-B	ME20200052	2020/07/09	Silica	20200717	4/4	200721Q1	No	N/A	N/A	eFish1	1/8	200722Q3
4-C	ME20200053	2020/07/09	Silica	20200717	4/4	200721Q1	No	N/A	N/A	eFish1	1/8	200722Q3
5-A	ME20200054	2020/07/09	Silica	20200717	0/4[3]	200721Q1	Yes[3]	4/4	200722Q1	eFish1	7/8	200722Q3
5-B	ME20200055	2020/07/09	Silica	20200717	0/4[3]	200721Q1	Yes[3]	4/4	200722Q1	eFish1	7/8	200722Q3
5-C	ME20200056	2020/07/09	Silica	20200717	0/4[3]	200721Q1	Yes[3]	4/4	200722Q1	eFish1	6/8	200722Q3
6-A	ME20200057	2020/07/09	Silica	20200717	4/4	200721Q1	No	N/A	N/A	eFish1	2/8	200722Q3
6-B	ME20200058	2020/07/09	Silica	20200717	0/4[3]	200721Q1	Yes[3]	4/4	200722Q1	eFish1	2/8	200722Q3
6-C	ME20200059	2020/07/09	Silica	20200717	0/4[3]	200721Q1	Yes[3]	4/4	200722Q1	eFish1	0/8	200722Q3
Field Blank	ME20200060	2020/07/09	Silica	20200717	4/4	200721Q1	No	N/A	N/A	eFish1	0/8	200722Q3

[1] **IntegritE-DNA™ Assay:** Four technical replicates were assayed for each eDNA sample. The cut-off Ct value for IntegritE-DNA™ assay was 30. Results are reported as the number of positive detections (n) out of a total of 4 technical replicates, n/4.

[2] **Target Species Assay:** Eight technical replicates were assayed per eDNA sample. The cut-off Ct value for target species assay was 50. Results are reported as the number of positive detections (n) out of a total of 8 technical replicates, n/8.

[3] The IntegritE-DNA™ assay failed and cleanup is required.

[4] eFISH1: qPCR primer/probe assay to assess the presence of Fish species eDNA (confirmed to detect several fish including 19 species; Sockeye Salmon (*Oncorhynchus nerka*), Pink Salmon (*Oncorhynchus gorbuscha*), Chum Salmon (*Oncorhynchus keta*), Arctic Grayling (*Thymallus arcticus*), Cutthroat Trout (*Oncorhynchus clarkii*), Rainbow Trout (*Oncorhynchus mykiss*), Chinook Salmon (*Oncorhynchus tshawytscha*), Coho Salmon (*Oncorhynchus kisutch*), Atlantic Salmon (*Salmo salar*), Dolly Varden (*Salvelinus malma*), Round Whitefish (*Prosopium cylindraceum*), Slimy Sculpin (*Cottus cognatus*), American Eel (*Anguilla rostrata*), Northern Pike (*Esox lucius*), Smallmouth Bass (*Micropterus dolomieu*), Largemouth Bass (*Micropterus salmoides*), Bull Trout (*Salvelinus confluentus*), Eulachon (*Thaleichthys pacificus*)). This assay is designed to be non-specific. It may detect eDNA from other fish species in addition or instead of the specific species listed here, which the assay has been validated for.

GENERAL COMMENTS

A Brook trout (*Salvelinus fontinalis*) fin tissue was submitted to BV labs (Guelph) by Melanie MacDonald. The genomic DNA was extracted, and it was detected by eFish assay.

The IntegritE-DNA result for Field Blank (BV case ID, ME20200060) was positive. The IntegritE-DNA assay detects plant DNA and it is normal to get positive result if tap or bottled water have been used as field blank. Reverse osmosis (RO) or distilled water is recomended as field negative cotrol for future projects. The eFish assay was performed for Field Blank to eliminate the possiblity of fish contamination. No fish DNA was detected for Field Blank sample.

Results relate only to the items tested.

BV JOB #: E20200717
Report Date: 2020/07/23
Report #: ME20200723

Client Name: McCallum Environmental Ltd
Client Project #: 17-175
Site Location: Beaver Dam
Sampler Initials: MMD

QUALITY ASSURANCE REPORT

			eDNA Isolation Negative Control[1]		qPCR Positive Controls[2]		qPCR Negative Controls[3]	
QC Batch	**Parameter**	**Date**	**Detection at: Ct 30 (IntegritE-DNA™) Ct 50 (other assays)**	**Pass/Fail**	**Detection at: Ct 30 (IntegritE-DNA™) Ct 50 (other assays)**	**Pass/Fail**	**Detection at: Ct 30 (IntegritE-DNA™) Ct 50 (other assays)**	**Pass/Fail**
200721Q1	IntegritE-DNA	2020/07/21	0 of 4 technical replicates	Pass	2 of 2 technical replicates	Pass	0 of 4 technical replicates	Pass
200722Q1	IntegritE-DNA	2020/07/22	eDNA Isolation Negative Control is assessed using IntegritE-DNATM only once for each extraction batch.	N/A	2 of 2 technical replicates	Pass	0 of 4 technical replicates	Pass
200722Q2	eFish1	2020/07/22			2 of 2 technical replicates	Pass	0 of 8 technical replicates	Pass
200722Q3	eFish1	2020/07/22			2 of 2 technical replicates	Pass	0 of 8 technical replicates	Pass

[1]**eDNA Isolation Negative Control:** Blank filters were included for each batch of eDNA extraction to monitor for laboratory contamination during eDNA isolation. eDNA Isolation Negative Control is assessed using IntegritE-DNA™ only. QC results show no eDNA was isolated from the negative control, therefore there was no indication of sample contamination during handling. Acceptance criteria: 0 of 4 technical replicates

[2]**qPCR Positive Controls:** Two technical replicates of isolated eDNA from freshwater sample were used as positive controls for IntegritE-DNA™. Two technical replicates of total DNA or synthetic DNA from the target species were used as positive controls for eDNA assays. Results show that 100% of the technical replicates amplified the positive control eDNA as expected, therefore an observation of negative result in eDNA samples is not related to the qPCR performance. Acceptance criteria: 2 of 2 technical replicates

[3]**qPCR Negative Controls (Ultrapure water):** Four technical replicates for IntegritE-DNA™ and eight technical replicates for target species or genera were used to monitor for laboratory contamination. Results show that 0% of the technical replicates in the negative controls had amplified eDNA, indicating no contamination was detected. Acceptance criteria: 0 of 4 technical replicates for IntegritE-DNA™, and 0 of 8 technical replicates for other assays.

LABORATORY RESULTS VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

<Original signed by>

Reporter: ALI MIRABZADEH, M.Sc.
Senior Analyst, Bureau Veritas Laboratories, DNA Services

==

<Original signed by>

Reviewer: HEATHER ALLEN, M.Sc.
Supervisor, Bureau Veritas Laboratories, DNA Services

==

Fish Species Assay Validation Information

eDNA assay Validation

All eDNA assays are validated through a rigorous multi-step evaluation protocol that includes tests of DNA target specificity and amplification sensitivity. All eDNA tests available at Bureau Veritas Laboratories have been validated for performance using interlaboratory verification.

General eDNA Assay Information

Target Species	Various Fish Species	eDNA qPCR Primer/Probe set	eFish1
Species Abbreviation	Fish	eDNA qPCR Format	TaqMan

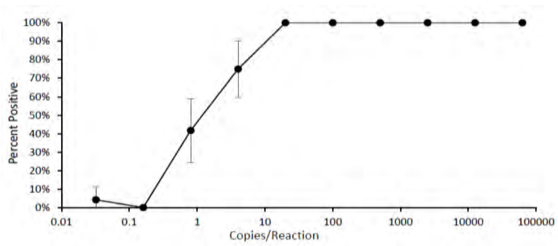
eDNA Assay Specificity Tests

A. qPCR Activity: Multi-species analysis of eDNA assay efficiency. This assay is designed to be non-specific. It may detect eDNA from other fish species in addition or instead of the specific species listed here, which the assay has been validated for. Each qPCR reaction in the specificity assay contained 10 picograms of voucher target gDNA. Technical replicates: n=25

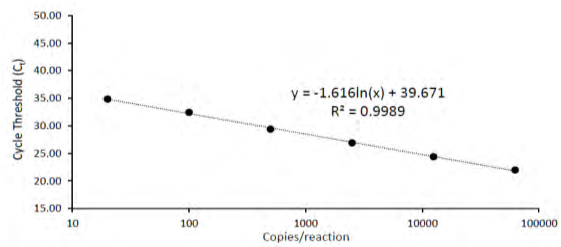
Species:	ANRO	COCO	ESLU	HOSA	LICA	MIDO	MISA	ONCL	ONGO	ONKE	ONKI
Detection:	Yes	Yes	Yes	No	No	Yes*	Yes	Yes	Yes	Yes	Yes
Species:	ONMY	ONNE	ONTS	PRCY	SACO	SAMA	SASA	THAR	THPA	NTC	
Detection:	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes*	No	

* This tool weakly detects Smallmouth Bass and Eulachon DNA

eDNA Assay Sensitivity Test using gBlocks™ synthetic DNA



>100 copies/reaction were tested with n=8 technical replicates.
≤100 copies/reaction were tested with n=24 technical replicates.
The eFish1 gBlocks sequence is based on Chinook Salmon (Oncorhynchus tschawytscha)



The relationship between Cycle Threshold and Copy Number does not necessarily remain linear when fewer than 100% of technical replicates are positive.

eDNA Assay Sensitivity Test using tissue-derived gDNA

COCO

DNA (µg/L)	Detection Frequency (n=25)	Binomial Standard error (n=8)
5	96%	7%
1	96%	7%
0.2	32%	16%
0.04	8%	10%
0.008	0%	0%
0	0%	0%

ONCL

DNA (µg/L)	Detection Frequency (n=25)	Binomial Standard error (n=8)
5	100%	0%
1	20%	14%
0.2	0%	0%
0.04	0%	0%
0.008	0%	0%
0	0%	0%

ONGO

DNA (µg/L)	Detection Frequency (n=25)	Binomial Standard error (n=8)
5	96%	7%
1	100%	0%
0.2	100%	0%
0.04	92%	10%
0.008	20%	14%
0	0%	0%

ONKE

DNA (µg/L)	Detection Frequency (n=25)	Binomial Standard error (n=8)
5	100%	0%
1	100%	0%
0.2	40%	17%
0.04	16%	13%
0.008	0%	0%
0	0%	0%

ONKI

DNA (µg/L)	Detection Frequency (n=25)	Binomial Standard error (n=8)
5	100%	0%
1	40%	17%
0.2	0%	0%
0.04	0%	0%
0.008	0%	0%
0	0%	0%

ONMY

DNA (µg/L)	Detection Frequency (n=25)	Binomial Standard error (n=8)
5	100%	0%
1	88%	11%
0.2	36%	17%
0.04	16%	13%
0.008	0%	0%
0	0%	0%

ONNE

DNA (µg/L)	Detection Frequency (n=25)	Binomial Standard error (n=8)
5	96%	7%
1	4%	7%
0.2	0%	0%
0.04	0%	0%
0.008	0%	0%
0	0%	0%

ONTS

DNA (µg/L)	Detection Frequency (n=25)	Binomial Standard error (n=8)
5	100%	0%
1	64%	17%
0.2	20%	14%
0.04	0%	0%
0.008	4%	7%
0	0%	0%

PRCY

DNA (µg/L)	Detection Frequency (n=25)	Binomial Standard error (n=8)
5	100%	0%
1	4%	7%
0.2	0%	0%
0.04	0%	0%
0.008	0%	0%
0	0%	0%

SASA

DNA (µg/L)	Detection Frequency (n=25)	Binomial Standard error (n=8)
5	96%	7%
1	28%	16%
0.2	12%	11%
0.04	0%	0%
0.008	0%	0%
0	0%	0%

THAR

DNA (µg/L)	Detection Frequency (n=25)	Binomial Standard error (n=8)
5	100%	0%
1	100%	0%
0.2	68%	16%
0.04	20%	14%
0.008	8%	10%
0	0%	0%

Abbreviations

American Eel (*Anguilla rostrata*)	ANRO	Pink Salmon (*Oncorhynchus gorbuscha*)	ONGO	Dolly Varden (*Salvelinus malma*)	SAMA
Slimy Sculpin (*Cottus cognatus*)	COCO	Chum Salmon (*Oncorhynchus keta*)	ONKE	Atlantic Salmon (*Salmo Salar*)	SASA
Northern Pike (*Esox lucius*)	ESLU	Coho Salmon (*Oncorhynchus kisutch*)	ONKI	Arctic Grayling (*Thymallus arcticus*)	THAR
Human (*Homo sapiens*)	HOSA	Round Whitefish (*Prosopium cylindraceum*)	PRCY	Eulachon (*Thaleichthys pacificus*)	THPA
Bullfrog (*Lithobates (Rana) catesbeiana*)	LICA	Rainbow Trout (*Oncorhynchus mykiss*)	ONMY	qPCR no template control	NTC
Smallmouth Bass (*Micropterus dolomieu*)	MIDO	Sockeye Salmon (*Oncorhynchus nerka*)	ONNE	quantitative real-time polymerase chain reaction	qPCR
Largemouth Bass (*Micropterus salmoides*)	MISA	Chinook Salmon(*Oncorhynchus tshawytscha*)	ONTS	environmental DNA	eDNA
Cutthroat Trout (*Oncorhynchus clarkii*)	ONCL	Bull Trout (*Salvelinus confluentus*)	SACO		

References

1. Hobbs, J, Adams, IT, Round, JM, Goldberg, CS, Allison, MJ, Bergman, LC, Mirabzadeh, A, Allen, H, Helbing, CC (2020) Revising the range of Rocky Mountain tailed frog, Ascaphus montanus, in British Columbia, Canada, using environmental DNA methods. Environmental DNA. 2020; 00: 1– 12. https://doi.org/10.1002/edn3.82
2. Hobbs, J, Round, JM, Allison, MJ, Helbing, CC (2019) Expansion of the known distribution of the coastal tailed frog, Ascaphus truei, in British Columbia, Canada, using robust eDNA detection methods. PLOS ONE 14(3): e0213849.
3. Klymus, KE, Merkes, CM, Allison, MJ, Goldberg, CS, Helbing, CC, Hunter, ME, Jackson, CA, Lance, RF, Mangan, AM, Monroe, EM, Piaggio, AJ, Stokdyk, JP, Wilson, CC, Richter, CA (2019) Reporting the limits of detection and quantification for
4. Veldhoen N, Hobbs J, Ikonomou G, Hii M, Lesperance M, Helbing, CC (2016) Implementation of novel design features for qPCR-based eDNA assessment. PLOS ONE 11(11): e0164907. https://doi.org/10.1371/journal.pone.0164907

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335 Laird Rd #2
Guelph, ON N1G 4P7
eDNA@bvlabs.com

From USA, send to:
Bureau Veritas Laboratories
240 Portage Rd
Po Box 670, PMB 19
Lewiston NY 149092-1604

ENVIRONMENTAL DNA (eDNA) CHAIN OF CUSTODY RECORD

Page 1 of 2

«‹An incomplete or incorrect form may lead to delays in testing›»

COC# 20200717

1 Invoice Information (Required)		2 Report Information (if differs from invoice)		3 Project Information (where applicable)		4 Turnaround Time (TAT) (Required)
Company Name:	McCallum Environmental Ltd	Company Name:	McCallum Environmental Ltd.	Quotation #:		Regular TAT (Most analyses)
						☐ 10 business days (Sample # ≤ 50)
Contact Name:	Olena Kharytonova	Contact Name:	Melanie MacDonald	P.O. #:		☐ 15 business days (Sample # > 50)
						From date received
Address:	2 Bluewater Road, Suite 115	Address:	Same	Project #:	17-175	PLEASE REQUEST RUSH FROM CUSTOMER SERVICE
	Halifax, NS, B4B 1G7			Site Location:	Beaver Dam	
				Sampled By:	MMD	Rush TAT (Surcharges will be applied)
Phone:	782-233-1717 Fax:	Phone:	(902) 817-2444 Fax:	Note:1		☐ 5 business days (Sample # ≤ 50)
						☐ 10 business days (Sample # > 50)
Email:	olena@mccallumenvironmental.com	Email:	melanie@mccallumenvironmental.com			From date received

eDNA ANALYSIS

5 IMPORTANT INFORMATION

- Water samples should be kept cool and filtered as soon as possible (within 24 hours of collection).
- Cellulose Nitrate (CN) filter is recommended to use for eDNA test because of higher eDNA recovery.
- Preserve filter in self-indicating silica beads (2-4 mm diameter) or molecular grade ethanol (95 to 100%) immediately following sample filtration.

6 CLIENT SPECIAL INSTRUCTIONS

1 We have submitted a gDNA sample for Brook Trout - Salvelinus fontinalis - please complete eFish after verifying that it detects S. fontinalis. Contact Melanie MacDonald for more info if required (920-817-2444). Sample collection and filtration data submitted via e-mail to Aron Weir.

Number	7 Sample identification	8 Date Sampled (YYYY/MM/DD)	9 Date Filtered and Preserved (YYYY/MM/DD)	10 Filter Material	11 Filter Size (Diameter)	12 Filter Pore Size (µm)	13 Preservation Method (Ethanol / Silica)	14 Assays Requested[1]	15 Comments
1	1A	2020-07-09	2020-07-09	CN	as provided by BV	45	Silica	eFish	
2	1B	2020-07-09	2020-07-09	CN	as provided by BV	45	Silica	eFish	
3	1C	2020-07-09	2020-07-09	CN	as provided by BV	45	Silica	eFish	
4	2A	2020-07-09	2020-07-09	CN	as provided by BV	45	Silica	eFish	
5	2B	2020-07-09	2020-07-09	CN	as provided by BV	45	Silica	eFish	
6	2C	2020-07-09	2020-07-09	CN	as provided by BV	45	Silica	eFish	
7	3A	2020-07-09	2020-07-09	CN	as provided by BV	45	Silica	eFish	
8	3B	2020-07-09	2020-07-09	CN	as provided by BV	45	Silica	eFish	
9	3C	2020-07-09	2020-07-09	CN	as provided by BV	45	Silica	eFish	
10	4A	2020-07-09	2020-07-09	CN	as provided by BV	45	Silica	eFish	
11	4B	2020-07-09	2020-07-09	CN	as provided by BV	45	Silica	eFish	
12	4C	2020-07-09	2020-07-09	CN	as provided by BV	45	Silica	eFish	
13	5A	2020-07-09	2020-07-09	CN	as provided by BV	45	Silica	eFish	
14	5B	2020-07-09	2020-07-09	CN	as provided by BV	45	Silica	eFish	
15	5C	2020-07-09	2020-07-09	CN	as provided by BV	45	Silica	eFish	

16 RELINQUISHED BY: (Signature/Print)	17 DATE: (YYYY/MM/DD)	18 TIME: (HH:MM)	RECEIVED BY: (Signature/Print)	DATE: (YYYY/MM/DD)	TIME: (HH:MM)	CASE RANGE
Melanie MacDonald	2020-07-13		Rec'd by Joan L / Imported by Ali M.	For Lab Use Only 2020/07/17	11:24	

[1] **Available Assays at Bureau Veritas Laboratories: AMMV**[2] (Western tiger salamander), **ANBO** (Western toad), **ASMO** (Rocky mountain tailed frog), **eFish**[3] (General fish assay), **LICA** (North American bullfrog), **ONCL** (Cutthroat trout), **ONKI** (Coho salmon), **ONMY** (Rainbow trout - Steelhead trout), **ONNE** (Sockeye Salmon), **ONTS** (Chinook salmon), **RAAU** (Northern red-legged frog), **RAPR** (Oregon spotted frog), **SOBE** (Pacific water shrew), **THAR** (Arctic grayling), **ASTR** (Pacific (Coastal) tailed frog), **MISA** (Largemouth Bass) and **ESLU** (Northern Pike)

[2] **AMMV** assay also detects *Ambystoma tigrinum* (AMTI) Tiger Salamander.

[3] **eFish** assay can detect DNA from 12 fish species (Sockeye salmon, Pink salmon, Chum salmon, Arctic grayling, Cutthroat trout, Rainbow trout, Chinook salmon, Coho salmon, Atlantic Salmon, Dolly Varden, Round Whitefish and Slimy Sculpin). This assay is designed to be non-specific. It may detect eDNA from other fish species in addition or instead of the specific species listed here, which the assay has been validated for.

Unless otherwise agreed to in writing, work submitted on this Chain of Custody is subject to Bureau Veritas Laboratories' standard Terms and Conditions. Signing of this Chain of Custody document is acknowledgment and acceptance of our terms which are available for viewing at http://www.bvlabs.com/terms-and-conditions and https://www.bvlabs.com/fr/conditions-generales

BUREAU VERITAS 1828

BV JOB #: E20200717
Report Date: 2020/07/23
Report #: ME20200723

Client Name: McCallum Environmental Ltd
Client Project #: 17-175
Site Location: Beaver Dam
Sampler Initials: MMD

Bureau Veritas Laboratories
G 00441/7
CHAIN OF CUSTODY RECORD

From Canada, send to:
Bureau Veritas Laboratories, DNA Services
335 Laird Rd #2
Guelph, ON N1G 4P7
eDNA@bvlabs.com

From USA, send to:
Bureau Veritas Laboratories
240 Portage Rd
Po Box 670, PMB 19
Lewiston NY 149092-1604

ENVIRONMENTAL DNA (eDNA) CHAIN OF CUSTODY RECORD

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Address:	2 Bluewater Road, Suite 115 Halifax, NS, B4B 1G7	Address:	Same	Project #:	17-175	PLEASE REQUEST RUSH FROM CUSTOMER SERVICE
				Site Location:	Beaver Dam	Rush TAT (Surcharges will be applied)
Phone:	782-233-1717 Fax:	Phone:	(902) 817-2444 Fax:	Sampled By:	MMD	☐ 5 business days (Sample # ≤ 50) ☐ 10 business days (Sample # > 50) From date received
Email:	olena@mccallumenvironmental.com	Email:	melanie@mccallumenvironmental.com	Note:1		

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Number	7 Sample Identification	8 Date Sampled (YYYY/MM/DD)	9 Date Filtered and Preserved (YYYY/MM/DD)	10 Filter Material	11 Filter Size (Diameter)	12 Filter Pore Size (µm)	13 Preservation Method (Ethanol / Silica)	14 Assays Requested[1]	15 Comments
1	6A	2020-07-09	2020-07-09	CN	as provided by BV	45	Silica	eFish	
2	6B	2020-07-09	2020-07-09	CN	as provided by BV	45	Silica	eFish	
3	6C	2020-07-09	2020-07-09	CN	as provided by BV	45	Silica	eFish	
4	Blank	2020-07-09	2020-07-09	CN	as provided by BV	45	Silica	eFish	
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									

16 RELINQUISHED BY: (Signature/Print)	17 DATE: (YYYY/MM/DD)	18 TIME: (HH:MM)	RECEIVED BY: (Signature/Print)	DATE: (YYYY/MM/DD) TIME: (HH:MM)	CASE RANGE
Melanie MacDonald	2020-07-13		rec'd by Joom L. Imported by Ali M	For Lab Use Only 2020/07/17 11:24	

[1] **Available Assays at Bureau Veritas Laboratories: AMMV**[2] (Western tiger salamander), **ANBO** (Western toad), **ASMO** (Rocky mountain tailed frog), **eFish**[3] (General fish assay), **LICA** (North American bullfrog), **ONCL** (Cutthroat trout), **ONKI** (Coho salmon), **ONMY** (Rainbow trout - Steelhead trout), **ONNE** (Sockeye Salmon), **ONTS** (Chinook salmon), **RAAU** (Northern red-legged frog), **RAPR** (Oregon spotted frog), **SOBE** (Pacific water shrew), **THAR** (Arctic grayling), **ASTR** (Pacific (Coastal) tailed frog), **MISA** (Largemouth Bass) and **ESLU** (Northern Pike)

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[3] **eFish** assay can detect DNA from 12 fish species (Sockeye salmon, Pink salmon, Chum salmon, Arctic grayling, Cutthroat trout, Rainbow trout, Chinook salmon, Coho salmon, Atlantic Salmon, Dolly Varden, Round Whitefish and Slimy Sculpin). This assay is designed to be non-specific. It may detect eDNA from other fish species in addition or instead of the specific species listed here, which the assay has been validated for.

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Unit 2 - 335 Laird Road
Guelph, ON N1G 4P7

Phone: (519) 836-2400
Toll Free: (877) 706-7678
Fax: (519) 836-4218
www.bvlabs.com

APPENDIX E: TRAPPING EFFORTS & RESULTS

Table 1. 2019-2020 Fish Sampling Program Results: Trapping

Survey Season	Survey Date	Location			Survey Type	Survey Effort	Results
		Easting	Northing	Site			
Summer 2019	09-Sep-19	520058	4990169	WC21	Minnow trap	21 hrs, 15 mins	No fish
	09-Sep-19	520080	4989952	WC20	Minnow trap	21 hrs	No fish
	09-Sep-19	520087	4989847	WC20	Minnow trap	20 hrs, 30 mins	No fish
	09-Sep-19	520274	4989780	WC20	Minnow trap	20 hrs, 10 mins	No fish
	17-Sep-19	520058	4990169	WC21	Minnow trap	22 hrs, 30 mins	No fish
	17-Sep-19	520080	4989952	WC20	Minnow trap	22 hrs	No fish
	17-Sep-19	520087	4989847	WC20	Minnow trap	22 hrs, 10 mins	No fish
	17-Sep-19	520274	4989780	WC20	Minnow trap	20 hrs, 20 mins	No fish
Fall 2019	06-Nov-19	520058	4990169	WC21	Minnow trap	25 hrs, 10 mins	No fish
	06-Nov-19	520080	4989952	WC20	Minnow trap	24 hrs, 40 mins	No fish
	06-Nov-19	520087	4989847	WC20	Minnow trap	24 hrs, 15 mins	No fish
	06-Nov-19	520274	4989780	WC20	Minnow trap	25 hrs	No fish
	06-Nov-19	519711	4989280	WC23	Minnow trap	25 hrs, 25 mins	No fish
	06-Nov-19	519711	4989280	WC23	Minnow trap	25 hrs, 25 mins	No fish
	21-Nov-19	520058	4990169	WC21	Minnow trap	23 hrs, 55 mins	No fish
	21-Nov-19	520080	4989952	WC20	Minnow trap	23 hrs, 20 mins	No fish
	21-Nov-19	520080	4989952	WC20	Minnow trap	23 hrs, 20 mins	No fish
	21-Nov-19	520052	4989847	WC20	Minnow trap	22 hrs, 55 mins	No fish
	21-Nov-19	520087	4989847	WC20	Minnow trap	22 hrs, 55 mins	No fish
	21-Nov-19	520274	4989780	WC20	Minnow trap	22 hrs, 30 mins	No fish
	21-Nov-19	519711	4989280	WC23	Minnow trap	28 hrs	No fish
	21-Nov-19	519711	4989280	WC23	Minnow trap	28 hrs	No fish
	21-Nov-19	519711	4989280	WC23	Fyke net	28 hrs	1 Brook Trout
	04-Dec-19	520058	4990169	WC21	Minnow trap	25 hrs	No fish
	04-Dec-19	520080	4989952	WC20	Minnow trap	25 hrs	No fish
	04-Dec-19	520080	4989952	WC20	Minnow trap	25 hrs	No fish

Survey Season	Survey Date	Location			Survey Type	Survey Effort	Results
		Easting	Northing	Site			
	04-Dec-19	520052	4989847	WC20	Minnow trap	25 hrs	No fish
	04-Dec-19	520087	4989847	WC20	Minnow trap	25 hrs	No fish
	04-Dec-19	520274	4989780	WC20	Minnow trap	25 hrs	No fish
	04-Dec-19	519711	4989280	WC23	Minnow trap	27 hrs, 20 mins	No fish
	04-Dec-19	519711	4989280	WC23	Minnow trap	27 hrs, 20 mins	No fish
	04-Dec-19	519711	4989280	WC23	Fyke net	27 hrs, 25 mins	No fish
	16-Dec-19	520058	4990169	WC21	Minnow trap	24 hrs, 40 mins	No fish
	16-Dec-19	520080	4989952	WC20	Minnow trap	24 hrs, 25 mins	No fish
	16-Dec-19	520080	4989952	WC20	Minnow trap	24 hrs, 25 mins	No fish
	16-Dec-19	520052	4989847	WC20	Minnow trap	24 hrs, 20 mins	No fish
	16-Dec-19	520087	4989847	WC20	Minnow trap	24 hrs, 20 mins	No fish
	16-Dec-19	520274	4989780	WC20	Minnow trap	24 hrs, 15 mins	No fish
	16-Dec-19	519711	4989280	WC23	Minnow trap	24 hrs, 30 mins	No fish
	16-Dec-19	519711	4989280	WC23	Minnow trap	24 hrs, 30 mins	No fish
	16-Dec-19	519711	4989280	WC23	Fyke net	24 hrs, 40 mins	No fish
Spring 2020 Spring 2020	08-Apr-20	520058	4990169	WC21	Minnow trap	24 hrs, 30 mins	No fish
	08-Apr-20	520080	4989952	WC20	Minnow trap	24 hrs	No fish
	08-Apr-20	520080	4989952	WC20	Minnow trap	24 hrs	No fish
	08-Apr-20	520052	4989847	WC20	Minnow trap	23 hrs, 55 mins	No fish
	08-Apr-20	520087	4989847	WC20	Minnow trap	23 hrs, 55 mins	No fish
	08-Apr-20	520274	4989780	WC20	Minnow trap	23 hrs, 50 mins	No fish
	08-Apr-20	519711	4989280	WC23	Minnow trap	23 hrs, 40 mins	No fish
	08-Apr-20	519711	4989280	WC23	Minnow trap	23 hrs, 35 mins	No fish
	08-Apr-20	519711	4989280	WC23	Fyke net	23 hrs, 35 mins	No fish
	22-Apr-20	520058	4990169	WC21	Minnow trap	24 hrs, 10 mins	No fish
	22-Apr-20	520080	4989952	WL205	Minnow trap	24 hrs, 10 mins	No fish
	22-Apr-20	520080	4989952	WL205	Minnow trap	24 hrs, 10 mins	No fish
	22-Apr-20	4989847	520052	WC22	Minnow trap	24 hrs, 10 mins	No fish

Survey Season	Survey Date	Location			Survey Type	Survey Effort	Results
		Easting	Northing	Site			
	22-Apr-20	4989847	4989847	WC22	Minnow trap	24 hrs, 10 mins	No fish
	22-Apr-20	4989780	520274	WC20	Minnow trap	24 hrs, 5 mins	No fish
	22-Apr-20	520051	4989887	WC20	Eel pot	21 hrs, 5 mins	No fish
	22-Apr-20	520058	4989900	WC20	Minnow trap	21 hrs, 30 mins	No fish
	22-Apr-20	519712	4989311	WC23	Fyke net	21 hrs, 55 mins	No fish
	22-Apr-20	519711	4989280	WC23	Minnow trap	21 hrs, 30 mins	No fish
	22-Apr-20	519711	4989280	WC23	Eel pot	21 hrs, 35 mins	1 Brook Trout
	22-Apr-20	519711	4989280	WC23	Fyke net	21 hrs, 30 mins	No fish
	13-May-20	520041	4990195	WL220	Minnow trap	46 hrs, 20 mins	No fish
	13-May-20	520038	4990178	WL220	Minnow trap	46 hrs, 15 mins	No fish
	13-May-20	520057	4990172	WC21	Minnow trap	46 hrs, 10 mins	No fish
	13-May-20	520069	4990163	WC21	Minnow trap	46 hrs, 10 mins	No fish
	13-May-20	520078	4990156	WC21	Minnow trap	46 hrs, 5 mins	No fish
	13-May-20	520083	4990149	WC21	Minnow trap	46 hrs, 5 mins	No fish
	13-May-20	520087	4989948	WL205	Minnow trap	46 hrs, 25 mins	No fish
	13-May-20	520086	4989943	WL205	Minnow trap	46 hrs, 25 mins	No fish
	13-May-20	520079	4989941	WL205	Minnow trap	46 hrs, 15 mins	No fish
	13-May-20	519937	4990198	WL220	Eel pot	46 hrs, 25 mins	No fish
	13-May-20	520087	4989944	WL205	Eel pot	46 hrs, 20 mins	No fish
	13-May-20	520052	4989885	WC20	Minnow trap	47 hrs	No fish
	13-May-20	520049	4989874	WC20	Minnow trap	47 hrs	No fish
	13-May-20	520041	4989802	WC20	Minnow trap	46 hrs, 20 mins	No fish
	13-May-20	520039	4989796	WC20	Minnow trap	46 hrs, 20 mins	No fish
	13-May-20	520042	4989793	WC20	Minnow trap	46 hrs, 20 mins	No fish
	13-May-20	520052	4989870	WC20	Eel pot	47 hrs	No fish
	13-May-20	520041	4989796	WC20	Eel pot	46 hrs, 20 mins	No fish
	13-May-20	520050	4989894	WC20	Fyke net	47 hrs, 20 mins	No fish
	13-May-20	520029	4989788	WC20	Minnow trap	23 hrs, 40 mins	No fish

Survey Season	Survey Date	Location			Survey Type	Survey Effort	Results
		Easting	Northing	Site			
	13-May-20	520031	4989784	WC20	Minnow trap	23 hrs, 40 mins	No fish
	13-May-20	519705	4989290	WC23	Minnow trap	47 hrs, 5 mins	1 Brook Trout
	13-May-20	519706	4989292	WC23	Minnow trap	47 hrs, 15 mins	No fish
	13-May-20	519706	4989289	WC23	Minnow trap	47 hrs, 5 mins	No fish
	13-May-20	519706	4989278	WC23	Fyke net	46 hrs, 45 mins	No fish
	13-May-20	519708	4989296	WC23	Minnow trap	47 hrs,15 mins	No fish
	13-May-20	519708	4989296	WC23	Minnow trap	47 hrs, 15 mins	No fish
	13-May-20	519708	4989321	WC23	Eel pot	47 hrs, 20 mins	No fish
	13-May-20	519709	4989295	WC23	Minnow trap	47 hrs, 15 mins	No fish
	18-May-20	520061	4989921	WC20	Minnow trap	48 hrs, 45 mins	No fish
	18-May-20	520063	4989917	WC20	Minnow trap	48 hrs, 45 mins	No fish
	18-May-20	520079	4989938	WL205	Minnow trap	48 hrs, 30 mins	No fish
	18-May-20	520079	4989933	WL205	Minnow trap	48 hrs, 30 mins	No fish
	18-May-20	520087	4989949	WL205	Minnow trap	48 hrs, 30 mins	No fish
	18-May-20	520022	4990184	WL220	Minnow trap	49 hrs	No fish
	18-May-20	519924	4990202	WL220	Eel pot	48 hrs, 50 mins	No fish
	18-May-20	520017	4989780	WC20	Eel pot	48 hrs, 50 mins	No fish
	18-May-20	520016	4989783	WC20	Minnow trap	48 hrs, 50 mins	No fish
	18-May-20	520011	4989776	WC20	Minnow trap	48 hrs, 50 mins	No fish
	18-May-20	520010	4989776	WC20	Minnow trap	48 hrs, 45 mins	No fish
	18-May-20	520004	4989774	WC20	Minnow trap	48 hrs, 45 mins	No fish
	18-May-20	519999	4989768	WC20	Minnow trap	48 hrs, 40 mins	No fish
	18-May-20	520057	4989909	WC20	Eel pot	49 hrs	No fish
	18-May-20	520055	4989897	WC20	Fyke net	48 hrs, 50 mins	No fish
	18-May-20	519699	4989329	WC23	Minnow trap	48 hrs, 10 mins	No fish
	18-May-20	519703	4989310	WC23	Minnow trap	48 hrs, 25 mins	No fish
	18-May-20	519703	4989327	WC23	Minnow trap	48 hrs, 10 mins	No fish
	18-May-20	519705	4989312	WC23	Minnow trap	48 hrs, 30 mins	No fish

Survey Season	Survey Date	Location			Survey Type	Survey Effort	Results
		Easting	Northing	Site			
	18-May-20	519707	4989314	WC23	Minnow trap	48 hrs, 20 mins	No fish
	18-May-20	519707	4989318	WC23	Eel pot	48 hrs, 15 mins	2 Brook Trout
	18-May-20	519708	4989312	WC23	Minnow trap	48 hrs, 20 mins	No fish
	18-May-20	519711	4989280	WC23	Fyke net	48 hrs, 35 mins	No fish
	18-May-20	519711	4989321	WC23	Eel pot	48 hrs, 10 mins	1 Brook Trout
	18-May-20	520041	4990189	WC23	Minnow trap	48 hrs, 55 mins	No fish
	18-May-20	520088	4989950	WC23	Eel pot	48 hrs, 40 mins	No fish
	18-May-20	520090	4990145	WC23	Minnow trap	49 hrs	No fish
	18-May-20	520100	4990139	WC23	Minnow trap	48 hrs, 55 mins	No fish
	18-May-20	520100	4990135	WC23	Minnow trap	48 hrs, 55 mins	No fish
	20-May-20	520022	4990184	WC21	Minnow trap	47 hrs	No fish
	20-May-20	520041	4990189	WC21	Minnow trap	47 hrs	No fish
	20-May-20	519929	4990202	WC21	Eel pot	47 hrs	No fish
	20-May-20	520076	4989789	WC20	Eel pot	47 hrs, 30 mins	No fish
	20-May-20	520080	4989787	WC20	Minnow trap	47 hrs, 30 mins	No fish
	20-May-20	520066	4989784	WC20	Minnow trap	47 hrs, 35 mins	No fish
	20-May-20	519999	4989757	WC20	Minnow trap	47 hrs, 30 mins	No fish
	20-May-20	519995	4989746	WC20	Minnow trap	47 hrs, 30 mins	No fish
	20-May-20	520005	4989734	WC20	Minnow trap	47 hrs, 30 mins	No fish
	20-May-20	520059	4989890	WC20	Eel pot	47 hrs, 25 mins	No fish
	20-May-20	520055	4989897	WC20	Fyke net	47 hrs, 40 mins	No fish
	20-May-20	520053	4989883	WC20	Minnow trap	47 hrs, 25 mins	No fish
	20-May-20	520057	4989878	WC20	Minnow trap	47 hrs, 20 mins	No fish
	20-May-20	520062	4989873	WC20	Eel pot	47 hrs, 20 mins	No fish
	20-May-20	520061	4989867	WC20	Minnow trap	47 hrs, 15 mins	No fish
	20-May-20	520060	4989876	WC20	Minnow trap	47 hrs, 20 mins	No fish
	20-May-20	520055	4989892	WC20	Minnow trap	47 hrs, 15 mins	No fish
	20-May-20	520090	4990145	WC20	Minnow trap	47 hrs 10 mins	No fish

Survey Season	Survey Date	Location			Survey Type	Survey Effort	Results
		Easting	Northing	Site			
	20-May-20	520100	4990139	WC20	Minnow trap	47 hrs, 10 mins	No fish
	20-May-20	520100	4990135	WC20	Minnow trap	47 hrs, 10 mins	No fish
	20-May-20	520100	4990124	WC20	Minnow trap	47 hrs, 10 mins	No fish
	20-May-20	519684	4989376	WC23	Minnow trap	47 hrs, 30 mins	No fish
	20-May-20	519685	4989370	WC23	Minnow trap	47 hrs, 35 mins	No fish
	20-May-20	519686	4989373	WC23	Minnow trap	47 hrs, 35 mins	No fish
	20-May-20	519688	4989366	WC23	Minnow trap	47 hrs, 35 mins	No fish
	20-May-20	519693	4989358	WC23	Minnow trap	47 hrs, 35 mins	No fish
	20-May-20	519697	4989351	WC23	Minnow trap	47 hrs, 35 mins	No fish
	20-May-20	519701	4989329	WC23	Eel pot	47 hrs, 15 mins	1 Brook Trout
	20-May-20	519704	4989325	WC23	Eel pot	47 hrs, 15 mins	1 Brook Trout
	20-May-20	519711	4989280	WC23	Fyke net	47 hrs, 50 mins	No fish
	25-May-20	519680	4989382	WC21	Minnow trap	97 hrs, 50 mins	No fish
	25-May-20	519680	49809382	WC21	Minnow trap	97 hrs, 50 mins	No fish
	25-May-20	519670	4989458	WC21	Fyke net	24 hrs, 25 mins	No fish
	25-May-20	519679	4989471	WC21	Eel pot	95 hrs, 40 mins	No fish
	25-May-20	519978	4989699	WC20	Minnow trap	38 hrs, 30 mins	No fish
	25-May-20	519989	4989706	WC20	Minnow trap	95 hrs, 50 mins	No fish
	25-May-20	519993	4989720	WC20	Minnow trap	38 hrs, 30 mins	No fish
	25-May-20	520111	4989792	WC22	Minnow trap	38 hrs, 25 mins	No fish
	25-May-20	520086	4989787	WC22	Minnow trap	38 hrs, 30 mins	No fish
	25-May-20	520044	4989815	WC20	Minnow trap	39 hrs, 10 mins	No fish
	25-May-20	520046	4989817	WC20	Minnow trap	38 hrs, 10 mins	No fish
	25-May-20	520043	4989827	WC20	Minnow trap	38 hrs, 10 mins	No fish
	25-May-20	520054	4989834	WC20	Minnow trap	95 hrs, 55 mins	No fish
	25-May-20	520052	4989843	WC20	Minnow trap	95 hrs, 45 mins	No fish
	25-May-20	520049	4989845	WC20	Minnow trap	95 hrs, 50 mins	No fish
	25-May-20	520054	4989874	WC20	Minnow trap	23 hrs, 35 mins	No fish

Survey Season	Survey Date	Location			Survey Type	Survey Effort	Results
		Easting	Northing	Site			
	25-May-20	520054	4989874	WC20	Minnow trap	23 hrs, 35 mins	No fish
	25-May-20	520054	4989874	WC20	Minnow trap	23 hrs, 35 mins	No fish
	25-May-20	520052	4989893	WC20	Fyke net	95 hrs, 45 mins	No fish
	25-May-20	520059	4989860	WC20	Eel pot	96 hrs, 10 mins	No fish
	25-May-20	520052	4989830	WC20	Eel pot	96 hrs	No fish
	25-May-20	519664	4989466	WC23	Minnow trap	24 hrs, 40 mins	No fish
	25-May-20	519664	4989454	WC23	Minnow trap	24 hrs, 30 mins	No fish
	25-May-20	519671	4989466	WC23	Minnow trap	24 hrs, 45 mins	No fish
	25-May-20	519676	4889415	WC23	Minnow trap	50 hrs	No fish
	25-May-20	519676	4989395	WC23	Minnow trap	24 hrs, 15 mins	No fish
	25-May-20	519677	4989419	WC23	Minnow trap	26 hrs	No fish
	25-May-20	519709	4989280	WC23	Eel pot	95 hrs, 35 mins	No fish
	26-May-20	520057	4989864	WC20	Minnow trap	26 hrs, 30 mins	No fish
	26-May-20	520054	4989860	WC20	Minnow trap	26 hrs, 30 mins	No fish
	26-May-20	520058	4989869	WC20	Minnow trap	26 hrs, 30 mins	No fish
	26-May-20	519660	4989450	WC23	Minnow trap	25 hrs, 25 mins	No fish
	26-May-20	519670	4989458	WC23	Minnow trap	25 hrs, 20 mins	No fish
	26-May-20	519679	4989471	WC23	Minnow trap	25 hrs, 15 mins	No fish
	26-May-20	519680	4989382	WC23	Minnow trap	25 hrs, 40 mins	No fish
	26-May-20	519710	498318	WC23	Fyke net	67 hrs, 45 mins	No fish
	27-May-20	520061	4989912	WC20	Minnow trap	45 hrs, 50 mins	No fish
	27-May-20	519995	4989718	WC20	Minnow trap	45 hrs, 30 mins	No fish
	27-May-20	519995	4989722	WC20	Minnow trap	45 hrs, 20 mins	No fish
	27-May-20	520119	4989793	WC22	Minnow trap	44 hrs, 50 mins	No fish
	27-May-20	520123	4989801	WC22	Minnow trap	45 hrs, 50 mins	No fish
	27-May-20	520061	4989905	WC20	Minnow trap	45 hrs, 50 mins	No fish
	27-May-20	520058	4989901	WC20	Minnow trap	45 hrs, 50 mins	No fish
	27-May-20	519684	4989468	WC23	Minnow trap	22 hrs, 10 mins	No fish

Survey Season	Survey Date	Location			Survey Type	Survey Effort	Results
		Easting	Northing	Site			
	27-May-20	519688	4989479	WC23	Minnow trap	22 hrs, 5 mins	No fish
	27-May-20	519695	4989486	WC23	Minnow trap	22 hrs, 5 mins	No fish
	27-May-20	519701	4989494	WC23	Minnow trap	22 hrs, 5 mins	No fish
	27-May-20	519707	4989497	WC23	Minnow trap	22 hrs, 5 mins	No fish
	27-May-20	519708	4989501	WC23	Minnow trap	22 hrs, 5 min	No fish
	28-May-20	519678	4989469	WC20	Minnow trap	23 hrs, 50 mins	No fish
	28-May-20	519670	4989457	WC20	Minnow trap	23 hrs, 45 mins	No fish
	28-May-20	519659	4989449	WC20	Minnow trap	23 hrs, 35 mins	No fish
	28-May-20	520057	4989863	WC20	Minnow trap	23 hrs, 30 mins	No fish
	28-May-20	520054	4989858	WC20	Minnow trap	23 hrs, 25 mins	No fish
	28-May-20	519679	4989387	WC20	Minnow trap	23 hrs, 15 mins	No fish
Summer 2020	08-Jun-20	521209	4990125	Crusher Lake	Minnow trap	23 hrs, 5 mins	No fish
	08-Jun-20	521213	4990116	Crusher Lake	Minnow trap	23 hrs, 5 mins	No fish
	08-Jun-20	521264	4990119	Crusher Lake	Minnow trap	23 hrs	No fish
	08-Jun-20	521275	4990119	Crusher Lake	Minnow trap	23 hrs	No fish
	08-Jun-20	521292	4990126	Crusher Lake	Minnow trap	23 hrs	No fish
	08-Jun-20	521161	4990136	Crusher Lake	Minnow trap	22 hrs, 50 mins	1 Ninespine Stickleback
	08-Jun-20	521136	4990137	Crusher Lake	Minnow trap	23 hrs, 35 mins	No fish
	08-Jun-20	521111	4990158	Crusher Lake	Minnow trap	23 hrs, 35 mins	No fish
	08-Jun-20	521099	4990157	Crusher Lake	Minnow trap	23 hrs, 35 mins	No fish
	08-Jun-20	521093	4990157	Crusher Lake	Minnow trap	23 hrs, 35 mins	No fish
	08-Jun-20	521187	4990141	Crusher Lake	Eel pot	23 hrs, 25 mins	No fish
	08-Jun-20	521171	4990138	Crusher Lake	Eel pot	23 hrs, 25 mins	No fish
	08-Jun-20	521148	4990141	Crusher Lake	Eel pot	25 hrs, 40 mins	No fish
	08-Jun-20	521169	4990139	Crusher Lake	Fyke net	25 hrs, 10 mins	2 Brook Trout
	09-Jun-20	522264	4990380	WL59	Minnow trap	24 hrs, 35 mins	9 Golden Shiners
	09-Jun-20	522314	4990366	WL59	Minnow trap	25 hrs, 5 mins	23 Golden Shiners
	09-Jun-20	522331	4990347	WL59	Minnow trap	25 hrs, 10 mins	15 Golden Shiners

Survey Season	Survey Date	Location			Survey Type	Survey Effort	Results
		Easting	Northing	Site			
	09-Jun-20	522335	4990328	WL59	Minnow trap	25 hrs, 25 mins	9 Golden Shiners
	09-Jun-20	522345	4990334	WL59	Minnow trap	25 hrs, 30 mins	No fish
	09-Jun-20	522393	4990313	WL59	Minnow trap	25 hrs, 30 mins	No fish
	09-Jun-20	522434	4990296	WL59	Minnow trap	25 hrs, 30 mins	No fish
	09-Jun-20	522474	4990283	WL59	Minnow trap	25 hrs, 35 mins	137 Banded Killifish
	09-Jun-20	522482	4990284	WL59	Minnow trap	25 hrs, 45 mins	54 Banded Killifish
	09-Jun-20	522502	4990259	WL59	Minnow trap	25 hrs, 40 mins	33 Banded Killifish
	09-Jun-20	522285	4990374	WL59	Eel pot	24 hrs, 55 mins	7 Brown Bullheads and 1 Brook Trout
	09-Jun-20	522328	4990337	WL59	Eel pot	25 hrs, 20 mins	No fish
	09-Jun-20	522420	4990300	WL59	Eel pot	25 hrs, 30 mins	3 Brown Bullheads
	09-Jun-20	522243	4990385	WL59	Fyke net	24 hrs, 40 mins	1 Brook Trout
	10-Jun-20	522742	4990319	Cameron flowage	Minnow trap	21 hrs, 45 mins	No fish
	10-Jun-20	522744	4990318	Cameron flowage	Minnow trap	21 hrs, 45 mins	25 Banded Killifish and 1 White Sucker
	10-Jun-20	522747	4990313	Cameron flowage	Minnow trap	21 hrs, 45 mins	No fish
	10-Jun-20	522774	4990298	Cameron flowage	Minnow trap	21 hrs, 40 mins	7 Banded Killifish
	10-Jun-20	522782	4990295	Cameron flowage	Minnow trap	21 hrs, 40 mins	No fish
	10-Jun-20	522784	4990297	Cameron flowage	Minnow trap	21 hrs, 40 mins	No fish
	10-Jun-20	522789	4990294	Cameron flowage	Minnow trap	21 hrs, 40 mins	3 Banded Killifish, 1 American Eel and 1 Golden Shiner
	10-Jun-20	522792	4990295	Cameron flowage	Minnow trap	21 hrs, 40 mins	7 Banded Killifish, 1 White Sucker and 1 Yellow Perch
	10-Jun-20	522794	4990295	Cameron flowage	Minnow trap	21 hrs, 40 mins	3 Banded Killifish
	10-Jun-20	522800	4990293	Cameron flowage	Minnow trap	21 hrs, 40 mins	3 Banded Killifish
	10-Jun-20	522749	4990315	Cameron flowage	Eel pot	21 hrs, 45 mins	1 Yellow Perch
	10-Jun-20	522759	4990308	Cameron flowage	Eel pot	21 hrs, 45 mins	No fish
	10-Jun-20	522777	4990299	Cameron flowage	Eel pot	21 hrs, 45 mins	No fish
	10-Jun-20	522766	4990306	Cameron flowage	Fyke net	21 hrs, 25 mins	No fish
	15-Jun-20	521231	4991175	Mud lake and outlet	Minnow trap	24 hrs	38 Golden Shiners and 1 White Sucker

Survey Season	Survey Date	Location			Survey Type	Survey Effort	Results
		Easting	Northing	Site			
	15-Jun-20	521234	4991172	Mud lake and outlet	Minnow trap	24 hrs, 35 mins	3 Golden Shiners
	15-Jun-20	521250	4991143	Mud lake and outlet	Minnow trap	24 hrs	24 Golden Shiners
	15-Jun-20	521250	4991141	Mud lake and outlet	Minnow trap	24 hrs	No fish
	15-Jun-20	521339	4991057	Mud lake and outlet	Minnow trap	24 hrs	20 Golden Shiners
	15-Jun-20	521417	4990926	Mud lake and outlet	Minnow trap	24 hrs	3 Banded Killifish
	15-Jun-20	521429	4990907	Mud lake and outlet	Minnow trap	24 hrs	44 Golden Shiners, 1 Banded Killifish and 1 Ninespine Stickleback
	15-Jun-20	521429	4990900	Mud lake and outlet	Minnow trap	24 hrs	5 Golden Shiners and 3 Banded Killifish
	15-Jun-20	521419	4990893	Mud lake and outlet	Minnow trap	24 hrs	28 Golden Shiners and 1 Ninespine Stickleback
	15-Jun-20	521405	4990882	Mud lake and outlet	Minnow trap	24 hrs	7 Banded Killifish, 5 Ninespine Stickleback and 3 Golden Shiners
	15-Jun-20	521231	4991176	Mud lake and outlet	Eel pot	24 hrs	No fish
	15-Jun-20	521341	4991059	Mud lake and outlet	Eel pot	24 hrs	4 White Suckers and 1 Yellow Perch
	15-Jun-20	521407	4990954	Mud lake and outlet	Eel pot	24 hrs	4 Banded Killifish and 1 American Eel
	15-Jun-20	521352	4991027	Mud lake and outlet	Fyke net	24 hrs	25 White Suckers, 7 Yellow Perch, 1 Brown Bullhead, 1 Brook Trout, and 1 American Eel
	06-Jul-20	522274	4990374	WL59	Minnow trap	23 hrs, 35 mins	23 Golden Shiners and 1 Ninespine Stickleback
	06-Jul-20	522286	4990364	WL59	Minnow trap	23 hrs, 30 mins	45 Golden Shiners
	06-Jul-20	522329	4990338	WL59	Minnow trap	24 hrs	19 Golden Shiners
	06-Jul-20	522346	4990325	WL59	Minnow trap	24 hrs	No fish
	06-Jul-20	522398	4990301	WL59	Minnow trap	24 hrs, 10 mins	No fish
	06-Jul-20	522410	4990296	WL59	Minnow trap	24 hrs, 10 mins	No fish
	06-Jul-20	522467	4990259	WL59	Minnow trap	24 hrs, 15 mins	2 Banded Killifish
	06-Jul-20	522474	4990249	WL59	Minnow trap	24 hrs, 10 mins	No fish
	06-Jul-20	522481	4990273	WL59	Minnow trap	24 hrs, 15 mins	19 Banded Killifish
	06-Jul-20	522494	4990273	WL59	Minnow trap	24 hrs, 10 mins	No fish

Survey Season	Survey Date	Location			Survey Type	Survey Effort	Results
		Easting	Northing	Site			
	06-Jul-20	522233	4990377	WL59	Eel pot	23 hrs, 25 mins	2 Golden Shiners
	06-Jul-20	522279	4990366	WL59	Eel pot	23 hrs, 20 mins	No fish
	06-Jul-20	522239	4990380	WL59	Fyke net	23 hrs, 25 mins	1 Brown Bullhead and 1 Golden Shiner
	07-Jul-20	521199	4990125	Crusher Lake	Eel pot	18 hrs, 10 mins	No fish
	07-Jul-20	521184	4990131	Crusher Lake	Minnow trap	18 hrs, 10 mins	No fish
	07-Jul-20	521173	4990131	Crusher Lake	Minnow trap	18 hrs, 05 mins	No fish
	07-Jul-20	521162	4990132	Crusher Lake	Minnow trap	18 hrs	No fish
	07-Jul-20	521154	4990136	Crusher Lake	Minnow trap	17 hrs, 55 mins	No fish
	07-Jul-20	521154	4990136	Crusher Lake	Minnow trap	17 hrs, 55 mins	No fish
	07-Jul-20	521207	4990120	Crusher Lake	Minnow trap	18 hrs, 30 mins	No fish
	07-Jul-20	521232	4990125	Crusher Lake	Eel pot	17 hrs, 40 mins	No fish
	07-Jul-20	521285	4990116	Crusher Lake	Minnow trap	17 hrs, 45 mins	No fish
	07-Jul-20	521289	4990120	Crusher Lake	Minnow trap	17 hrs, 45 mins	No fish
	07-Jul-20	521303	4990120	Crusher Lake	Minnow trap	17 hrs, 40 mins	No fish
	07-Jul-20	521317	4990115	Crusher Lake	Minnow trap	17 hrs, 45 mins	No fish
	07-Jul-20	521169	4990136	Crusher Lake	Fyke net	17 hrs, 25 mins	1 Golden Shiner and 1 Brook Trout
	07-Jul-20	522734	4990337	Cameron flowage	Minnow trap	25 hrs, 55 mins	No fish
	07-Jul-20	522734	4990338	Cameron flowage	Minnow trap	25 hrs, 55 mins	7 Banded Killifish and 3 Creek Chubs
	07-Jul-20	522743	4990321	Cameron flowage	Minnow trap	25 hrs, 55 mins	No fish
	07-Jul-20	522750	4990312	Cameron flowage	Minnow trap	25 hrs, 55 mins	No fish
	07-Jul-20	522756	4990309	Cameron flowage	Minnow trap	25 hrs, 55 mins	33 Banded Killifish
	07-Jul-20	522776	4990298	Cameron flowage	Minnow trap	26 hrs, 5 mins	10 Banded Killifish
	07-Jul-20	522791	4990295	Cameron flowage	Minnow trap	26 hrs, 5 mins	65 Banded Killifish
	07-Jul-20	522818	4990295	Cameron flowage	Minnow trap	26 hrs, 5 mins	24 Banded Killifish
	07-Jul-20	522842	4990289	Cameron flowage	Minnow trap	26 hrs	No fish
	07-Jul-20	522866	4990288	Cameron flowage	Minnow trap	26 hrs	40 Banded Killifish
	07-Jul-20	522735	4990365	Cameron flowage	Eel pot	25 hrs, 50 mins	No fish
	07-Jul-20	522789	4990288	Cameron flowage	Eel pot	25 hrs, 50 mins	1 White Sucker

Survey Season	Survey Date	Location			Survey Type	Survey Effort	Results
		Easting	Northing	Site			
	07-Jul-20	522767	4990308	Cameron flowage	Fyke net	26 hrs, 10 mins	No fish
	07-Jul-20	5212356	4990876	Mud lake and outlet	Fyke net	27 hrs	No fish
	07-Jul-20	521416	4990892	Mud lake and outlet	Eel pot	27 hrs	3 Yellow Perch, 2 White Suckers, and 1 Banded Killifish
	07-Jul-20	521417	4990889	Mud lake and outlet	Minnow trap	27 hrs	3 Golden Shiners and 1 Lake Chub
	07-Jul-20	521411	4990884	Mud lake and outlet	Minnow trap	27 hrs	15 Golden Shiners
	07-Jul-20	521399	4990883	Mud lake and outlet	Minnow trap	27 hrs	34 Golden Shiners
	07-Jul-20	521373	4990870	Mud lake and outlet	Minnow trap	27 hrs	No fish
	07-Jul-20	521429	4990885	Mud lake and outlet	Minnow trap	27 hrs	1 Golden Shiner and 1 Yellow Perch
	07-Jul-20	521330	4991075	Mud lake and outlet	Minnow trap	27 hrs	56 Golden Shiners and 24 Banded Killifish
	07-Jul-20	521330	4991084	Mud lake and outlet	Minnow trap	27 hrs	1 Yellow Perch
	07-Jul-20	521307	4991095	Mud lake and outlet	Minnow trap	27 hrs	17 Banded Killifish, 11 Golden Shiners, and 1 Yellow Perch
	07-Jul-20	521296	4991098	Mud lake and outlet	Minnow trap	27 hrs	No fish
	07-Jul-20	521288	4991103	Mud lake and outlet	Minnow trap	27 hrs	No fish
	07-Jul-20	521338	4991064	Mud lake and outlet	Eel pot	27 hrs	No fish
	25-Aug-20	522561	4990294	WL59	Minnow trap	24 hrs, 45 mins	No fish
	25-Aug-20	522559	4990274	WL59	Minnow trap	24 hrs, 45 mins	6 Banded Killifish
	25-Aug-20	522555	4990268	WL59	Minnow trap	24 hrs, 45 mins	No fish
	25-Aug-20	522555	4990264	WL59	Minnow trap	24 hrs, 45 mins	No fish
	25-Aug-20	522547	4990269	WL59	Minnow trap	25 hrs, 15 mins	3 Banded Killifish
	25-Aug-20	522547	4990272	WL59	Minnow trap	25 hrs, 15 mins	No fish
	25-Aug-20	522549	4990276	WL59	Minnow trap	25 hrs, 15 mins	No fish
	25-Aug-20	522548	4990281	WL59	Minnow trap	25 hrs, 15 mins	No fish
	25-Aug-20	522551	4990264	WL59	Fyke net	25 hrs, 35 mins	1 Brown Bullhead
	25-Aug-20	522551	4990261	WL59	Eel pot	25 hrs	7 Golden Shiners
	25-Aug-20	522545	4990266	WL59	Eel pots	25 hrs	No fish

Survey Season	Survey Date	Location			Survey Type	Survey Effort	Results
		Easting	Northing	Site			
	25-Aug-20	521155	4990137	Crusher Lake	Minnow trap	24 hrs, 50 mins	No fish
	25-Aug-20	521158	4990136	Crusher Lake	Minnow trap	24 hrs, 50 mins	No fish
	25-Aug-20	521162	4990134	Crusher Lake	Minnow trap	24 hrs, 50 mins	No fish
	25-Aug-20	521166	4990132	Crusher Lake	Minnow trap	24 hrs, 50 mins	No fish
	25-Aug-20	521186	4990133	Crusher Lake	Minnow trap	24 hrs, 50 mins	No fish
	25-Aug-20	521189	4990130	Crusher Lake	Minnow trap	24 hrs, 50 mins	No fish
	25-Aug-20	521205	4990126	Crusher Lake	Minnow trap	24 hrs, 50 mins	No fish
	25-Aug-20	521210	4990122	Crusher Lake	Minnow trap	24 hrs, 50 mins	No fish
	25-Aug-20	521174	4990132	Crusher Lake	Eel pot	24 hrs, 50 mins	No fish
	25-Aug-20	521184	4990133	Crusher Lake	Eel pots	24 hrs, 50 mins	No fish
	25-Aug-20	521173	4990134	Crusher Lake	Fyke net	24 hrs, 50 mins	No fish
	26-Aug-20	522477	4990652	Cameron flowage	Minnow trap	21 hrs, 5 mins	No fish
	26-Aug-20	522479	4990648	Cameron flowage	Minnow trap	21 hrs, 5 mins	13 Banded Killifish and 1 Yellow Perch
	26-Aug-20	522506	4990628	Cameron flowage	Minnow trap	21 hrs, 5 mins	8 Golden Shiner and 2 Banded Killifish
	26-Aug-20	522513	4990622	Cameron flowage	Minnow trap	21 hrs, 5 mins	4 Banded Killifish and 2 Yellow Perch
	26-Aug-20	522516	4990621	Cameron flowage	Minnow trap	21 hrs, 5 mins	No fish
	26-Aug-20	522519	4990618	Cameron flowage	Minnow trap	21 hrs, 5 mins	No fish
	26-Aug-20	522520	4990615	Cameron flowage	Minnow trap	21 hrs, 5 mins	1 Banded Killifish
	26-Aug-20	522525	4990613	Cameron flowage	Minnow trap	21 hrs, 5 mins	1 Banded Killifish
	26-Aug-20	522482	4990642	Cameron flowage	Eel pot	21 hrs, 5 mins	No fish
	26-Aug-20	522521	4990613	Cameron flowage	Eel pots	21 hrs, 5 mins	1 White Sucker
	26-Aug-20	522493	4990635	Cameron flowage	Fyke net	21 hrs, 10 mins	1 Brook Trout
	26-Aug-20	521233	4991165	Mud lake and outlet	Minnow trap	21 hrs, 45 mins	No fish
	26-Aug-20	521249	4991142	Mud lake and outlet	Minnow trap	21 hrs, 45 mins	No fish
	26-Aug-20	521282	4991102	Mud lake and outlet	Minnow trap	21 hrs, 35 mins	No fish
	26-Aug-20	521314	4991089	Mud lake and outlet	Minnow trap	21 hrs, 35 mins	No fish
	26-Aug-20	521406	4990956	Mud lake and outlet	Minnow trap	21 hrs, 20 mins	No fish
	26-Aug-20	521415	4990925	Mud lake and outlet	Minnow trap	21 hrs, 20 mins	No fish

Survey Season	Survey Date	Location			Survey Type	Survey Effort	Results
		Easting	Northing	Site			
	26-Aug-20	521428	4990892	Mud lake and outlet	Minnow trap	21 hrs, 20 mins	9 Golden Shiners, 4 Yellow Perch and 1 Banded Killifish
	26-Aug-20	521397	4990877	Mud lake and outlet	Minnow trap	21 hrs, 20 mins	No fish
	26-Aug-20	521253	4991138	Mud lake and outlet	Eel pot	21 hrs, 40 mins	No fish
	26-Aug-20	521286	4991100	Mud lake and outlet	Eel pots	21 hrs, 40 mins	1 White Sucker
	26-Aug-20	521330	4991075	Mud lake and outlet	Fyke net	21 hrs, 55 mins	8 Brown Bullheads, 5 White Suckers and 5 Yellow Perch

APPENDIX F: INDIVIDUAL FISH DATA

Survey Season	Survey Date	Site	Capture Method	Species	Fork Length (mm)	Total Length (mm)	Weight (g)
Spring	April 23, 2020	WC23	Eel Pot	Brook Trout	122	126	2.00
	May 15, 2020	WC23	Minnow Trap	Brook Trout	135	145	32.54
	May 19, 2020	WC23	Eel Pot	Brook Trout	115	120	20.30
	May 20, 2020	WC23	Eel Pot	Brook Trout	132.5	140	27
	May 20, 2020	WC23	Eel Pot	Brook Trout	135	142.5	26.3
	May 21, 2020	WC23	Eel Pot	Brook Trout	125	140	36
	May 21, 20200	WC23	Eel Pot	Brook Trout	135	145	32
Summer	June 9, 2020	Crusher Lake	Minnow Trap	Ninespine Stickleback	N/A	55	3.64
	June 9, 2020	Crusher Lake	Fyke Net	Brook Trout	135	140	29.55
	June 9, 2020	Crusher Lake	Fyke Net	Brook Trout	127	127	31.87
	June 10, 2020	WL59	Fyke Net	Brook Trout	135	140	26.73
	June 10, 2020	WL59	Minnow Trap	Golden Shiner	77	87	6
	June 10, 2020	WL59	Minnow Trap	Golden Shiner	55	60	4.39
	June 10, 2020	WL59	Minnow Trap	Golden Shiner	67	72	5.87
	June 10, 2020	WL59	Minnow Trap	Golden Shiner	81	86	5.41
	June 10, 2020	WL59	Minnow Trap	Golden Shiner	70	78	4.46
	June 10, 2020	WL59	Minnow Trap	Golden Shiner	64	68	3.34
	June 10, 2020	WL59	Minnow Trap	Golden Shiner	104	112	16.62
	June 10, 2020	WL59	Minnow Trap	Golden Shiner	60	65	4.95
	June 10, 2020	WL59	Minnow Trap	Golden Shiner	60	64	3.03
	June 10, 2020	WL59	Eel pot	Brown Bullhead	N/A	146	40.48
	June 10, 2020	WL59	Eel pot	Brown Bullhead	N/A	160	46.31
	June 10, 2020	WL59	Eel pot	Brown Bullhead	N/A	154	56.1
	June 10, 2020	WL59	Eel pot	Brown Bullhead	N/A	158	53.43
	June 10, 2020	WL59	Eel pot	Brown Bullhead	N/A	170	60.51
	June 10, 2020	WL59	Eel pot	Brook Trout	113	117	12.84
	June 10, 2020	WL59	Eel pot	Brown Bullhead	N/A	172	72.86
	June 10, 2020	WL59	Eel pot	Brown Bullhead	N/A	157	62.05
	June 10, 2020	WL59	Minnow Trap	Golden Shiner	70	75	6.78
	June 10, 2020	WL59	Minnow Trap	Golden Shiner	70	75	3.41
	June 10, 2020	WL59	Minnow Trap	Golden Shiner	71	77	8.07

Survey Season	Survey Date	Site	Capture Method	Species	Fork Length (mm)	Total Length (mm)	Weight (g)
	June 10, 2020	WL59	Minnow Trap	Golden Shiner	75	80	10.03
	June 10, 2020	WL59	Minnow Trap	Golden Shiner	58	63	8.11
	June 10, 2020	WL59	Minnow Trap	Golden Shiner	85	93	8.78
	June 10, 2020	WL59	Minnow Trap	Golden Shiner	80	85	8.45
	June 10, 2020	WL59	Minnow Trap	Golden Shiner	67	72	3.75
	June 10, 2020	WL59	Minnow Trap	Golden Shiner	65	68	3.23
	June 10, 2020	WL59	Minnow Trap	Golden Shiner	71	70	4.49
	June 10, 2020	WL59	Minnow Trap	Golden Shiner	65	75	2.93
	June 10, 2020	WL59	Minnow Trap	Golden Shiner	80	70	3.25
	June 10, 2020	WL59	Minnow Trap	12 Golden Shiners	Various	Various	Various
	June 10, 2020	WL59	Minnow Trap	16 Golden Shiners	Various	Various	Various
	June 10, 2020	WL59	Minnow Trap	10 Golden Shiners	Various	Various	Various
	June 10, 2020	WL59	Eel Pot	Brown Bullhead	N/A	161	48.25
	June 10, 2020	WL59	Eel Pot	Brown Bullhead	N/A	160	65
	June 10, 2020	WL59	Eel Pot	Brown Bullhead	N/A	153	53.42
	June 10, 2020	WL59	Minnow Trap	138 Banded Killifish	Various	Various	Various
	June 10, 2020	WL59	Minnow Trap	55 Banded Killifish	Various	Various	Various
	June 10, 2020	WL59	Minnow Trap	34 Banded Killifish	Various	Various	Various
	June 10, 2020	WC13	Pass 1	Ninespine Stickleback	N/A	55	3.64
	June 10, 2020	WC13	Pass 1	Brook Trout	135	140	29.55
	June 10, 2020	WC13	Pass 1	Brook Trout	127	127	31.87
	June 10, 2020	WC13	Pass 1	Lake Chub	85	90	5.16
	June 10, 2020	WC13	Pass 1	Brook Trout	43	45	2.13
	June 10, 2020	WC13	Pass 1	Banded Killifish	N/A	65	3.77
	June 10, 2020	WC13	Pass 1	Brook Trout	49	51	3.25
	June 10, 2020	WC13	Pass 1	Brook Trout	48	50	4.83
	June 10, 2020	WC13	Pass 1	Brook Trout	N/A	62	4.53
	June 10, 2020	WC13	Pass 1	Brook Trout	48	50	3.44
	June 10, 2020	WC13	Pass 1	Brook Trout	51	53	3.63
	June 10, 2020	WC13	Pass 1	Brook Trout	44	45	2.02
	June 10, 2020	WC13	Pass 1	Brook Trout	35	36	2.51
	June 10, 2020	WC13	Pass 1	Brook Trout	47	50	3.29
	June 10, 2020	WC13	Pass 1	Brook Trout	88	90	9.7

Survey Season	Survey Date	Site	Capture Method	Species	Fork Length (mm)	Total Length (mm)	Weight (g)
	June 10, 2020	WC13	Pass 1	Brook Trout	53	55	3.23
	June 10, 2020	WC13	Pass 1	Brook Trout	54	55	3.35
	June 10, 2020	WC13	Pass 1	Brook Trout	48	50	3.46
	June 10, 2020	WC13	Pass 1	Brook Trout	52	54	4.74
	June 10, 2020	WC13	Pass 1	Brook Trout	51	52	5.27
	June 10, 2020	WC13	Pass 1	Ninespine Stickleback	N/A	43	0.81
	June 10, 2020	WC13	Pass 1	Brook Trout	49	52	2.12
	June 10, 2020	WC13	Pass 1	Brook Trout	54	55	2.07
	June 10, 2020	WC13	Pass 1	Brook Trout	48	50	1.5
	June 10, 2020	WC13	Pass 1	Brook Trout	111	115	17.03
	June 10, 2020	WC13	Pass 1	Brook Trout	150	155	45.12
	June 10, 2020	WC13	Pass 1	Lake Chub	85	88	7.84
	June 10, 2020	WC13	Pass 1	Brook Trout	47	48	2.22
	June 10, 2020	WC13	Pass 1	Ninespine Stickleback	N/A	50	1.23
	June 10, 2020	WC13	Pass 1	Brook Trout	53	55	4.04
	June 10, 2020	WC13	Pass 1	Brook Trout	49	50	1.8
	June 10, 2020	WC13	Pass 1	Brook Trout	54	55	2.44
	June 10, 2020	WC13	Pass 1	Brook Trout	57	60	2.28
	June 10, 2020	WC13	Pass 1	Lake Chub	87	95	9.37
	June 10, 2020	WC13	Pass 1	Brook Trout	98	102	12.46
	June 10, 2020	WC13	Pass 1	Brook Trout	107	110	14.06
	June 10, 2020	WC13	Pass 1	Banded Killifish	N/A	70	4.51
	June 10, 2020	WC13	Pass 2	Brook Trout	55	57	2.51
	June 10, 2020	WC13	Pass 2	Brook Trout	52	54	1.18
	June 10, 2020	WC13	Pass 2	Ninespine Stickleback	N/A	53	1.2
	June 10, 2020	WC13	Pass 2	Banded Killifish	N/A	72	3.76
	June 10, 2020	WC13	Pass 2	Brook Trout	44	45	2.54
	June 10, 2020	WC13	Pass 2	Ninespine Stickleback	N/A	53	2.32
	June 10, 2020	WC13	Pass 2	Brook Trout	49	51	2.73
	June 10, 2020	WC13	Pass 2	Ninespine Stickleback	N/A	45	1.63
	June 10, 2020	WC13	Pass 2	Lake Chub	60	65	2.68
	June 10, 2020	WC13	Pass 2	Brook Trout	57	60	3.05
	June 10, 2020	WC13	Pass 2	Brook Trout	45	47	2.65

Survey Season	Survey Date	Site	Capture Method	Species	Fork Length (mm)	Total Length (mm)	Weight (g)
	June 10, 2020	WC13	Pass 2	Brook Trout	55	57	3.38
	June 10, 2020	WC13	Pass 2	Brook Trout	57	59	2.96
	June 10, 2020	WC13	Pass 2	Brook Trout	51	53	3.55
	June 10, 2020	WC13	Pass 2	Brook Trout	53	54	1.32
	June 10, 2020	WC13	Pass 2	Brook Trout	47	48	1.68
	June 10, 2020	WC13	Pass 2	Brook Trout	122	126	26.38
	June 10, 2020	WC13	Pass 2	Brook Trout	119	123	22.98
	June 10, 2020	WC13	Pass 2	Brook Trout	110	116	19.62
	June 10, 2020	WC13	Pass 3	Brook Trout	139	143	33.36
	June 10, 2020	WC13	Pass 3	Ninespine Stickleback	N/A	14	N/A
	June 10, 2020	WC13	Pass 3	Brook Trout	43	45	2.68
	June 10, 2020	WC13	Pass 3	Lake Chub	90	95	8.05
	June 10, 2020	WC13	Pass 3	Brook Trout	48	50	2.32
	June 10, 2020	WC13	Pass 3	Banded Killifish	N/A	65	4.45
	June 10, 2020	WC13	Pass 3	Brook Trout	109	113	14.41
	June 10, 2020	WC13	Pass 3	Lake Chub	63	66	4.86
	June 10, 2020	WC13	Pass 3	Brook Trout	40	42	2.82
	June 10, 2020	WC13	Pass 3	Brook Trout	57	59	5.56
	June 10, 2020	WC13	Pass 3	Ninespine Stickleback	N/A	46	2.31
	June 10, 2020	WC13	Pass 3	Brook Trout	53	55	4.54
	June 10, 2020	WC13	Pass 3	Brook Trout	49	50	1.98
	June 10, 2020	WC13	Pass 3	Banded Killifish	N/A	70	4.82
	June 10, 2020	WC13	Pass 3	Lake Chub	90	98	10.61
	June 10, 2020	WC13	Pass 4	Banded Killifish	N/A	72	5.35
	June 10, 2020	WC13	Pass 4	Lake Chub	82	86	7.13
	June 10, 2020	WC13	Pass 4	Brook Trout	57	59	1.52
	June 10, 2020	WC13	Pass 4	Brook Trout	53	55	3.88
	June 10, 2020	WC13	Pass 4	Brook Trout	97	102	10.49
	June 10, 2020	WC13	Pass 4	Brook Trout	60	62	3.04
	June 10, 2020	WC13	Pass 4	Brook Trout	51	53	1.47
	June 10, 2020	WC13	Pass 4	Banded Killifish	N/A	63	2.15
	June 10, 2020	WC13	Pass 4	Brook Trout	54	56	1.85
	June 10, 2020	WC13	Pass 4	Brook Trout	51	53	2.04

Survey Season	Survey Date	Site	Capture Method	Species	Fork Length (mm)	Total Length (mm)	Weight (g)
	June 10, 2020	WC13	Pass 4	Brook Trout	57	58	1.42
	June 10, 2020	WC13	Pass 4	Lake Chub	83	90	6.24
	June 11, 2020	Killag	Pass 1	Lake Chub	84	91	5.76
	June 11, 2020	Killag	Pass 1	Lake Chub	52	55	1.2
	June 11, 2020	Killag	Pass 1	White Sucker	58	61	3.34
	June 11, 2020	Killag	Pass 1	White Sucker	54	58	0.93
	June 11, 2020	Killag	Pass 1	Lake Chub	70	75	2.19
	June 11, 2020	Killag	Pass 1	Lake Chub	83	90	7.36
	June 11, 2020	Killag	Pass 1	Lake Chub	80	87	6
	June 11, 2020	Killag	Pass 1	Lake Chub	81	89	6.27
	June 11, 2020	Killag	Pass 1	White Sucker	63	67	5
	June 11, 2020	Killag	Pass 1	Lake Chub	84	92	8.14
	June 11, 2020	Killag	Pass 1	Lake Chub	40	43	2.34
	June 11, 2020	Killag	Pass 1	Lake Chub	88	95	10.59
	June 11, 2020	Killag	Pass 1	Lake Chub	46	49	0.85
	June 11, 2020	Killag	Pass 1	Lake Chub	75	80	6.02
	June 11, 2020	Killag	Pass 1	Lake Chub	75	83	4.82
	June 11, 2020	Killag	Pass 1	Lake Chub	74	80	3.81
	June 11, 2020	Killag	Pass 1	Lake Chub	52	55	1.43
	June 11, 2020	Killag	Pass 1	Lake Chub	64	70	2.42
	June 11, 2020	Killag	Pass 1	Lake Chub	75	80	4.44
	June 11, 2020	Killag	Pass 1	Lake Chub	80	87	5.65
	June 11, 2020	Killag	Pass 1	Lake Chub	73	79	5.06
	June 11, 2020	Killag	Pass 1	Lake Chub	77	82	3.36
	June 11, 2020	Killag	Pass 1	Lake Chub	43	45	1.06
	June 11, 2020	Killag	Pass 1	Lake Chub	109	114	11.37
	June 11, 2020	Killag	Pass 1	Lake Chub	46	50	1.19
	June 11, 2020	Killag	Pass 1	Lake Chub	52	54	3.43
	June 11, 2020	Killag	Pass 1	Lake Chub	42	45	1.57
	June 11, 2020	Killag	Pass 1	Lake Chub	46	50	1.82
	June 11, 2020	Killag	Pass 1	Lake Chub	47	50	1.3
	June 11, 2020	Killag	Pass 1	Lake Chub	47	50	1.66
	June 11, 2020	Killag	Pass 1	Lake Chub	43	45	3.46

Survey Season	Survey Date	Site	Capture Method	Species	Fork Length (mm)	Total Length (mm)	Weight (g)
	June 11, 2020	Killag	Pass 1	Lake Chub	50	53	3.07
	June 11, 2020	Killag	Pass 1	White Sucker	52	55	2.88
	June 11, 2020	Killag	Pass 1	Lake Chub	47	50	2.1
	June 11, 2020	Killag	Pass 1	Lake Chub	51	54	3.58
	June 11, 2020	Killag	Pass 1	Lake Chub	70	76	4.42
	June 11, 2020	Killag	Pass 2	American Eel	N/A	270	57.06
	June 11, 2020	Killag	Pass 2	American Eel	N/A	250	38.79
	June 11, 2020	Killag	Pass 2	American Eel	N/A	210	21.24
	June 11, 2020	Killag	Pass 2	White Sucker	59	62	7.91
	June 11, 2020	Killag	Pass 2	Lake Chub	82	90	10.25
	June 11, 2020	Killag	Pass 2	Lake Chub	55	60	4.03
	June 11, 2020	Killag	Pass 2	White Sucker	57	60	5.09
	June 11, 2020	Killag	Pass 2	Lake Chub	40	45	4.55
	June 11, 2020	Killag	Pass 2	Lake Chub	50	55	4.72
	June 11, 2020	Killag	Pass 2	Lake Chub	47	50	5.1
	June 11, 2020	Killag	Pass 2	Lake Chub	85	92	7
	June 11, 2020	Killag	Pass 2	Lake Chub	45	50	1
	June 11, 2020	Killag	Pass 2	Lake Chub	70	73	4.03
	June 11, 2020	Killag	Pass 2	Lake Chub	37	40	1.28
	June 11, 2020	Killag	Pass 2	Lake Chub	43	47	2.51
	June 11, 2020	Killag	Pass 2	Lake Chub	46	50	1.72
	June 11, 2020	Killag	Pass 2	Lake Chub	45	48	3.68
	June 11, 2020	Killag	Pass 2	Lake Chub	75	80	6.47
	June 11, 2020	Killag	Pass 2	Lake Chub	47	52	3.01
	June 11, 2020	Killag	Pass 2	Lake Chub	46	50	2.7
	June 11, 2020	Killag	Pass 2	White Sucker	55	58	3.75
	June 11, 2020	Killag	Pass 2	Lake Chub	100	105	8.73
	June 11, 2020	Killag	Pass 2	Lake Chub	75	80	5.29
	June 11, 2020	Killag	Pass 2	Lake Chub	68	72	5.99
	June 11, 2020	Killag	Pass 2	Lake Chub	50	55	2.08
	June 11, 2020	Killag	Pass 2	White Sucker	53	55	2.87
	June 11, 2020	Killag	Pass 2	Lake Chub	44	48	3.04
	June 11, 2020	Killag	Pass 2	Lake Chub	42	45	3.02

Survey Season	Survey Date	Site	Capture Method	Species	Fork Length (mm)	Total Length (mm)	Weight (g)
	June 11, 2020	Killag	Pass 2	Brook Trout	N/A	25	N/A
	June 11, 2020	Killag	Pass 2	Lake Chub	49	53	2.13
	June 11, 2020	Killag	Pass 2	Lake Chub	53	55	2.18
	June 11, 2020	Killag	Pass 3	Lake Chub	55	60	1.47
	June 11, 2020	Killag	Pass 3	Lake Chub	72	76	3.17
	June 11, 2020	Killag	Pass 3	Lake Chub	50	57	0.91
	June 11, 2020	Killag	Pass 3	Lake Chub	46	50	0.76
	June 11, 2020	Killag	Pass 3	Lake Chub	81	86	5.5
	June 11, 2020	Killag	Pass 3	Lake Chub	40	43	1.37
	June 11, 2020	Killag	Pass 3	Lake Chub	47	50	1.76
	June 11, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	62	1.33
	June 11, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	68	2.7
	June 11, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	69	3.86
	June 11, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	70	4.53
	June 11, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	78	5.82
	June 11, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	67	4.46
	June 11, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	66	4
	June 11, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	68	5.6
	June 11, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	70	3.09
	June 11, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	73	4.93
	June 11, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	45	1.32
	June 11, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	68	3.3
	June 11, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	66	5.25
	June 11, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	62	5.76
	June 11, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	70	4.47
	June 11, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	66	4.18
	June 11, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	68	5.45
	June 11, 2020	Cameron Flowage	Minnow Trap	White Sucker	67	70	5.55
	June 11, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	70	5.00
	June 11, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	79	5.29
	June 11, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	64	2.75
	June 11, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	70	3.59
	June 11, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	62	2.58

Survey Season	Survey Date	Site	Capture Method	Species	Fork Length (mm)	Total Length (mm)	Weight (g)
	June 11, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	70	3.16
	June 11, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	68	2.77
	June 11, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	50	1.43
	June 11, 2020	Cameron Flowage	Eel Pot	Yellow Perch	105	113	13.89
	June 11, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	69	4.74
	June 11, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	74	5.59
	June 11, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	66	3.68
	June 11, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	70	3.55
	June 11, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	72	3.89
	June 11, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	70	3.7
	June 11, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	76	4.78
	June 11, 2020	Cameron Flowage	Minnow Trap	Golden Shiner	62	67	3.36
	June 11, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	70	3.58
	June 11, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	70	3.23
	June 11, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	N/A	N/A
	June 11, 2020	Cameron Flowage	Minnow Trap	American Eel	N/A	370	134.78
	June 11, 2020	Cameron Flowage	Minnow Trap	White Sucker	115	120	17.4
	June 11, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	84	6.76
	June 11, 2020	Cameron Flowage	Minnow Trap	Yellow Perch	67	70	5.85
	June 11, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	65	4.35
	June 11, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	65	4.03
	June 11, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	68	4.58
	June 11, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	67	4.4
	June 11, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	63	3.2
	June 11, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	62	3.79
	June 11, 2020	Cameron Flowage	Minnow Trap	Yellow Perch	N/A	70	3.5
	June 11, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	81	4.14
	June 11, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	68	3.4
	June 11, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	70	4.55
	June 11, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	62	3.82
	June 11, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	70	4.36
	June 11, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	66	3.79
	June 15, 2020	WC26	Pass 2	Ninespine Stickleback	N/A	48	2.33

Survey Season	Survey Date	Site	Capture Method	Species	Fork Length (mm)	Total Length (mm)	Weight (g)
	June 16, 2020	WC23	Pass 1	Brook Trout	135	140	33.77
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	65	70	3.82
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	65	70	3.11
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	69	75	3.21
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	53	57	1.56
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	90	96	7.93
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	62	67	3.75
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	61	66	2.66
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	62	67	2.55
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	82	89	7.23
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	62	67	2.25
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	78	85	5.75
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	60	64	3.55
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	100	110	14.22
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	65	69	4.33
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	55	60	2.81
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	65	70	3.75
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	77	82	7.86
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	White Sucker	56	60	2.28
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	73	78	4.15
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	65	68	3.83
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	103	110	14.7
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	58	62	2.66
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	63	67	2.35
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	62	67	2.62
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	76	81	5.36
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	63	69	3.27
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	62	67	3.1
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	54	57	1.45
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	65	70	4.18
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	58	63	3.04
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	68	74	3.62
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	70	75	5.26

Survey Season	Survey Date	Site	Capture Method	Species	Fork Length (mm)	Total Length (mm)	Weight (g)
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	57	62	2.57
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	63	67	2.66
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	80	86	6.23
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	83	90	7.94
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	65	70	2.9
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	65	70	2.54
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	67	71	1.86
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	55	60	3.12
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	65	70	3.48
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	73	80	3.83
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	63	67	3.84
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	57	62	2.53
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	71	76	3.35
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	56	60	1.46
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	79	85	5.58
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	64	68	1.6
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	70	75	3.79
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	78	85	5.16
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	80	86	6.08
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	15 Golden Shiners	Various	Various	Various
	June 16, 2020	Mud Lake and Outlet	Eel Pot	White Sucker	280	300	4.5
	June 16, 2020	Mud Lake and Outlet	Eel Pot	White Sucker	330	360	4.25
	June 16, 2020	Mud Lake and Outlet	Eel Pot	White Sucker	270	290	3.4
	June 16, 2020	Mud Lake and Outlet	Eel Pot	White Sucker	240	260	2.25
	June 16, 2020	Mud Lake and Outlet	Eel Pot	Yellow Perch	137	140	36.23
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	20 Golden Shiners	Various	Various	Various
	June 16, 2020	Mud Lake and Outlet	Fyke Net	Yellow Perch	148	152	42.33
	June 16, 2020	Mud Lake and Outlet	Fyke Net	Yellow Perch	140	148	40.4
	June 16, 2020	Mud Lake and Outlet	Fyke Net	White Sucker	167	180	69.7
	June 16, 2020	Mud Lake and Outlet	Fyke Net	White Sucker	150	170	33.94
	June 16, 2020	Mud Lake and Outlet	Fyke Net	White Sucker	165	180	63.74
	June 16, 2020	Mud Lake and Outlet	Fyke Net	Brown Bullhead	N/A	130	44.48
	June 16, 2020	Mud Lake and Outlet	Fyke Net	White Sucker	155	165	55.18

Survey Season	Survey Date	Site	Capture Method	Species	Fork Length (mm)	Total Length (mm)	Weight (g)
	June 16, 2020	Mud Lake and Outlet	Fyke Net	White Sucker	175	187	71.02
	June 16, 2020	Mud Lake and Outlet	Fyke Net	White Sucker	165	180	60.03
	June 16, 2020	Mud Lake and Outlet	Fyke Net	White Sucker	165	176	65.77
	June 16, 2020	Mud Lake and Outlet	Fyke Net	Brook Trout	175	182	75.33
	June 16, 2020	Mud Lake and Outlet	Fyke Net	Yellow Perch	180	163	50.17
	June 16, 2020	Mud Lake and Outlet	Fyke Net	White Sucker	170	182	67.84
	June 16, 2020	Mud Lake and Outlet	Fyke Net	White Sucker	170	180	57.83
	June 16, 2020	Mud Lake and Outlet	Fyke Net	White Sucker	170	180	55.2
	June 16, 2020	Mud Lake and Outlet	Fyke Net	Yellow Perch	145	150	41.62
	June 16, 2020	Mud Lake and Outlet	Fyke Net	Yellow Perch	142	148	43.3
	June 16, 2020	Mud Lake and Outlet	Fyke Net	White Sucker	163	173	53.75
	June 16, 2020	Mud Lake and Outlet	Fyke Net	Yellow Perch	149	150	48.95
	June 16, 2020	Mud Lake and Outlet	Fyke Net	American Eel	N/A	640	22.5
	June 16, 2020	Mud Lake and Outlet	Fyke Net	White Sucker	310	336	450
	June 16, 2020	Mud Lake and Outlet	Fyke Net	White Sucker	280	300	225
	June 16, 2020	Mud Lake and Outlet	Fyke Net	White Sucker	260	290	375
	June 16, 2020	Mud Lake and Outlet	Fyke Net	White Sucker	250	260	179.85
	June 16, 2020	Mud Lake and Outlet	Fyke Net	White Sucker	200	210	104.3
	June 16, 2020	Mud Lake and Outlet	Fyke Net	White Sucker	200	205	86.31
	June 16, 2020	Mud Lake and Outlet	Fyke Net	Yellow Perch	130	135	32.5
	June 16, 2020	Mud Lake and Outlet	Fyke Net	White Sucker	175	185	162.9
	June 16, 2020	Mud Lake and Outlet	Fyke Net	White Sucker	150	155	22.1
	June 16, 2020	Mud Lake and Outlet	Fyke Net	White Sucker	200	210	189.25
	June 16, 2020	Mud Lake and Outlet	Fyke Net	White Sucker	200	210	106.3
	June 16, 2020	Mud Lake and Outlet	Fyke Net	White Sucker	200	210	82.59
	June 16, 2020	Mud Lake and Outlet	Fyke Net	White Sucker	180	190	77.93
	June 16, 2020	Mud Lake and Outlet	Fyke Net	White Sucker	190	205	88.64
	June 16, 2020	Mud Lake and Outlet	Fyke Net	White Sucker	206	210	105.11
	June 16, 2020	Mud Lake and Outlet	Eel Pot	American Eel	N/A	600	380
	June 16, 2020	Mud Lake and Outlet	Eel Pot	Banded Killifish	N/A	90	5.41
	June 16, 2020	Mud Lake and Outlet	Eel Pot	Banded Killifish	N/A	90	8.09
	June 16, 2020	Mud Lake and Outlet	Eel Pot	Banded Killifish	N/A	100	9.14
	June 16, 2020	Mud Lake and Outlet	Eel Pot	Banded Killifish	N/A	95	5.56

Survey Season	Survey Date	Site	Capture Method	Species	Fork Length (mm)	Total Length (mm)	Weight (g)
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	Banded Killifish	N/A	50	1.54
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	Banded Killifish	N/A	86	7.83
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	Banded Killifish	N/A	85	8.22
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	Ninespine Stickleback	N/A	55	1.04
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	1 Banded Killifish	Various	Various	Various
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	44 Golden Shiners	Various	Various	Various
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	3 Banded Killifish	Various	Various	Various
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	5 Golden Shiners	Various	Various	Various
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	Ninespine Stickleback	N/A	57	2.25
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	28 Golden Shiners	Various	Various	Various
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	Ninespine Stickleback	N/A	51	2.17
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	Ninespine Stickleback	N/A	60	2.05
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	Ninespine Stickleback	N/A	56	1.4
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	Ninespine Stickleback	N/A	55	1.18
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	Ninespine Stickleback	N/A	56	0.85
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	3 Golden Shiners	Various	Various	Various
	June 16, 2020	Mud Lake and Outlet	Minnow Trap	7 Banded Killifish	Various	Various	Various
	June 17, 2020	WC5B	Pass 1	Brook Trout	115	120	23.2
	June 17, 2020	WC5B	Pass 1	Brook Trout	129	133	29.45
	June 17, 2020	WC5B	Pass 1	Brook Trout	102	105	13.9
	June 17, 2020	WC5B	Pass 3	Brook Trout	107	111	15.96
	July 3, 2020	WC23	Pass 2	Brook Trout	145	165	60.92
	July 6, 2020	WC5B	pass 1	Brook Trout	102	107	15.36
	July 6, 2020	WC5B	pass 1	Brook Trout	147	150	39
	July 6, 2020	WC5B	pass 1	Brook Trout	86	90	10.93
	July 6, 2020	WC5B	pass 1	Brook Trout	113	119	23.37
	July 6, 2020	WC5B	pass 1	Brook Trout	119	125	28.86
	July 6, 2020	WC5B	pass 1	Brook Trout	100	106	13.64
	July 6, 2020	WC5B	pass 2	Brook Trout	105	110	14.27
	July 6, 2020	WC5B	pass 2	Brook Trout	114	117	19.61
	July 6, 2020	WC5B	pass 2	Brook Trout	129	138	29.87
	July 6, 2020	WC5B	pass 2	Brook Trout	107	111	19.15
	July 6, 2020	WC5B	pass 2	Brook Trout	113	118	20.17

Survey Season	Survey Date	Site	Capture Method	Species	Fork Length (mm)	Total Length (mm)	Weight (g)
	July 6, 2020	WC5B	pass 2	Brook Trout	116	120	20.09
	July 6, 2020	WC5B	pass 2	Brook Trout	N/A	N/A	N/A
	July 6, 2020	WC5B	pass 2	Brook Trout	63	65	3.21
	July 6, 2020	WC5B	pass 2	Brook Trout	85	88	8.44
	July 6, 2020	WC5B	pass 2	Brook Trout	106	110	14.04
	July 6, 2020	WC5B	pass 2	Brook Trout	113	116	19.51
	July 6, 2020	WC5B	pass 2	Brook Trout	48	50	1.31
	July 6, 2020	WC5B	pass 2	Brook Trout	63	65	0.72
	July 6, 2020	WC5B	pass 3	Brook Trout	114	119	19.33
	July 6, 2020	WC5B	pass 3	Brook Trout	129	134	40.65
	July 6, 2020	WC5B	pass 3	Brook Trout	130	134	29.6
	July 6, 2020	WC5B	pass 3	Brook Trout	143	146	37.47
	July 6, 2020	WC5B	pass 3	Brook Trout	57	60	2.34
	July 6, 2020	WC5B	pass 3	Brook Trout	62	65	3.37
	July 6, 2020	WC5B	pass 4	Brook Trout	129	134	29.87
	July 6, 2020	WC5B	pass 4	Brook Trout	83	34	8.18
	July 6, 2020	WC13	Pass 1	Brook Trout	119	124	19.8
	July 6, 2020	WC13	Pass 1	Brook Trout	43	45	1.21
	July 6, 2020	WC13	Pass 1	Banded Killifish	N/A	84	8.71
	July 6, 2020	WC13	Pass 1	Brook Trout	51	52	3.46
	July 6, 2020	WC13	Pass 1	American Eel	N/A	260	38.12
	July 6, 2020	WC13	Pass 1	Brook Trout	62	65	2.69
	July 6, 2020	WC13	Pass 1	Brook Trout	55	56	1.66
	July 6, 2020	WC13	Pass 1	Brook Trout	49	51	2.2
	July 6, 2020	WC13	Pass 1	Brook Trout	61	63	3.71
	July 6, 2020	WC13	Pass 1	Brook Trout	45	46	1.83
	July 6, 2020	WC13	Pass 1	Brook Trout	60	61	3.04
	July 6, 2020	WC13	Pass 1	Brook Trout	53	54	1.59
	July 6, 2020	WC13	Pass 1	Brook Trout	59	61	2.75
	July 6, 2020	WC13	Pass 1	Brook Trout	54	55	2.13
	July 6, 2020	WC13	Pass 1	Brook Trout	50	51	1.3
	July 6, 2020	WC13	Pass 1	Brook Trout	55	57	1.96
	July 6, 2020	WC13	Pass 1	Brook Trout	49	50	1.45

Survey Season	Survey Date	Site	Capture Method	Species	Fork Length (mm)	Total Length (mm)	Weight (g)
	July 6, 2020	WC13	Pass 1	Brook Trout	52	53	1.98
	July 6, 2020	WC13	Pass 1	Brook Trout	58	60	2.56
	July 6, 2020	WC13	Pass 1	Brook Trout	56	57	2.51
	July 6, 2020	WC13	Pass 1	Brook Trout	49	50	2.7
	July 6, 2020	WC13	Pass 1	Brook Trout	56	59	2.25
	July 6, 2020	WC13	Pass 1	Ninespine Stickleback	N/A	26	small
	July 6, 2020	WC13	Pass 1	Brook Trout	50	52	1.33
	July 6, 2020	WC13	Pass 1	Brook Trout	44	45	1.45
	July 6, 2020	WC13	Pass 1	Brook Trout	45	47	1.13
	July 6, 2020	WC13	Pass 1	Brook Trout	40	42	0.76
	July 6, 2020	WC13	Pass 1	Brook Trout	105	110	15.52
	July 6, 2020	WC13	Pass 1	Brook Trout	50	51	0.99
	July 6, 2020	WC13	Pass 1	Brook Trout	55	56	1.47
	July 6, 2020	WC13	Pass 1	Brook Trout	93	95	9
	July 6, 2020	WC13	Pass 1	Banded Killifish	N/A	70	2.36
	July 6, 2020	WC13	Pass 1	Brook Trout	116	121	15.62
	July 6, 2020	WC13	Pass 1	Brook Trout	52	53	1.55
	July 6, 2020	WC13	Pass 1	Lake Chub	73	76	4.71
	July 6, 2020	WC13	Pass 1	Brook Trout	52	53	1.68
	July 6, 2020	WC13	Pass 1	Brook Trout	50	51	1.99
	July 6, 2020	WC13	Pass 1	Brook Trout	61	63	2.81
	July 6, 2020	WC13	Pass 1	Brook Trout	55	56	1.85
	July 6, 2020	WC13	Pass 1	Banded Killifish	N/A	70	3.99
	July 6, 2020	WC13	Pass 1	Brook Trout	32	33	2.19
	July 6, 2020	WC13	Pass 1	Brook Trout	45	46	1.34
	July 6, 2020	WC13	Pass 1	Brook Trout	55	57	2.05
	July 6, 2020	WC13	Pass 1	Brook Trout	44	45	1.11
	July 6, 2020	WC13	Pass 2	Ninespine Stickleback	N/A	25	small
	July 6, 2020	WC13	Pass 2	Banded Killifish	N/A	61	3.65
	July 6, 2020	WC13	Pass 2	Ninespine Stickleback	N/A	45	0.97
	July 6, 2020	WC13	Pass 2	Brook Trout	47	49	1.35
	July 6, 2020	WC13	Pass 2	Brook Trout	106	112	14.43
	July 6, 2020	WC13	Pass 3	Creek Chub	102	105	13.03

Survey Season	Survey Date	Site	Capture Method	Species	Fork Length (mm)	Total Length (mm)	Weight (g)
	July 6, 2020	WC13	Pass 3	Banded Killifish	N/A	63	3.46
	July 6, 2020	WC13	Pass 3	Brook Trout	58	61	2.93
	July 6, 2020	WC13	Pass 3	Brook Trout	60	61	2.32
	July 6, 2020	WC13	Pass 3	Brook Trout	52	53	0.85
	July 6, 2020	WC13	Pass 3	Brook Trout	55	56	2.72
	July 6, 2020	WC13	Pass 3	Brook Trout	49	51	2.21
	July 6, 2020	WC13	Pass 3	Brook Trout	48	50	1.44
	July 6, 2020	WC13	Pass 3	Brook Trout	44	46	0.48
	July 6, 2020	WC13	Pass 3	Creek Chub	69	71	4.83
	July 6, 2020	WC13	Pass 3	Brook Trout	125	129	19.57
	July 6, 2020	WC13	Pass 3	Brook Trout	49	50	3.56
	July 6, 2020	WC13	Pass 4	Brook Trout	51	53	1.91
	July 6, 2020	WC13	Pass 4	Brook Trout	55	57	2.73
	July 6, 2020	WC13	Pass 4	Brook Trout	51	53	1.98
	July 6, 2020	WC13	Pass 4	Brook Trout	55	57	2.44
	July 6, 2020	WC13	Pass 4	Brook Trout	48	50	1.3
	July 6, 2020	WC13	Pass 4	Creek Chub	100	108	13.64
	July 7, 2020	Crusher Lake	Fyke Net	Golden Shiner	11.5	12.4	24.17
	July 7, 2020	Crusher Lake	Fyke Net	Brook Trout	14	14.5	39.68
	July 7, 2020	WL59	Eel Pot	Golden Shiner	94	105	9.37
	July 7, 2020	WL59	Eel Pot	Golden Shiner	90	100	8.66
	July 7, 2020	WL59	Fyke Net	Brown Bullhead	N/A	164	56.95
	July 7, 2020	WL59	Fyke Net	Golden Shiner	117	127	N/A
	July 7, 2020	WL59	Minnow Trap	Golden Shiner	95	104	12.21
	July 7, 2020	WL59	Minnow Trap	Golden Shiner	84	90	7
	July 7, 2020	WL59	Minnow Trap	Golden Shiner	100	110	13.6
	July 7, 2020	WL59	Minnow Trap	Golden Shiner	55	58	3.55
	July 7, 2020	WL59	Minnow Trap	Golden Shiner	60	65	4.91
	July 7, 2020	WL59	Minnow Trap	Golden Shiner	104	112	15.82
	July 7, 2020	WL59	Minnow Trap	Golden Shiner	116	125	21.91
	July 7, 2020	WL59	Minnow Trap	Golden Shiner	60	66	6.1
	July 7, 2020	WL59	Minnow Trap	Golden Shiner	44	48	4.81
	July 7, 2020	WL59	Minnow Trap	Golden Shiner	91	101	9.04

Survey Season	Survey Date	Site	Capture Method	Species	Fork Length (mm)	Total Length (mm)	Weight (g)
	July 7, 2020	WL59	Minnow Trap	Golden Shiner	105	115	14.85
	July 7, 2020	WL59	Minnow Trap	Golden Shiner	65	71	5.16
	July 7, 2020	WL59	Minnow Trap	Golden Shiner	105	115	13.19
	July 7, 2020	WL59	Minnow Trap	Golden Shiner	69	75	4.69
	July 7, 2020	WL59	Minnow Trap	Golden Shiner	79	84	5.5
	July 7, 2020	WL59	Minnow Trap	Golden Shiner	84	91	8.04
	July 7, 2020	WL59	Minnow Trap	Golden Shiner	70	75	4.05
	July 7, 2020	WL59	Minnow Trap	Golden Shiner	94	103	12.66
	July 7, 2020	WL59	Minnow Trap	Golden Shiner	61	75	6.02
	July 7, 2020	WL59	Minnow Trap	Golden Shiner	80	84	7.27
	July 7, 2020	WL59	Minnow Trap	Golden Shiner	99	108	11.64
	July 7, 2020	WL59	Minnow Trap	Golden Shiner	68	73	4.7
	July 7, 2020	WL59	Minnow Trap	Golden Shiner	83	90	7.18
	July 7, 2020	WL59	Minnow Trap	Ninespine Stickleback	N/A	45	1.07
	July 7, 2020	WL59	Minnow Trap	Golden Shiner	45	47	0.93
	July 7, 2020	WL59	Minnow Trap	Golden Shiner	42	46	2.21
	July 7, 2020	WL59	Minnow Trap	Golden Shiner	40	45	0.67
	July 7, 2020	WL59	Minnow Trap	Golden Shiner	46	50	1.27
	July 7, 2020	WL59	Minnow Trap	Golden Shiner	78	84	6.55
	July 7, 2020	WL59	Minnow Trap	Golden Shiner	51	55	1.24
	July 7, 2020	WL59	Minnow Trap	Golden Shiner	51	56	1.61
	July 7, 2020	WL59	Minnow Trap	Golden Shiner	64	70	3.06
	July 7, 2020	WL59	Minnow Trap	Golden Shiner	67	72	3.94
	July 7, 2020	WL59	Minnow Trap	Golden Shiner	45	51	0.97
	July 7, 2020	WL59	Minnow Trap	Golden Shiner	52	57	1.61
	July 7, 2020	WL59	Minnow Trap	Golden Shiner	46	50	0.9
	July 7, 2020	WL59	Minnow Trap	Golden Shiner	55	60	1.4
	July 7, 2020	WL59	Minnow Trap	Golden Shiner	54	59	1.41
	July 7, 2020	WL59	Minnow Trap	Golden Shiner	43	48	1.47
	July 7, 2020	WL59	Minnow Trap	Golden Shiner	52	56	3.14
	July 7, 2020	WL59	Minnow Trap	Golden Shiner	47	52	1.15
	July 7, 2020	WL59	Minnow Trap	Golden Shiner	45	49	0.5
	July 7, 2020	WL59	Minnow Trap	Golden Shiner	100	108	11.7

Survey Season	**Survey Date**	**Site**	**Capture Method**	**Species**	**Fork Length (mm)**	**Total Length (mm)**	**Weight (g)**
	July 7, 2020	WL59	Minnow Trap	Golden Shiner	63	67	3.17
	July 7, 2020	WL59	Minnow Trap	Golden Shiner	65	68	2.27
	July 7, 2020	WL59	Minnow Trap	Golden Shiner	59	65	2.63
	July 7, 2020	WL59	Minnow Trap	Golden Shiner	49	54	1.42
	July 7, 2020	WL59	Minnow Trap	Golden Shiner	69	75	4.04
	July 7, 2020	WL59	Minnow Trap	11 Golden Shiners	Various	Various	Various
	July 7, 2020	WL59	Minnow Trap	19 Golden Shiners	Various	Various	Various
	July 7, 2020	WL59	Minnow Trap	Banded Killifish	N/A	47	1.09
	July 7, 2020	WL59	Minnow Trap	Banded Killifish	N/A	76	4.82
	July 7, 2020	WL59	Minnow Trap	Banded Killifish	N/A	70	3.83
	July 7, 2020	WL59	Minnow Trap	Banded Killifish	N/A	60	2.99
	July 7, 2020	WL59	Minnow Trap	Banded Killifish	N/A	60	2.71
	July 7, 2020	WL59	Minnow Trap	Banded Killifish	N/A	50	2.2
	July 7, 2020	WL59	Minnow Trap	Banded Killifish	N/A	48	1.33
	July 7, 2020	WL59	Minnow Trap	Banded Killifish	N/A	47	1.61
	July 7, 2020	WL59	Minnow Trap	Banded Killifish	N/A	50	1.37
	July 7, 2020	WL59	Minnow Trap	Banded Killifish	N/A	75	5.33
	July 7, 2020	WL59	Minnow Trap	Banded Killifish	N/A	48	1.7
	July 7, 2020	WL59	Minnow Trap	Banded Killifish	N/A	53	1.63
	July 7, 2020	WL59	Minnow Trap	Banded Killifish	N/A	53	1.62
	July 7, 2020	WL59	Minnow Trap	Banded Killifish	N/A	59	2
	July 7, 2020	WL59	Minnow Trap	Banded Killifish	N/A	69	3.1
	July 7, 2020	WL59	Minnow Trap	Banded Killifish	N/A	55	2
	July 7, 2020	WL59	Minnow Trap	Banded Killifish	N/A	51	1.67
	July 7, 2020	WL59	Minnow Trap	Banded Killifish	N/A	49	1.85
	July 7, 2020	WL59	Minnow Trap	Banded Killifish	N/A	54	1.64
	July 7, 2020	WL59	Minnow Trap	Banded Killifish	N/A	56	1.73
	July 7, 2020	WL59	Minnow Trap	Banded Killifish	N/A	56	1.92
	July 8, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	70	4.48
	July 8, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	70	3.16
	July 8, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	49	0.91
	July 8, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	66	2
	July 8, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	72	2.75

Survey Season	Survey Date	Site	Capture Method	Species	Fork Length (mm)	Total Length (mm)	Weight (g)
	July 8, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	67	2.78
	July 8, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	50	0.78
	July 8, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	65	2.08
	July 8, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	52	1.2
	July 8, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	55	2.39
	July 8, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	80	4.26
	July 8, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	55	0.66
	July 8, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	75	1.83
	July 8, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	48	0.7
	July 8, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	64	1.93
	July 8, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	70	2.7
	July 8, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	64	2.17
	July 8, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	53	1.6
	July 8, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	66	1.95
	July 8, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	60	1.87
	July 8, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	52	0.63
	July 8, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	52	1.83
	July 8, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	50	1.09
	July 8, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	54	1.42
	July 8, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	50	1.4
	July 8, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	56	1.84
	July 8, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	53	0.75
	July 8, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	50	1.56
	July 8, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	54	1.3
	July 8, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	69	2.53
	July 8, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	75	3.56
	July 8, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	70	2.88
	July 8, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	45	0.7
	July 8, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	80	3.8
	July 8, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	55	2.15
	July 8, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	49	0.58
	July 8, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	50	0.74
	July 8, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	49	1.68

Survey Season	Survey Date	Site	Capture Method	Species	Fork Length (mm)	Total Length (mm)	Weight (g)
	July 8, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	53	1.69
	July 8, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	58	1.55
	July 8, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	70	3.12
	July 8, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	65	2.07
	July 8, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	50	0.72
	July 8, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	52	1.39
	July 8, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	50	0.96
	July 8, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	49	0.65
	July 8, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	50	0.7
	July 8, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	49	1.42
	July 8, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	51	0.72
	July 8, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	53	1.06
	July 8, 2020	Cameron Flowage	Minnow Trap	25 Banded Killifish	Various	Various	Various
	July 8, 2020	Cameron Flowage	Minnow Trap	24 Banded Killifish	Various	Various	Various
	July 8, 2020	Cameron Flowage	Minnow Trap	40 Banded Killifish	Various	Various	Various
	July 8, 2020	Cameron Flowage	Minnow Trap	33 Banded Killifish	Various	Various	Various
	July 8, 2020	Cameron Flowage	Minnow Trap	7 Banded Killifish	Various	Various	Various
	July 8, 2020	Cameron Flowage	Minnow Trap	Creek Chub	110	117	15.88
	July 8, 2020	Cameron Flowage	Minnow Trap	Creek Chub	114	122	16.9
	July 8, 2020	Cameron Flowage	Minnow Trap	Creek Chub	113	119	17.55
	July 8, 2020	Cameron Flowage	Eel Pot	White Sucker	N/A	250	EST
	July 8, 2020	Killag	Pass 1	Lake Chub	56	60	1.49
	July 8, 2020	Killag	Pass 1	Lake Chub	47	52	1.45
	July 8, 2020	Killag	Pass 1	White Sucker	23	24	N/A
	July 8, 2020	Killag	Pass 1	White Sucker	23	24	N/A
	July 8, 2020	Killag	Pass 1	Lake Chub	52	55	1.31
	July 8, 2020	Killag	Pass 1	Lake Chub	49	53	1.4
	July 8, 2020	Killag	Pass 1	Lake Chub	52	57	1.99
	July 8, 2020	Killag	Pass 1	Lake Chub	53	57	2.31
	July 8, 2020	Killag	Pass 1	Lake Chub	52	56	2
	July 8, 2020	Killag	Pass 1	White Sucker	24	25	0.46
	July 8, 2020	Killag	Pass 1	Lake Chub	51	55	1.43
	July 8, 2020	Killag	Pass 1	Lake Chub	45	50	1.52

Survey Season	Survey Date	Site	Capture Method	Species	Fork Length (mm)	Total Length (mm)	Weight (g)
	July 8, 2020	Killag	Pass 1	Lake Chub	65	72	4.7
	July 8, 2020	Killag	Pass 1	Lake Chub	50	54	1.77
	July 8, 2020	Killag	Pass 1	Lake Chub	50	55	1.8
	July 8, 2020	Killag	Pass 1	Lake Chub	65	70	2.51
	July 8, 2020	Killag	Pass 1	Lake Chub	50	54	1.33
	July 8, 2020	Killag	Pass 1	Lake Chub	54	59	1.45
	July 8, 2020	Killag	Pass 1	Lake Chub	65	70	3.4
	July 8, 2020	Killag	Pass 1	Lake Chub	50	53	2.3
	July 8, 2020	Killag	Pass 1	Lake Chub	50	53	2.6
	July 8, 2020	Killag	Pass 1	Brook Trout	30	32	1.49
	July 8, 2020	Killag	Pass 1	Lake Chub	54	60	2.29
	July 8, 2020	Killag	Pass 1	Lake Chub	49	52	1.14
	July 8, 2020	Killag	Pass 1	Lake Chub	98	105	10.08
	July 8, 2020	Killag	Pass 1	Lake Chub	50	55	1.81
	July 8, 2020	Killag	Pass 1	Atlantic Salmon	111	118	17.67
	July 8, 2020	Killag	Pass 1	Lake Chub	52	55	1.47
	July 8, 2020	Killag	Pass 1	Lake Chub	50	54	1.77
	July 8, 2020	Killag	Pass 1	White Sucker	25	26	0.56
	July 8, 2020	Killag	Pass 1	Lake Chub	53	56	1.78
	July 8, 2020	Killag	Pass 1	Lake Chub	48	53	2.6
	July 8, 2020	Killag	Pass 1	Lake Chub	49	63	1.38
	July 8, 2020	Killag	Pass 1	Lake Chub	64	70	2.38
	July 8, 2020	Killag	Pass 1	Lake Chub	56	60	1.83
	July 8, 2020	Killag	Pass 1	Lake Chub	57	61	2.77
	July 8, 2020	Killag	Pass 1	Lake Chub	52	55	1.43
	July 8, 2020	Killag	Pass 1	Lake Chub	51	55	1.5
	July 8, 2020	Killag	Pass 1	Lake Chub	51	56	0.89
	July 8, 2020	Killag	Pass 1	Lake Chub	53	55	2.23
	July 8, 2020	Killag	Pass 1	Lake Chub	54	58	1.95
	July 8, 2020	Killag	Pass 1	White Sucker	209	220	100.44
	July 8, 2020	Killag	Pass 1	Lake Chub	55	59	2.25
	July 8, 2020	Killag	Pass 1	Lake Chub	48	51	1.12
	July 8, 2020	Killag	Pass 1	Lake Chub	54	59	2.66

Survey Season	Survey Date	Site	Capture Method	Species	Fork Length (mm)	Total Length (mm)	Weight (g)
	July 8, 2020	Killag	Pass 1	Lake Chub	51	55	1.68
	July 8, 2020	Killag	Pass 1	Lake Chub	52	55	1.29
	July 8, 2020	Killag	Pass 1	Lake Chub	52	55	1.6
	July 8, 2020	Killag	Pass 1	Lake Chub	47	51	2.15
	July 8, 2020	Killag	Pass 1	Lake Chub	47	51	1.64
	July 8, 2020	Killag	Pass 1	Lake Chub	57	61	2.9
	July 8, 2020	Killag	Pass 1	Lake Chub	51	55	3.64
	July 8, 2020	Killag	Pass 1	Lake Chub	52	56	1.46
	July 8, 2020	Killag	Pass 1	Lake Chub	54	58	2.43
	July 8, 2020	Killag	Pass 1	Lake Chub	49	52	1.35
	July 8, 2020	Killag	Pass 1	Lake Chub	51	55	1.46
	July 8, 2020	Killag	Pass 1	White Sucker	150	160	8.28
	July 8, 2020	Killag	Pass 1	Lake Chub	75	82	3.67
	July 8, 2020	Killag	Pass 1	41 Lake Chubs	Various	Various	Various
	July 8, 2020	Killag	Pass 1	White Sucker	19	20	N/A
	July 8, 2020	Killag	Pass 1	White Sucker	22	25	N/A
	July 8, 2020	Killag	Pass 1	White Sucker	22	25	N/A
	July 8, 2020	Killag	Pass 1	White Sucker	22	25	N/A
	July 8, 2020	Killag	Pass 1	White Sucker	22	25	N/A
	July 8, 2020	Killag	Pass 1	23 Lake Chub	Various	Various	Various
	July 8, 2020	Killag	Pass 1	White Sucker	N/A	150	41
	July 8, 2020	Killag	Pass 1	White Sucker	105	110	15.12
	July 8, 2020	Killag	Pass 1	American Eel	N/A	250	46.27
	July 8, 2020	Killag	Pass 1	American Eel	N/A	220	22.63
	July 8, 2020	Killag	Pass 1	Lake Chub	48	51	1.09
	July 8, 2020	Killag	Pass 1	Lake Chub	47	50	1.42
	July 8, 2020	Killag	Pass 1	Lake Chub	52	55	1.46
	July 8, 2020	Killag	Pass 1	Lake Chub	55	59	1.91
	July 8, 2020	Killag	Pass 2	Atlantic Salmon	98	105	11.83
	July 8, 2020	Killag	Pass 2	Atlantic Salmon	100	109	12.95
	July 8, 2020	Killag	Pass 2	White Sucker	131	140	27.13
	July 8, 2020	Killag	Pass 2	American Eel	N/A	230	21.42
	July 8, 2020	Killag	Pass 2	American Eel	N/A	110	9.52

Survey Season	Survey Date	Site	Capture Method	Species	Fork Length (mm)	Total Length (mm)	Weight (g)
	July 8, 2020	Killag	Pass 2	Lake Chub	55	59	2.1
	July 8, 2020	Killag	Pass 2	Lake Chub	56	60	1.23
	July 8, 2020	Killag	Pass 2	73 Lake Chubs	Various	Various	Various
	July 8, 2020	Killag	Pass 2	White Sucker	67	71	3.28
	July 8, 2020	Killag	Pass 2	White Sucker	91	96	8.44
	July 8, 2020	Killag	Pass 2	White Sucker	56	59	2.93
	July 8, 2020	Killag	Pass 2	White Sucker	33	35	N/A
	July 8, 2020	Killag	Pass 2	Atlantic Salmon	111	116	18.18
	July 8, 2020	Killag	Pass 3	White Sucker	115	120	17.16
	July 8, 2020	Killag	Pass 3	American Eel	N/A	350	87.25
	July 8, 2020	Killag	Pass 3	American Eel	N/A	210	21.9
	July 8, 2020	Killag	Pass 3	American Eel	N/A	185	9.54
	July 8, 2020	Killag	Pass 3	White Sucker	66	70	3.9
	July 8, 2020	Killag	Pass 3	30 Lake Chubs	Various	Various	Various
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Lake Chub	95	105	9.11
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	66	73	3
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	65	72	3.45
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	72	76	3.55
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	62	67	2.45
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	73	80	4.69
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	83	90	7.15
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	84	91	5.44
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	85	92	7.65
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	63	68	3.66
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	85	90	6.44
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	77	82	4.25
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	73	77	3.93
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	90	97	7.4
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	80	85	6.01
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	80	87	5.1
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	63	69	2.2
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	57	63	2.44
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	72	78	3.94

Survey Season	Survey Date	Site	Capture Method	Species	Fork Length (mm)	Total Length (mm)	Weight (g)
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	66	70	3.41
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	62	67	2.36
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	80	85	5.94
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	55	60	2.63
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	64	68	3.29
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	70	74	2.53
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	82	90	6.06
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	75	81	4.17
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	75	78	4.08
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	70	75	3.55
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	87	95	5.29
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	100	107	13.6
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	90	100	8.01
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	80	87	3.85
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	92	100	8.08
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	69	73	3.43
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	69	74	3.16
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	89	95	5.99
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	78	84	4.21
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	65	72	2.13
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	75	83	4.75
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	60	65	3.31
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	73	80	3.61
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	74	79	4.01
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	74	81	5.32
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	79	85	6.1
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	60	77	3.53
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	67	72	4.59
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	80	85	5.17
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	69	74	3.76
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	70	74	2.83
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	73	79	4.7
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	2 Golden Shiners	Various	Various	Various

Survey Season	Survey Date	Site	Capture Method	Species	Fork Length (mm)	Total Length (mm)	Weight (g)
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Yellow Perch	95	100	12.82
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	1 Golden Shiner	Various	Various	Various
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	White Sucker	280	290	250.18
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Yellow Perch	105	110	16.81
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Banded Killifish	N/A	100	11.57
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	White Sucker	145	150	33.57
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Yellow Perch	135	140	31.86
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Yellow Perch	118	122	24.57
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Yellow Perch	107	112	17.94
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Yellow Perch	109	116	19.53
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	3 Golden Shiners	Various	Various	Various
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	8 Golden Shiners	Various	Various	Various
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Banded Killifish	N/A	70	1.66
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Banded Killifish	N/A	72	2.41.
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Banded Killifish	N/A	51	1.08
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Banded Killifish	N/A	45	1.22
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Banded Killifish	N/A	70	2.22
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Banded Killifish	N/A	85	3.67
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Banded Killifish	N/A	55	1.68
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Banded Killifish	N/A	60	2.85
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Banded Killifish	N/A	62	2.58
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Banded Killifish	N/A	70	2.03
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Banded Killifish	N/A	55	1.61
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Banded Killifish	N/A	50	1.67
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Banded Killifish	N/A	71	3.29
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Banded Killifish	N/A	50	1.55
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Banded Killifish	N/A	87	6.26
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Banded Killifish	N/A	80	4.25
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Banded Killifish	N/A	50	1.02
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Banded Killifish	N/A	56	1.4
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Banded Killifish	N/A	56	1.93
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Banded Killifish	N/A	90	6.41
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Banded Killifish	N/A	80	5.02

Survey Season	Survey Date	Site	Capture Method	Species	Fork Length (mm)	Total Length (mm)	Weight (g)
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Banded Killifish	N/A	95	7.9
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Banded Killifish	N/A	82	6.19
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Banded Killifish	N/A	78	4.38
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Banded Killifish	N/A	92	7.77
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Banded Killifish	N/A	73	3.79
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Banded Killifish	N/A	88	6.56
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Banded Killifish	N/A	78	4.29
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Banded Killifish	N/A	77	4.64
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Banded Killifish	N/A	61	3.37
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Banded Killifish	N/A	80	5.44
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Banded Killifish	N/A	80	5.82
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Banded Killifish	N/A	52	1.68
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Banded Killifish	N/A	75	5.13
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Banded Killifish	N/A	51	1.9
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Banded Killifish	N/A	89	8.67
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Banded Killifish	N/A	59	1.9
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Banded Killifish	N/A	62	3.27
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Banded Killifish	N/A	65	3.63
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Banded Killifish	N/A	53	2.11
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	Banded Killifish	N/A	53	2
	July 8, 2020	Mud Lake and Outlet	Minnow Trap	56 Golden Shiners	Various	Various	Various
	July 9, 2020	WC23	Pass 1	Brook Trout	165	170	69.94
	July 9, 2020	WC23	Pass 2	Brook Trout	157	163	57.71
	August 21, 2020	WC23	PASS 1	Brook Trout	175	182	72.06
	August 25, 2020	WC5B	Pass 1	Brook Trout	126	131	22.4
	August 25, 2020	WC5B	Pass 1	Brook Trout	132	135	23.07
	August 25, 2020	WC5B	Pass 1	Brook Trout	124	127	21.61
	August 25, 2020	WC5B	Pass 1	Brook Trout	58	60	1.34
	August 25, 2020	WC5B	Pass 1	Brook Trout	104	108	12.38
	August 25, 2020	WC5B	Pass 1	Brook Trout	96	100	10.48
	August 25, 2020	WC5B	Pass 1	Brook Trout	146	152	39.7
	August 25, 2020	WC5B	Pass 1	Brook Trout	132	135	24.79
	August 25, 2020	WC5B	Pass 1	Brook Trout	116	120	17.36

Survey Season	Survey Date	Site	Capture Method	Species	Fork Length (mm)	Total Length (mm)	Weight (g)
	August 25, 2020	WC5B	Pass 1	Brook Trout	125	128	22.53
	August 25, 2020	WC5B	Pass 1	Brook Trout	109	113	13.09
	August 25, 2020	WC5B	Pass 1	Brook Trout	68	70	4.02
	August 25, 2020	WC5B	Pass 1	Lake Chub	62	66	4.8
	August 25, 2020	WC5B	Pass 2	Brook Trout	68	70	3.11
	August 25, 2020	WC5B	Pass 2	Brook Trout	150	157	36.09
	August 25, 2020	WC5B	Pass 2	Brook Trout	116	122	15.62
	August 25, 2020	WC5B	Pass 2	Brook Trout	116	120	17.8
	August 25, 2020	WC5B	Pass 3	Brook Trout	128	131	23
	August 26, 2020	WL59	Minnow Trap	Banded Killifish	N/A	80	4.14
	August 26, 2020	WL59	Minnow Trap	Banded Killifish	N/A	60	2.24
	August 26, 2020	WL59	Minnow Trap	Banded Killifish	N/A	75	5.27
	August 26, 2020	WL59	Minnow Trap	Banded Killifish	N/A	62	3.65
	August 26, 2020	WL59	Minnow Trap	Banded Killifish	N/A	66	3.91
	August 26, 2020	WL59	Minnow Trap	Banded Killifish	N/A	43	1.81
	August 26, 2020	WL59	Eel Pot	Golden Shiner	112	120	16.03
	August 26, 2020	WL59	Eel Pot	Golden Shiner	123	136	22.45
	August 26, 2020	WL59	Eel Pot	Golden Shiner	118	129	27.29
	August 26, 2020	WL59	Eel Pot	Golden Shiner	111	120	27.38
	August 26, 2020	WL59	Eel Pot	Golden Shiner	107	116	20.83
	August 26, 2020	WL59	Eel Pot	Golden Shiner	104	115	17.25
	August 26, 2020	WL59	Eel Pot	Golden Shiner	103	109	21.64
	August 26, 2020	WL59	Minnow Trap	Banded Killifish	N/A	68	4.27
	August 26, 2020	WL59	Minnow Trap	Banded Killifish	N/A	65	5.58
	August 26, 2020	WL59	Minnow Trap	Banded Killifish	N/A	67	3.86
	August 26, 2020	WL59	Fyke Net	Brown Bullhead	167	175	66.02
	August 26, 2020	WC13	Pass 1	Brook Trout	54	57	3.46
	August 26, 2020	WC13	Pass 1	White Sucker	58	61	3.58
	August 26, 2020	WC13	Pass 1	Ninespine Stickleback	N/A	49	1.75
	August 26, 2020	WC13	Pass 1	Banded Killifish	N/A	80	4.77
	August 26, 2020	WC13	Pass 1	White Sucker	63	67	2.19
	August 26, 2020	WC13	Pass 1	White Sucker	50	54	1.85
	August 26, 2020	WC13	Pass 1	Brook Trout	61	64	1.49

Survey Season	Survey Date	Site	Capture Method	Species	Fork Length (mm)	Total Length (mm)	Weight (g)
	August 26, 2020	WC13	Pass 1	Ninespine Stickleback	N/A	41	0.87
	August 26, 2020	WC13	Pass 1	White Sucker	49	53	1.71
	August 26, 2020	WC13	Pass 1	Lake Chub	71	76	4.01
	August 26, 2020	WC13	Pass 1	White Sucker	53	56	1.49
	August 26, 2020	WC13	Pass 1	White Sucker	51	54	1.34
	August 26, 2020	WC13	Pass 1	Lake Chub	65	76	2.64
	August 26, 2020	WC13	Pass 2	Ninespine Stickleback	N/A	48	0.45
	August 26, 2020	WC13	Pass 2	Ninespine Stickleback	N/A	47	0.55
	August 26, 2020	WC13	Pass 2	Lake Chub	53	58	5.69
	August 26, 2020	WC13	Pass 2	Lake Chub	74	78	2.32
	August 26, 2020	WC13	Pass 3	Brook Trout	48	50	2.94
	August 26, 2020	WC13	Pass 3	Banded Killifish	N/A	70	5.87
	August 26, 2020	WC13	Pass 3	Ninespine Stickleback	N/A	43	1.25
	August 26, 2020	Killag	Pass 1	Lake Chub	53	58	1.48
	August 26, 2020	Killag	Pass 1	Lake Chub	58	63	2.08
	August 26, 2020	Killag	Pass 1	Lake Chub	54	58	1.85
	August 26, 2020	Killag	Pass 1	Lake Chub	64	68	3.34
	August 26, 2020	Killag	Pass 1	Lake Chub	60	65	2.25
	August 26, 2020	Killag	Pass 1	Lake Chub	55	59	1.59
	August 26, 2020	Killag	Pass 1	Lake Chub	59	64	2.3
	August 26, 2020	Killag	Pass 1	Lake Chub	62	66	2.33
	August 26, 2020	Killag	Pass 1	Lake Chub	54	57	1.71
	August 26, 2020	Killag	Pass 1	Lake Chub	55	60	2.91
	August 26, 2020	Killag	Pass 1	White Sucker	66	70	5.31
	August 26, 2020	Killag	Pass 1	White Sucker	154	157	43.33
	August 26, 2020	Killag	Pass 1	American Eel	N/A	320	86.76
	August 26, 2020	Killag	Pass 1	American Eel	N/A	270	45.73
	August 26, 2020	Killag	Pass 1	American Eel	N/A	400	121.03
	August 26, 2020	Killag	Pass 1	Lake Chub	72	78	4.77
	August 26, 2020	Killag	Pass 1	Lake Chub	56	62	2.25
	August 26, 2020	Killag	Pass 1	White Sucker	50	55	2.1
	August 26, 2020	Killag	Pass 1	Lake Chub	67	72	3.65
	August 26, 2020	Killag	Pass 1	Lake Chub	35	38	0.84

Survey Season	Survey Date	Site	Capture Method	Species	Fork Length (mm)	Total Length (mm)	Weight (g)
	August 26, 2020	Killag	Pass 2	White Sucker	42	45	1.27
	August 26, 2020	Killag	Pass 2	Lake Chub	40	44	0.71
	August 26, 2020	Killag	Pass 2	Lake Chub	62	66	3.68
	August 26, 2020	Killag	Pass 2	Lake Chub	62	65	2.78
	August 26, 2020	Killag	Pass 2	White Sucker	196	204	86.79
	August 26, 2020	Killag	Pass 2	Lake Chub	45	48	1.74
	August 26, 2020	Killag	Pass 2	White Sucker	120	126	21.38
	August 26, 2020	Killag	Pass 2	White Sucker	198	206	81.48
	August 26, 2020	Killag	Pass 2	White Sucker	49	52	3.96
	August 26, 2020	Killag	Pass 2	White Sucker	55	59	2.21
	August 26, 2020	Killag	Pass 2	American Eel	N/A	300	98.44
	August 26, 2020	Killag	Pass 2	White Sucker	82	86	4.48
	August 26, 2020	Killag	Pass 2	Lake Chub	61	65	1.54
	August 26, 2020	Killag	Pass 2	Yellow Perch	63	66	3.03
	August 26, 2020	Killag	Pass 2	Lake Chub	60	66	2.95
	August 26, 2020	Killag	Pass 2	White Sucker	185	195	76.17
	August 26, 2020	Killag	Pass 3	White Sucker	79	84	5.45
	August 26, 2020	Killag	Pass 3	White Sucker	47	50	1.27
	August 26, 2020	Killag	Pass 3	Lake Chub	57	62	1.97
	August 26, 2020	Killag	Pass 3	Lake Chub	60	65	2.86
	August 26, 2020	Killag	Pass 3	Lake Chub	40	42	0.66
	August 27, 2020	Cameron Flowage	Fyke Net	Brook Trout	196	202	81.95
	August 27, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	64	3.78
	August 27, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	66	3.08
	August 27, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	64	3.24
	August 27, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	66	3.25
	August 27, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	51	1.41
	August 27, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	62	2.77
	August 27, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	70	2.78
	August 27, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	61	3.17
	August 27, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	61	2.64
	August 27, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	55	3.31
	August 27, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	62	3.21

Survey Season	Survey Date	Site	Capture Method	Species	Fork Length (mm)	Total Length (mm)	Weight (g)
	August 27, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	63	3.02
	August 27, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	69	3.85
	August 27, 2020	Cameron Flowage	Minnow Trap	Yellow Perch	47	51	1.75
	August 27, 2020	Cameron Flowage	Minnow Trap	Golden Shiner	78	85	4.22
	August 27, 2020	Cameron Flowage	Minnow Trap	Golden Shiner	75	82	6.11
	August 27, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	70	3.83
	August 27, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	60	1.99
	August 27, 2020	Cameron Flowage	Minnow Trap	Golden Shiner	67	73	4.72
	August 27, 2020	Cameron Flowage	Minnow Trap	Golden Shiner	52	59	2.73
	August 27, 2020	Cameron Flowage	Minnow Trap	Golden Shiner	75	80	3.33
	August 27, 2020	Cameron Flowage	Minnow Trap	Golden Shiner	73	81	3.32
	August 27, 2020	Cameron Flowage	Minnow Trap	Golden Shiner	75	83	4.02
	August 27, 2020	Cameron Flowage	Minnow Trap	Golden Shiner	80	86	5.52
	August 27, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	55	2.73
	August 27, 2020	Cameron Flowage	Minnow Trap	Yellow Perch	45	47	1.42
	August 27, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	56	2.42
	August 27, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	66	3.43
	August 27, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	56	2.21
	August 27, 2020	Cameron Flowage	Minnow Trap	Yellow Perch	45	47	1.82
	August 27, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	66	2.64
	August 27, 2020	Cameron Flowage	Minnow Trap	Banded Killifish	N/A	71	3.25
	August 27, 2020	Cameron Flowage	Eel Pot	White Sucker	220	230	136.19
	August 27, 2020	Mud Lake and Outlet	Eel Pot	White Sucker	240	245	130.08
	August 27, 2020	Mud Lake and Outlet	Fyke Net	Yellow Perch	105	111	14.45
	August 27, 2020	Mud Lake and Outlet	Fyke Net	White Sucker	150	160	37.04
	August 27, 2020	Mud Lake and Outlet	Fyke Net	Yellow Perch	107	114	15.11
	August 27, 2020	Mud Lake and Outlet	Fyke Net	Yellow Perch	115	120	18.77
	August 27, 2020	Mud Lake and Outlet	Fyke Net	Brown Bullhead	N/A	150	51.21
	August 27, 2020	Mud Lake and Outlet	Fyke Net	White Sucker	160	165	42.05
	August 27, 2020	Mud Lake and Outlet	Fyke Net	White Sucker	240	250	136.07
	August 27, 2020	Mud Lake and Outlet	Fyke Net	Brown Bullhead	N/A	159	60.32
	August 27, 2020	Mud Lake and Outlet	Fyke Net	Brown Bullhead	N/A	145	42.25
	August 27, 2020	Mud Lake and Outlet	Fyke Net	Brown Bullhead	N/A	154	52.71

Survey Season	Survey Date	Site	Capture Method	Species	Fork Length (mm)	Total Length (mm)	Weight (g)
	August 27, 2020	Mud Lake and Outlet	Fyke Net	Yellow Perch	104	110	17.83
	August 27, 2020	Mud Lake and Outlet	Fyke Net	White Sucker	170	180	54.99
	August 27, 2020	Mud Lake and Outlet	Fyke Net	Brown Bullhead	N/A	175	74.22
	August 27, 2020	Mud Lake and Outlet	Fyke Net	Brown Bullhead	N/A	150	49.14
	August 27, 2020	Mud Lake and Outlet	Fyke Net	Brown Bullhead	N/A	160	54.22
	August 27, 2020	Mud Lake and Outlet	Fyke Net	Brown Bullhead	N/A	165	59.99
	August 27, 2020	Mud Lake and Outlet	Fyke Net	Yellow Perch	120	126	23.29
	August 27, 2020	Mud Lake and Outlet	Fyke Net	White Sucker	160	170	50.52
	August 27, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	80	88	5.73
	August 27, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	80	87	5.2
	August 27, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	70	76	2.73
	August 27, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	60	73	2.71
	August 27, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	70	75	3.73
	August 27, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	75	84	4.21
	August 27, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	81	90	6.71
	August 27, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	78	85	3.86
	August 27, 2020	Mud Lake and Outlet	Minnow Trap	Golden Shiner	73	80	2.9
	August 27, 2020	Mud Lake and Outlet	Minnow Trap	Banded Killifish	N/A	101	9.24
	August 27, 2020	Mud Lake and Outlet	Minnow Trap	Yellow Perch	77	80	5.87
	August 27, 2020	Mud Lake and Outlet	Minnow Trap	Yellow Perch	56	58	1.84
	August 27, 2020	Mud Lake and Outlet	Minnow Trap	Yellow Perch	52	55	2.16
	August 27, 2020	Mud Lake and Outlet	Minnow Trap	Yellow Perch	74	77	5.16
Fall 2020	September 30, 2020	WL56	Pass 1	Ninespine Stickleback	N/A	30	0.23
	September 30, 2020	WL56	Pass 1	Ninespine Stickleback	N/A	36	0.23
	September 30, 2020	WL56	Pass 1	Ninespine Stickleback	N/A	30	0.19

APPENDIX G: DETAILED FISH HABITAT ASSESSMENT DATA

Table 1. Detailed Fish Habitat Data, Reach Information, Part 1.

Survey Date	WC #	Reach #	Stream Order	Upstream Coordinates		Downstream Coordinates		Reach Length (m)	Gradient (%)	Entrenchment	Flow Type	Habitat Type	All included Habitat Types (Y OR N)					**Comments** (unique habitat features, survey method alterations, etc.)
				Easting	Northing	Easting	Northing						Riffle	Run	Flat	Pool	Other	
22-Jul-20	27	1	3	521352	4991027	521228	4991199	228	<1	SE	P	Flat	N	N	N	N	N	
14-Jul-20	5	1	2	521565	4990210	521564	4990227	15	20	HE	P	Cascade	N	N	N	N	N	
14-Jul-20	5	2	2	521564	4990227	521560	4990270	55	4	ME	P	Run	Y	N	N	N	Y - Chute	
14-Jul-20	5	3	2-3	521560	4990270	521474	4990394	195	<1 - 1	ME	P	Flat	Y	N	N	N	N	
14-Jul-20	5	4	3	521474	4990394	521447	4990447	66	2	ME	P	Pools	N	N	Y	N	N	Beaver pools connected by small runs
15-Jul-20	5	5	3	521447	4990447	521427	4990478	53	4	ME	P	Riffle - Run	Y	Y	N	N	N	
15-Jul-20	5	6	3	521427	4990478	521407	4990515	43	4	NE	P	No defined channel						At T3 reach 5, the channel disperses into multiple flow paths (reach 6), counted at least 6 different paths. Not possible to conduct transects, so instead measure depth/velocity thru reach whenever possible
15-Jul-20	5	7	3	521407	4990515	521411	4990577	65	6	ME	P	Rapid	N	Y	Y	Y	Y - Cascade	
15-Jul-20	5	8	3	521411	4990577	521531	4990845	340	<1	SE	P	Flat	N	N	N	N	N	
13-Jul-20	13	1	2	522688	4990227	522716	4990240	32	1	ME	P	Riffle	N	N	Y	N	N	
13-Jul-20	13	2	2	522716	4990240	522731	4990231	8	<1	ME	P	Pool	N	N	N	N	N	
13-Jul-20	13	3	2	522731	4990231	522749	4990224	20	2	SE	P	Riffle	N	N	N	N	N	
13-Jul-20	13	4	2	522750	4990231	522767	4990252	35	<1	SE	P	Flat	N	N	N	N	N	
13-Jul-20	13	5	2	522767	4990254	522778	4990294	46	2	ME	P	Riffle	N	N	N	Y	N	
13-Jul-20	14	1A	1	522770	4990120	522746	4990135	30	4	ME	I	Intermittent pockets, run or riffle	N	N	N	N	N	14A and B flow into 14R2
13-Jul-20	14	1B	1	522732	4990026	522746	4990135	115	10+	ME	I	Step-pool/NDC (50/50)	N	N	N	N	N	
13-Jul-20	14	2	2	522746	4990135	522736	4990161	32	18	ME	I	Step-pool	N	N	N	N	N	
17-Jul-20	20	1	1	520058	4989895	519983	4989705	200	1	SE	P	Flat	N	N	N	N	N	Stream order 1 because 2nd order stream just before T3, boulder field, subterranean sections
17-Jul-20	21	1	1	520059	4990173	520069	4990158	20	1	SE	P	Flat	N	N	N	N	N	
17-Jul-20	21	2	1	520069	4990158	520092	4990140	30	7	ME	P	Step - pool	N	N	N	N	N	Subterranean section
17-Jul-20	22	1	1	520131	4989803	520043	4989785	100	1	ME	P	Flat	N	N	N	N	N	
16-Jul-20	23	1	1	519779	4989575	519674	4989469	150	1	SE	P	Flat	N	N	N	N	N	
16-Jul-20	23	2	1	519674	4989469	519697	4989341	150	1	SE	P	Flat	N	N	N	N	N	
16-Jul-20	23	3	1	519697	4989341	519481	4988642	754	1	ME	P	Flat	N	N	N	N	Subterranean, step-pool	Multiple subterranean sections
16-Jul-20	26	1	1	520229	4990824	520094	4990947	205	<1	SE	I	Flat	N	N	N	N	No defined channel	
16-Jul-20	26	2	1	520094	4990947	520000	4991378	600	<1	ME	P	Flat	N	N	N	N	N	Connection to Killag
22-Jul-20	12	1	1	522148	4990329	522197	4990330	50	2	ME	E	Groundwater seep	N	N	N	N	N	**No water**. Did not continue assessment downstream of road. This habitat is contiguous with WL59 and is a function of standing water from WL and backing up by beavers
30-Sep-20	25	1	1	522422	4990526	522428	4990556	33	<1	SE	P	Flat	Y	N	Y	N	N	

Entrenchment: HE: Highly Entrenched, ME: Moderately Entrenched, SE: Somewhat Entrenched Flow Type: P: Perennial, I: Intermittent, E: Ephemeral

Table 2. Detailed Fish Habitat Data – Reach Information Part 2

Survey Date	WC #	Reach #	Water Quality						Cover %								Substrate (%)									Embeddedness (%)	Pebble Count (Y/N)
			Temp (℃)	pH	DO (mg/L)	CON (µS/cm)	TDS (mg/L)	Turbidity	Large Woody Debris	Boulders	Undercut Banks	Deep Pools	Overhang	Emergent	Submergent	TOTAL	Bed	B	R	C	G	Sa	Si	M/D	C/M		
22-Jul-20	27	1	22.7	5.39	3.7	29.7	-	C	0	0	2	20	3	30	10	65								100		N/A	N
14-Jul-20	5	1	23.1	5.35	6.51	20	-	C	30	10	0	0	0	0	0	40	10	50	30	10						10	N
14-Jul-20	5	2	24	5.42	5.88	21	-	C	2	3	0	0	5	0	0	10	3	10	15	20	25	20	2	5		15	Y
14-Jul-20	5	3	24.4	5.43	5.95	20	-	L	5	5	10	5	5		3	33		20	10	5	5	5	5	50		25	N
14-Jul-20	5	4	22.4	5.11	4.62	24	-	M	30	20		15	5			70	15	30	20					35		30	N
15-Jul-20	5	5	22.1	5.11	5.04	23	-	L - M	4	5	3		3	2		17		30	35	25	5	5		10		15	N
15-Jul-20	5	6	N/A	N/A	N/A	N/A	-	N/A	20	5			5	2		32		40	30	15				15		15	N
15-Jul-20	5	7	18.7	5.11	6.86	22	-	M	5	10	3		15			33	10	40	25	20	2			3		20	N
15-Jul-20	5	8	18.27	5.27	6.13	24	-	L			5	20	10	7	3	45		40						60		70	N
13-Jul-20	13	1	23.4	6.41	7.06	35	-	C	2				5	3		10		5	20	20	45	5		5		15	Y
13-Jul-20	13	2	24.2	6.1	67.5	35	-	C					10			10				15	30	5		50		50	N
13-Jul-20	13	3	24.7	6.54	6.26	35	-	C					10			10			15	40	40			5		10	Y
13-Jul-20	13	4	25.9	6.31	5.69	42	-	L - M			5	10	20	10		45			5					95		50	N
13-Jul-20	13	5	25.6	6.33	6.21	41	-	L			2		40	20		62		10	50		15			25		30	N
13-Jul-20	14A	1	23.5	5.36	6.09	23	-	C	10				70			80			80					20		75	N
13-Jul-20	14B	1	17.9	5.99	7.05	26	-	C	20				5			25			40					60		80	N
13-Jul-20	14	2	16.1	5.81	6.52	24	-	C					5			5		5	35	20	10			30		30	N
17-Jul-20	20	1	14.4	4.79	3.5	25	20.15	C	10		1		10	4		25		30						70		50 - 90	N
17-Jul-20	21	1	15.1	4.47	26	30	25.35	C					60			60								100		N/A	N
17-Jul-20	21	2	15.1	4.46	2.4	31.5	25.35	C	4		6		5			15		10	50	10				30		50 - 80	N
17-Jul-20	22	1	15.1	4.82	4	25	20.15	C	5		5		20	5		35		20				2			78	50 - 90	N
16-Jul-20	23	1	12.9	5.01	8.5	22.8	19.2	C	10	2	1	0	15	5	2	35		25						75		50 - 75	N
16-Jul-20	23	2	13.2	4.76	7.7	23.3	19.5	C	20				50	2	10	82		15						85		75	N
16-Jul-20	23	3	13.3	4.73	8.5	23.7	20.15	C	25	5	2		10	2	5	44	20	20	10					50		30	N
16-Jul-20	26	1	19.3	5.15	4.88	30	-	M						20	35	55								100		N/A	N
16-Jul-20	26	2	15.8	4.87	6.09	31	-	L	3		3		30	5	20	61		15						85		75	N
22-Jul-20	12	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0			20	40	10			30		60	N
30-Sep-20	25	1	15.6	6	3.6	49	39	C					10			10								100		N/A	N

Turbidity: C: Clear, L: Low turbidity, M: Moderate turbidity, H: High turbidity

Substrate: BED: Bedrock, B: Boulder, R: Rubble, C: Cobble, G: Gravel, Sa: Sand, Si: Silt, M/D: Muck-detritus, C/M: Clay/Mud

Table 3. Detailed Fish Habitat Data, Reach Information Part 3

Survey Date	WC #	Reach #	Banks and Riparian Area							
			Bank (L or R)	% Trees	% Shrubs	% Grass	% Bare	% Eroding	% Shade	Dominant Riparian Veg.
22-Jul-20	27	1	L	0	40	100	0	0	0	Wetland
22-Jul-20	27	1	R	2	40	100	0	0	0	Wetland
14-Jul-20	5	1	L	30	20	30	10	5	60	Mixed-Wood Forest
14-Jul-20	5	1	R	50	35	35	15	5	60	Mixed-Wood Forest
14-Jul-20	5	2	L	60	15	10	15	5	70	Mixed-Wood Forest
14-Jul-20	5	2	R	60	20	10	10	5	70	Mixed-Wood Forest
14-Jul-20	5	3	L	60	15	70	0	0	75	Wetland
14-Jul-20	5	3	R	65	10	65	0	0	75	Wetland
14-Jul-20	5	4	L	30	70	0	0	0	30	Mixed-Wood Forest
14-Jul-20	5	4	R	30	70	0	0	0	30	Mixed-Wood Forest
15-Jul-20	5	5	L	65	30	20	15	0	40	Mixed-Wood Forest
15-Jul-20	5	5	R	50	45	30	15	0	40	Mixed-Wood Forest
15-Jul-20	5	6	L	70	40	25	0	0	70	Mixed-Wood Forest
15-Jul-20	5	6	R	70	35	40	0	0	70	Mixed-Wood Forest
15-Jul-20	5	7	L	60	40	15	0	0	90	Mixed-Wood Forest
15-Jul-20	5	7	R	60	35	15	0	0	90	Mixed-Wood Forest
15-Jul-20	5	8	L	10	75	100	0	0	35	Wetland
15-Jul-20	5	8	R	5	80	100	0	0	35	Wetland
13-Jul-20	13	1	L	80	20	10	20	5	80	Mixed-Wood Forest
13-Jul-20	13	1	R	30	40	15	20	0	80	Mixed-Wood Forest
13-Jul-20	13	2	L	60	70	25	0	0	85	Mixed-Wood Forest
13-Jul-20	13	2	R	50	50	15	0	0	85	Mixed-Wood Forest
13-Jul-20	13	3	L	0	60	100	0	0	30	Wetland
13-Jul-20	13	3	R	10	60	100	0	0	30	Wetland
13-Jul-20	13	4	L	10	60	100	0	0	10	Wetland
13-Jul-20	13	4	R	25	55	100	0	0	10	Wetland
13-Jul-20	13	5	L	15	35	100	0	0	75	Wetland
13-Jul-20	13	5	R	25	30	100	0	0	75	Wetland
13-Jul-20	14A	1	L	80	50	0	0	0	95	Mixed-Wood Forest
13-Jul-20	14A	1	R	30	30	0	30	0	95	Mixed-Wood Forest
13-Jul-20	14B	1	L	60	30	10	0	0	90	Mixed-Wood Forest
13-Jul-20	14B	1	R	60	30	10	0	0	90	Mixed-Wood Forest
13-Jul-20	14	2	L	80	50	5	10	0	95	Mixed-Wood Forest
13-Jul-20	14	2	R	70	60	10	15	0	95	Mixed-Wood Forest
17-Jul-20	20	1	L	50	70	90	0	0	70	Wetland
17-Jul-20	20	1	R	50	70	90	0	0	70	Wetland
17-Jul-20	21	1	L	20	10	80	0	0	50	Wetland
17-Jul-20	21	1	R	20	10	80	0	0	50	Wetland
17-Jul-20	21	2	L	90	10	30	0	0	95	Mixed-Wood Forest
17-Jul-20	21	2	R	90	10	30	0	0	95	Mixed-Wood Forest
17-Jul-20	22	1	L	35	65	90	0	0	60	Wetland
17-Jul-20	22	1	R	35	65	90	0	0	60	Wetland
16-Jul-20	23	1	L	20	70	70	0	0	70	Wetland
16-Jul-20	23	1	R	15	75	7	0	0	70	Wetland
16-Jul-20	23	2	L	25	75	60	0	0	90	Wetland
16-Jul-20	23	2	R	25	75	60	0	0	90	Wetland
16-Jul-20	23	3	L	30	80	50	2	0	90	Wetland
16-Jul-20	23	3	R	30	80	50	2	0	90	Wetland
16-Jul-20	26	1	L	0	5	100	0	0	5	Wetland
16-Jul-20	26	1	R	0	15	100	0	0	5	Wetland
16-Jul-20	26	2	L	10	90	100	0	0	55	Wetland
16-Jul-20	26	2	R	15	90	100	0	0	55	Wetland
22-Jul-20	12	1	L	50	90	5	5	0	95	Mixed-Wood Forest
22-Jul-20	12	1	R	50	90	5	5	0	95	Mixed-Wood Forest
30-Sep-20	25	1	L	10	85	30	5	0	15	Grass, shrub, wetland
30-Sep-20	25	1	R	0	0	100	5	0	15	Grass, shrub, wetland

Table 4. Detailed Fish Habitat Data, Barrier Information

Survey Date	WC #	Reach #	**Types** (type Y to all that apply)						**Location and Comments**								**Permanency** (type Y to all that apply)		
									Waypoint		**Height**	**Width**	**Depth of Plunge Pool**	**Hydrological Indicators**	**Other Comments**				
			Underground Flow	**Beaver Dam**	**Dry**	**Falls**	**Culvert**	**Other**	**Easting**	**Northing**							**Permanent**	**Temporal/Seasonal**	**Man Made**
14-Jul-20	5	1		Y		Y					1.3m (falls on cascade series)		0.2m		Beaver dam at upstream end of reach likely impedes upstream passage during low flow; Small steps but no holding areas (<5cm deep) (permanent)		Y	Y	
14-Jul-20	5	3		Y					521505 (BD 1); 521484 (BD 2)	521484 (1); 4990379 (2)					2 beaver dams are fairly close together, likely impede passage during low flow			Y	
14-Jul-20	5	4		Y					521464	4990419					Likely impedes passage at low flow; another dam located at bottom of reach			Y	
13-Jul-20	13	1		Y											At upstream waypoint, likely impassable during low flow			Y	
13-Jul-20	13	4						Y - Debris jam				50cm			Debris jam held up by 2 vertical pieces of rebar - likely impassable during low flow conditions by most fish			Y	
13-Jul-20	14A	1			Y									25m distance of subterranean flow upstream (moss covered surface with pockets of water)	50% is dry, only accessible during high flow, only wet due to overnight rain			Y	
13-Jul-20	14b	1			Y										Channel is 70% dry, frequently becomes undefined, dries up considerably at DS end, therefore transect taken opportunistically in a wet area/near upstream extent)			Y	
17-Jul-20	20	1	Y						520001	4988770					Boulder field at waypoint			Y	
17-Jul-20	21	1					Y		520059	4990173					Culvert at upstream extent, water sourced from wetland on opposite site				Y
17-Jul-20	21	2	Y						520077 (1); 520084 (2)	4990153 (1); 4990153 (2)					Subterranean section			Y	
17-Jul-20	22	1	Y						520106 (1); 4989792 (2)	520090 (1); 4989790 (2)					Two subterranean sections			Y	
16-Jul-20	23	1	Y												Barrier at extreme upstream extent (<5 from top of WC)			Y	
16-Jul-20	23	3	Y				Y		519710 (Culvert), 519716 (SubT1), 519734 (SubT2), 519747 (SubT3), 519704 (SubT4), 519463-519428 (SubT5), 519411-519374 (Sub T6), 519348-519326 (SubT7), 519316-519233 (SubT8), 519182-519160 (SubT9)	4989284 (Culvert), 4989265 (SubT1), 4989236 (SubT2), 4989085 (SubT3), 4988946 (SubT4), 4988607-4988551 (SubT5), 4988528-4988511 (SubT6), 4988484-4988460 (SubT7), 4988436-4988410 (SubT8), 4988441-4988430 (SubT9)				Some flow visible in subterranean sections between boulders - each section marked by boulder fields.	9 marked subterranean sections			Y	Y
16-Jul-20	26	1	Y		Y										Pockets of SW in WL, discontinuous likely connect as sheet during high flow, dry channel prior to Reach 2, channel barely there (see T2)			Y	
22-Jul-20	12	1		Y	Y		Y		522215 (BD)	4990331 (BD)				Upstream of T1 channel is completely dry, downstream is likely fed by groundwater seep	Fish access only during high flow, culvert is crushed and impedes fish passage, not visible from downstream end			Y	Y

Table 5. Detailed Fish Habitat Data – Transect Data Part 1

Survey Date	WC #	Reach #	Transect #	Waypoint		Habitat Type	Width (m)		Left Bank Measurements (m)														Right Bank Measurements (m)													
				Easting	Northing		Wetted	Bankfull	Distance	Height	Distance	Height	Distance	Height	Distance	Height	Distance	Height	Distance	Height	Distance	Height	Distance	Height	Distance	Height	Distance	Height	Distance	Height	Distance	Height	Distance	Height	Distance	Height
22-Jul-20	27	1	1	521351	4991027	Flat	3.4	3.4	0	0.17													3.4	0.33												
22-Jul-20	27	1	2	521330	4991081	Flat	4.6	4.6	0	0.13													4.6	0.2												
22-Jul-20	27	1	3	521285	4991105	Flat	7.2	7.2	0	0.16													7.2	0.4												
22-Jul-20	27	1	4	521252	4991147	Flat	9	9	0	0.22													9	0.26												
14-Jul-20	5	1	1	521564	4990213	Cascade	1.2	2	0	0	0.1	0.05	0.2	0.1	0.3	0.12	0.4	0.12	0.5	0.26			2	0	1.94	0.03	1.88	0.28	1.82	0.18	1.76	0.2	1.7	0.28		
14-Jul-20	5	2	1	521562	4990243	Run	1.2	3.3	0	0	0.2	0.05	0.4	0.06	0.6	0.06	0.8	0.6	1	0.8			3.3	0	3.1	0.09	2.9	0.13	2.7	0.13	2.5	1.2	2.3	0.1		
14-Jul-20	5	2	2	521556	4990245	Riffle	1.2	4	0	0	0.3	0.06	0.6	0.25	0.9	0.14	1.2	0.22	1.5	0.15	1.8	0.31	4	0	3.8	0.1	3.6	0.21	3.4	0.29	3.2	0.31	3	0.34		
14-Jul-20	5	2	3	521549	4990242	Chute	0.9	1.7	0	0	0.08	0.36	0.16	0.27	0.24	0.26	0.32	0.29	0.4	0.51																
14-Jul-20	5	3	1	521555	4990278	Flat	1.3	1.6	0	0	0.05	0.08	0.1	0.08	0.15	0.09	0.2	0.12	0.25	0.14	0.3	0.2	1.6	0.22												
14-Jul-20	5	3	2	521554	4990300	Riffle	1.7	1.7	0	0.2													1.7	0.27												
14-Jul-20	5	3	3	521551	4990349	Flat	1.5	1.5	0	0.11													1.5	0.17												
14-Jul-20	5	3	4	521486	4990376	Flat	1.6	2.5	0	0	0.15	0.08	0.3	0.17	0.45	0.28	0.6	0.36	0.7	0.33			2.5	0	2.45	0.04	2.4	0.08	2.35	0.14	2.3	0.32				
14-Jul-20	5	4	1	521467	4990414	Pool	1.8	2.3	0	0	0.1	0.06	0.2	0.09	0.3	0.17	0.4	0.16					2.3	0	2.25	0.19	2.2	0.23								
14-Jul-20	5	4	2	521462	4990432	Run	1.7	2.3	0	0	0.15	0.04	0.3	0.02	0.45	0.09	0.6	0.15					2.3	0.28												
15-Jul-20	5	5	1	521439	4990460	Riffle	1.4	2.1	0	0	0.1	0.05	0.2	0.3	0.3	0.3	0.4	0.25	0.5	0.28			2.1	0	2.05	0.14	2	0.2	1.95	0.22	1.9	0.25				
15-Jul-20	5	5	2	512429	4990460	Run	2.3	2.5	0	0	0.05	0.02	0.1	0.1	0.15	0.15	0.2	0.3					2.5	0.28												
15-Jul-20	5	5	3	521428	4990476	Pool	2.9	3.2	0	0	0.05	0.06	0.1	0.04	0.15	0.15	0.2	0.17					3.2	0	3.15	0.37	3.1	0.38								
15-Jul-20	5	6	1	N/A	N/A	No defined channel	N/A	N/A	N/A														N/A													
15-Jul-20	5	7	1	521403	4990523	Run	1.7	1.7	0	0.35													1.7	0.33												
15-Jul-20	5	7	2	521404	4990529	Pool	2.3	2.3	0	0.26													2.3	0.28												
15-Jul-20	5	7	3	521402	4990535	Riffle	0.9	1.8	0	0	0.1	0.02	0.2	0.02	0.3	0.03	0.4	0.08	0.5	0.19			1.8	0	1.7	0.11	1.6	0.12	1.5	0.19	1.4	0.27				
15-Jul-20	5	8	1	521411	4990577	Flat	1.4	1.4	0	0.33													1.4	0.3												
15-Jul-20	5	8	2	521422	4990619	Flat	2.7	2.7	0	0.14													2.7	0.32												
15-Jul-20	5	8	3	521446	4990651	Flat	3.1	3.1	0	0.24													3.1	0.24												
15-Jul-20	5	8	4	521472	4990695	Flat	3.5	3.5	0	0													3.5	0												
15-Jul-20	5	8	5	521460	4990752	Flat	3	3	0	0.28													3	0.16												
15-Jul-20	5	8	6	521490	4990795	Flat	3.6	3.6	0	0.32													3.6	0.09												
15-Jul-20	5	8	7	521525	4990839	Flat	2.7	2.7	0	0.24													2.7	0.14												
13-Jul-20	13	1	1	522691	4990231	Pool	3	3.3	0	0	0.05	0.07	0.1	0.08	0.15	10							3.3	0	3.25	0.05	3.2	0.04	3.15	0.05						
13-Jul-20	13	1	2	522710	4990241	Riffle	1.7	4.8	0	0	0.2	0.11	0.4	0.41	0.6	0.45	0.8	0.55	1	0.58	1.2	1	4.8	0.01	4.5	0.01	4.2	0.08	3.9	0.18	3.6	0.36	3.3	0.51	3.1	0.63
13-Jul-20	13	2	1	522725	4990238	Pool	2.5	3.1	0	0	0.05	0.11	0.1	0.12	0.15	0.13	0.2	0.21					3.1	0	3.05	0.09	3	0.12	2.95	0.13	2.85	0.17	2.75	0.18	2.7	0.19
13-Jul-20	13	3	1	522741	4990225	Riffle	0.8	1.1	0.05	0	0.1	0.04	0.15	0.05	0.2	0.06							1.1	0	1.05	0.04	1	0.04	0.95	0.05	0.9	0.05	0.85	0.06		
13-Jul-20	13	4	1	522750	4990231	Flat	2.7	3	0	0	0.05	0.16	0.1	0.16	0.15	0.17	0.2	0.18	0.25	0.18	0.3	0.19	3	0.09												
13-Jul-20	13	5	1	522768	4990263	Pool	1.6	1.8	0	0	0.05	0.04	0.1	0.16	0.15	0.15	0.2	0.2					1.8	0.12												
13-Jul-20	13	5	2	522773	4990260	Riffle	0.6	0.9	0	0	0.05	0.04	0.1	0.2									0.9	0	0.85	0.1	0.8	0.13	0.75	0.17	0.7	0.22				
13-Jul-20	14A	1	1	522752	4990134	Run, low condition	0.4	0.5	0	0	0.05	0.05	0.1	0.06									0.5	0.04												
13-Jul-20	14B	1	1	522740	4990049	Step - pool	0.6	1	0	0	0.05	0.03	0.1	0.19	0.15	0.23	0.2	0.2					1	0.02	0.95	0.12	0.9	0.14	0.85	0.19	0.8	0.2				
13-Jul-20	14	2	1	522741	4990145	Step - pool	0.8	1.3	0	0	0.1	0.03	0.15	0.05	0.2	0.07	0.25	0.16	0.3	0.26			1.3	0	1.25	0.16	1.2	0.2	1.15	0.23	1.1	0.34				
17-Jul-20	20	1	1	520060	4989872	Flat	1.3	1.4	0	0	0.05	0.07	0.1	0.14									1.4	0.21												
17-Jul-20	20	1	2	520043	4989824	Flat	1.1	3.2	0	0	0.3	0.06	0.6	0.07	0.9	0.07	1.2	0.13	1.5	0.15			2.6	0.12	2.8	0.05	3	0.05	3.2	0						
17-Jul-20	20	1	3	520011	4989777	Flat	1.2	2.3	0	0.19	0.1	0.17	0.2	0.2	0.3	0.2	0.4	0.16	0.6	0.16			2.3	0	2.2	0.06	2.1	0.05	2	0.07	1.9	0.08	1.8	0.1		
17-Jul-20	20	1	4	520000	4989729	Flat	0.9	0.9	0	0.23													0.9	0.48												
17-Jul-20	21	1	1	520059	4990175	Flat	0.3	0.3	0	0.08													0.3	0.07												
17-Jul-20	21	2	1	520075	4990156	Step - pool	0.35	0.5	0	18													0.5	0	0.45	0.08	0.4	0.11	0.35	0.14						
17-Jul-20	22	1	1	520112	4988792	Flat	1	1	0	0.14													1	0.22												
17-Jul-20	22	1	2	520059	4989788	Flat	0.6	0.6	0	0.09	0.1	0.07											0.6	0.17												
16-Jul-20	23	1	1	519764	4989543	Flat	3.5	4.1	0	0	0.1	0.05	0.2	47	0.3	45	0.4	38	0.5	40	0.6	39	4.1	0												
16-Jul-20	23	1	2	519725	4989516	Flat	2.3	4	0	0	0.3	0.09	0.6	0.12	0.9	0.15	1.2	0.18	1.4	0.19			4	0	3.9	0.03	3.8	0.05	3.7	0.05						
16-Jul-20	23	2	3	519688	4989480	Flat	2.9	4.1	0	0	0.3	0.05	0.6	0.07	0.9	0.06	1.2	0.07					4.1	0.1												
16-Jul-20	23	2	1	519664	4989454	Flat	2.6	3.9	0	0	0.05	0.03	0.1	0.06	0.15	0.07	0.2	0.07	0.3	0.1			3.9	0.01	3.7	0.09	3.5	0.06	3.3	0.06	3.1	0.08	2.9	0.09		
16-Jul-20	23	2	2	519678	4989401	Flat	2.7	5.1	0	0	0.4	0.19	0.8	0.15	1.2	0.14	1.6	0.1	1.9	0.07			5.1	0	5	0.03	4.9	0.06	4.8	0.07	4.7	0.08	4.6	0.08		
16-Jul-20	23	2	3	519693	4989356	Flat	3.6	4.1	0	0	0.05	0.03	0.1	0.05									4.2	0	4.1	0.01	4	0.02	3.9	0.04	3.8	0.07	3.7	0.07		
16-Jul-20	23	3	1	519709	4989311	Flat	3	5	0	0	0.2	0.18	0.4	0.24	0.6	0.18	0.8	0.19	1.1	0.21			5	0	4.9	0.04	4.7	0.06	4.5	0.07	4.3	0.13	4.1	0.13		
16-Jul-20	23	3	2	519728	4989255	Flat	2	3.5	0	0	0.05	0.05	0.1	0.15	0.33	0.2	0.35						3.5	0	3.3	0.17	3.1	0.25	2.8	0.28	2.5	0.3	2.2	0.33		
16-Jul-20	23	3	3	519729	4989211	Flat	2.1	4.3	0	0	0.3	0.04	0.6	0.08	0.9	0.11	1.2	0.09	1.4	0.1			4.3	0	4.1	0.11	3.9	0.16	3.7	0.16	3.5	0.1				
27-Jul-20	23	3	4	519724	4989166	Flat	2.8	4	0	0.37													4	0	3.8	0.5	3.6	0.47	3.4	0.43	3.2	0.42	3	0.44		
27-Jul-20	23	3	5	519751	4989119	Flat	2.5	5.3	0	0	0.3	0.11	0.6	0.09	0.9	0.08	1.2	0.13	1.5	0.17			5.3	0	5.05	0.13	4.8	0.12	4.55	0.1	4.3	0.08	4.05	0.07		
27-Jul-20	23	3	6	519722	4989014	Flat	2	4.6	0	0	0.5	0.12	1	0.17	1.5	0.24	2	0.26	2.3	0.27			4.6	0	4.55	0.1	4.5	0.12	4.45	0.2	4.4	0.38				
27-Jul-20	23	3	7	519712	4988953	Step - pool	0.9	1.1	0	0.22													1.1	0.26												
27-Jul-20	23	3	8	519533	4988766	Flat	3	4.2	0	0	0.2	0.03	0.4	0.04	0.6	0.03	0.8	0.03	1	0.11			4.2	0	4.15	0.02	4.1	0.11	40.5	0.12	4	0.18				
27-Jul-20	23	3	9	519550	4988725	Flat	3	4.4	0	0	0.2	0.08	0.4	0.12	0.6	0.12	0.8	0.11	1	0.13			4.4	0	4.3	0.04	4.2	0.06	4.1	0.06	4	0.08				
27-Jul-20	23	3	10	519503	4988692	Flat	2.5	4.4	0	0	0.2	0.17	0.4	0.15	0.6	0.16	0.8	0.16	1	0.16			4.4	0	4.2	0.06	4	0.14	3.8	0.08	3.6	0.15				
21-Jul-20	23	3	11	519481	4988642	Flat	1.9	3.2	0	0	0.25	0.07	0.5	0.07	0.75	0.07	1	0.05	1.25	0.08			3.2	0.42												
21-Jul-20	23	3	12	519428	4988551	Flat	1.6	4.6	0	0	0.4	0.04	0.8	0.17	1.2	0.33	1.6	0.4	2	0.45			4.6	0.05	4.4	0.24	4.2	0.27	4	0.22	3.8	0.32	3.6	0.32		
21-Jul-20	23	3	13	519368	4988505	Flat	1.9	2.5	0	0	0.1	0.01	0.2	0.03	0.3	0.04	0.4	0.06	0.5	0.14	0.6	0.17	2.5	0.33												
21-Jul-20	23	3	14	519326	4988440	Flat	1.6	2.8	0	0	0.12	0.02	0.24	0.12	0.36	0.12	0.48	0.17	0.6	0.21			2.8	0	2.68	0.07	2.56	0.13	2.44	0.19	2.32	0.22	2.2	0.21		
21-Jul-20	23	3	15	519230	4988414	Flat	2.8	4.9	0	0	0.1	0.03	0.2	0.19	0.3	0.2	0.4	0.14	0.5	0.38			4.9	0	4.6	0.04	4.3	0.13	4	0.17	3.7	0.21	3.4	0.21		
21-Jul-20	23	3	16	519201	4988453	Flat	2.7	4.6	0	0	0.3	0.04	0.6	0.08	0.9	0.15	1.2	0.19	1.5	0.18			4.6	0	4.5	0.25	4.4	0.23	4.3	0.21	4.2	0.35	4.1	0		
16-Jul-20	26	1	1	520146	4990904	Flat	0.6	0.6	0	0.02													0.6	0.08												
16-Jul-20	26	1	2	520112	4990940	Dry (flat)	N/A	0.22	0	0.08													0.22	0.09												
16-Jul-20	26	2	1	520090	4990959	Flat	1	2	0	0	0.1	0.06	0.2	0.12	0.3	0.17	0.4	0.17	0.5	0.17			2	0	1.9	0.09	1.8	0.12	1.7	0.14	1.6	0.16	1.5	0.21		
16-Jul-20	26	2	2	520087	4991004	Flat	0.7	0.7	0	0.19													0.7	0.24												
16-Jul-20	26	2	3	520032	4991027	Flat	2	2.3	0	0	0.05	0.05	0.1	0.1	0.15	0.14	0.2	0.13	0.25	0.13	0.3	0.16	2.3	0	2.25	0.1	2.2	0.13	2.15	0.13	2.1	0.13	2.05	0.13	2	0.14
16-Jul-20	26	2	4	519983	4991044	Flat	1.4	1.4	0	10													1.4	0.12												
16-Jul-20	26	2	5	519962	4991090	Flat	1.5	1.5	0	0.08													1.5	0.1												
16-Jul-20	26	2	6	520001	4991125	Flat	1.3	1.3	0	0.33													1.3	0.33												
16-Jul-20	26	2	7	519993	4991168	Flat	1.4	1.8	0	0	0.1	0.07	0.2	0.14	0.3	0.21	0.4	0.23					1.8	0.32												
16-Jul-20	26	2	8	520001	4991221	Flat	1.4	1.4	0	0.27													1.4	0.27												
16-Jul-20	26	2	9	520017	4991267	Flat	1.5	1.5	0	0.15													1.5	0.31												
16-Jul-20	26	2	10	520043	4991303	Flat	4.7	4.7	0	0													4.7	0.15												
22-Jul-20	12	1	1	522188	4990328	Dry	N/A	1	0	0.12													1	0.13												
30-Sep-20	25	1	1	522421	4990534	Riffle	0.3	0.55	0	0	0.05	0.13	0.1	0.15	0.15	0.17	0.2	0.2					0.55	0	0.5	0.17										
30-Sep-20	25	1	2	522425	4990545	Flat	0.6	1	0	0	0.05	0.05	0.1	0.05	0.15	0.09	0.2	0.09	0.25	0.11	0.3	0.14	1	0	0.95	0.03	0.9	0.09								

Table 6. Detailed Fish Habitat Data – Transect Data Part 2

Survey Date	WC #	Reach #	Transect #	Depths and Velocities – left to right bank																																	Substrate Comments
				Distance (m)	Depth (m)	Velocity (m/s)	Distance (m)	Depth (m)	Velocity (m/s)	Distance (m)	Depth (m)	Velocity (m/s)	Distance (m)	Depth (m)	Velocity (m/s)	Distance (m)	Depth (m)	Velocity (m/s)	Distance (m)	Depth (m)	Velocity (m/s)	Distance (m)	Depth (m)	Velocity (m/s)	Distance (m)	Depth (m)	Velocity (m/s)	Distance (m)	Depth (m)	Velocity (m/s)	Distance (m)	Depth (m)	Velocity (m/s)	Distance (m)	Depth (m)	Velocity (m/s)	
22-Jul-20	27	1	1	0.3	0.48	0.05	0.6	0.59	0.05	0.9	0.7	0.05	1.2	0.71	0.05	1.5	0.69	0.05	1.8	0.38	0.05	2.1	0.36	0.05	2.4	0.4	0.05	2.7	0.46	0.05	3	0.28	0.05	3.3	0.13	0.05	Detritus, all muck
22-Jul-20	27	1	2	0.4	0.68	0.05	0.8	0.55	0.05	1.2	0.7	0.05	1.6	0.8	0.05	2	0.85	0.05	2.4	0.88	0.05	2.8	0.91	0.05	3.2	0.96	0.05	3.6	0.92	0.05	4	0.87	0.05	4.4	0.73	0.05	100% Muck/Detritus
22-Jul-20	27	1	3	0.65	0.48	0.05	1.3	0.65	0.05	1.95	0.85	0.05	2.6	0.76	0.05	3.25	0.58	0.05	3.9	0.56	0.05	4.55	0.63	0.05	5.2	0.59	0.05	5.85	0.55	0.05	6.5	0.34	0.05				Muck/detritus
22-Jul-20	27	1	4	0.8	0.17	0.05	1.6	0.23	0.05	2.4	0.72	0.05	3.2	0.9	0.05	4	0.71	0.05	4.8	0.73	0.05	5.6	0.55	0.05	6.4	0.23	0.05	7.2	0.25	0.05	8	0.27	0.05	8.8	0.24	0.05	Muck/detritus
14-Jul-20	5	1	1	0.6	0.21	0.05	0.7	0.2	0.05	0.8	0.18	0.05	0.9	0.18	0.55	1	0.06	0.39	1.1	0.01	0.05	1.2	-0.09	0	1.3	-0.1	0	1.4	0.23	0.05	1.5	0.17	0	1.5	0.15	0	Matches reach
14-Jul-20	5	2	1	1.1	0.04	0.05	1.2	0.11	0.05	1.3	0.11	0.05	1.4	0.12	0.05	1.5	0.12	0.05	1.6	0.1	0.23	1.7	0.14	0.49	1.8	0.12	0.46	1.9	0.1	0.3	1	0.1	0.05	1.1	0.05	0.05	Matches reach
14-Jul-20	5	2	2	1.9	0.06	0.2	2	0.11	0.44	2.1	0.07	0.44	2.2	0.08	0.4	2.3	0.06	0.31	2.4	0.04	0.36	2.5	0.02	0.31	2.6	0.03	0.41	2.7	0.05	0.05	2.8	0.03	0.05				Matches reach
14-Jul-20	5	2	3	0.5	0.15	0.05	0.6	0.1	0.05	0.7	0.06	0.58	0.8	0.09	0.91	0.9	0.04	0.9	1	0.06	0.9	1.1	0.05	0.9	1.2	0.02	0.05	1.3	0.05	0.05							100% boulder
14-Jul-20	5	3	1	0.4	0.27	0.05	0.5	0.26	0.05	0.6	0.38	0.05	0.7	0.32	0.05	0.8	0.34	0.05	0.9	0.33	0.05	1	0.33	0.05	1.1	0.36	0.05	1.2	0.37	0.05	1.3	0.36	0.05	1.4	0.37	0.05	
14-Jul-20	5	3	2	0.15	0.06	0.05	0.3	0.05	0.05	0.45	0.03	0.05	0.6	0.07	0.3	0.75	0.08	0.3	0.9	0.05	0.41	1.05	0.09	0.41	1.2	0.08	0.05	1.35	0.06	0.05	1.5	0.07	0.05	1.65	0.07	0.05	50% gravel, 50% sand
14-Jul-20	5	3	3	0.15	0.45	0.05	0.3	0.44	0.05	0.45	0.48	0.05	0.6	0.62	0.05	0.75	0.56	0.05	0.9	0.67	0.05	1.05	0.7	0.05	1.2	0.47	0.05	1.35	0.39	0.05							100% muck/detritius
14-Jul-20	5	3	4	0.85	0.64	0.05	1	0.68	0.05	1.15	0.71	0.05	1.3	0.72	0.05	1.45	0.76	0.05	1.6	0.7	0.05	1.75	0.68	0.05	1.9	0.63	0.05	2.05	0.51	0.05	2.2	0.11	0.05				50% rubble, 25% boulder, 25% cobble
14-Jul-20	5	4	1	0.55	0.06	0.05	0.7	0.09	0.05	0.85	0.24	0.05	1	0.56	0.05	1.15	0.5	0.05	1.3	0.45	0.05	1.45	0.38	0.05	1.6	0.35	0.05	1.75	0.32	0.05	1.9	0.28	0.05	2.05	0.23	0.05	
14-Jul-20	5	4	2	0.75	0.06	0.05	0.9	0.09	0.05	1.05	0.21	0.12	1.2	0.39	0.12	1.35	0.38	0.12	1.5	0.31	0.12	1.65	0.36	0.12	1.8	0.35	0.12	1.95	0.3	0.05	2.1	0.1	0.05				Bouldery, muck, buoyant object at first velocity
15-Jul-20	5	5	1	0.65	0.07	0.05	0.8	0.09	0.38	0.95	0.03	1.12	1.1	0.12	0.93	1.25	-0.07	0	1.4	-0.05	0	1.55	0.05	0.45	1.7	0.07	0.3	1.85	0.04	0.05							Matches reach
15-Jul-20	5	5	2	0.4	0.07	0.05	0.6	0.07	0.05	0.8	0.1	0.3	1	0.18	0.23	1.2	0.17	0.13	1.4	0.13	0.05	1.6	0.1	0.05	1.8	0.15	0.05	2	0.05	0.05	2.2	0.03	0.05	2.4	0.01	0.05	Matches reach
15-Jul-20	5	5	3	0.45	0.08	0.05	0.7	0.09	0.05	0.95	0.21	0.05	1.2	0.21	0.05	1.45	0.21	0.05	1.7	0.22	0.05	1.95	0.15	0.05	2.2	0.22	0.05	2.45	-0.1	0	2.7	0.15	0.05				CWD causing impoundment , 50/50 muck and rubble
15-Jul-20	5	6	1	N/A	0.1	0.23	N/A	0.13	0.36	N/A	0.8	0.48	N/A	0.11	0.38	N/A	0.26	0.49	N/A	0.06	0.4	N/A	0.2	0.42	N/A	0.13	0.6	N/A	0.13	n/a	N/A	0.32	N/A	N/A	0.38	N/A	Depth and velocities were taken randomly throughout reach, the depth and velocities do not match
15-Jul-20	5	7	1	0.15	0.11	0.05	0.3	0.07	0.05	0.45	0.04	0.2	0.6	0.11	0.2	0.75	0.1	0.2	0.9	0.1	0.2	1.05	0.15	0.3	1.2	0.07	0.37	1.35	0.08	0.05	1.5	-0.03	0				Mostly boulder (70%) cobble (15%), minor amounts of Cobble (5%) gravel/sand (5%)
15-Jul-20	5	7	2	0.2	0.11	0.05	0.4	0.12	0.05	0.6	0.14	0.05	0.8	0.21	0.05	1	0.21	0.19	1.2	0.19	0.11	1.4	0.14	0.05	1.6	0.15	0.05	1.8	0.16	0.05	2	0.08	0.05				
15-Jul-20	5	7	3	0.6	0.08	0.38	0.7	0.02	N/A	0.8	0.05	0.52	0.9	0.08	0.62	1	0.05	N/A	1.1	0.06	0.32	1.2	0.06	N/A	1.3	0.06	N/A	1.4	0.02	N/A							
15-Jul-20	5	8	1	0.15	0.24	0.05	0.3	0.24	0.05	0.45	0.31	0.05	0.6	0.32	0.05	0.75	0.24	0.05	0.9	0.21	0.05	1.05	0.16	0.05	1.2	0.15	0.05	1.35	0.08	0.05							Detritus, little bit of water (10%)
15-Jul-20	5	8	2	0.25	0.04	0.05	0.5	0.16	0.05	0.75	0.14	0.05	1	0.29	0.05	1.25	0.37	0.05	1.5	0.45	0.05	1.75	0.35	0.05	2	0.32	0.05	2.25	0.27	0.05	2.5	0.13	0.05				100% muck/debris
15-Jul-20	5	8	3	0.3	0.1	0.05	0.6	0.41	0.05	0.9	0.63	0.05	1.2	0.71	0.05	1.5	0.86	0.05	1.8	0.93	0.05	2.1	0.9	0.05	2.4	0.87	0.05	2.7	0.84	0.05	3	0.81	0.05				80% muck. 20% boulder (70% embedded in muck)
15-Jul-20	5	8	4	0.25	0.7	0.05	0.5	0.99	0.05	0.75	0.9	0.05																									Distances taken 1/4, 1/2 and 3/4 of the way across. 100% muck and detritus, too deep and mucky to establish transect by wading. There

																																					is no photo of the left bank since can't cross
15-Jul-20	5	8	5	0.3	0.27	0.05	0.6	0.26	0.05	0.9	0.46	0.05	1.2	0.1	0.05	1.5	0.36	0.05	1.8	0.25	0.05	2.1	0.32	0.05	2.4	0.33	0.05	2.7	0.44	0.05							80% boulder, 20% muck
15-Jul-20	5	8	6	0.35	0.06	0.05	0.7	0.28	0.05	1.05	0.4	0.05	1.4	0.43	0.05	1.75	0.44	0.05	2.1	0.56	0.05	2.45	0.63	0.05	2.8	0.4	0.05	3.15	0.43	0.05	3.5	0.32	0.05				Same as T5
15-Jul-20	5	8	7	0.25	0.34	0.05	0.5	0.4	0.05	0.75	0.65	0.05	1	0.8	0.05	1.25	1.03	0.05	1.5	1.1	0.05	1.75	1.11	0.05	2	0.55	0.05	2.25	0.35	0.05	2.5	0.15	0.05				100% muck
13-Jul-20	13	1	1	0.45	-0.05	0	0.75	0.07	0.05	1.05	0.1	0.05	1.35	0.16	0.05	1.65	0.17	0.05	1.95	0.15	0.05	2.25	0.16	0.05	2.55	0.16	0.05	2.85	0.1	0.05							100% muck/detritus, no propellor movement, estimated max velocity os 0.05
13-Jul-20	13	1	2	1.35	0.05	0.01	1.5	0.03	0.1	1.65	0.04	0.1	1.8	0.03	0.3	1.95	0.02	0.3	2.1	0.03	0.3	2.25	0.04	0.3	2.4	0.04	0.1	2.55	0.03	0.1	2.7	0.04	0.1				Same as reach, *velocity estimated by bouyant object, too shallow to measure
13-Jul-20	13	2	1	0.45	0.03	0	0.7	0.13	0.1	0.95	0.19	0.1	1.2	0.19	0.05	1.45	0.14	0.05	1.7	0.1	0.05	1.95	0.06	0.1	2.2	0.05	0.1	2.45	0.05	0	2.7	0.04	0				*Estimated based on bouyant object
13-Jul-20	13	3	1	0.35	-0.05	0	0.5	0.05	0.2	0.65	0.05	0.1																									Same as reach, *velocity estimated by bouyant object
13-Jul-20	13	4	1	0.6	0.12	0.05	0.9	0.29	0.05	1.2	0.32	0.05	1.5	0.56	0.05	1.8	0.6	0.05	2.1	0.7	0.05	2.4	0.71	0.05	2.7	0.49	0.05	3	0.32	0.05							Same as reach, *velocity estaimed based on no flow meter reading
13-Jul-20	13	5	1	0.35	0.12	0.001	0.5	0.13	0.001	0.65	0.16	0.001	0.8	0.17	0.001	0.95	0.18	0.02	1.1	0.16	0.03	1.25	0.17	0.05	1.4	0.18	0.05	1.55	0.17	0.05	1.7	0.14	0.001				100% detritus, *velocity estimated based on bouyant object
13-Jul-20	13	5	2	0.15	0.01	0.05	0.2	0.05	0.05	0.25	0.06	0.05	0.3	0.06	0.05	0.35	0.07	0.05	0.4	0.09	0.179	0.45	0.09	0.05	0.5	0.1	0.05	0.55	0.08	0.05	0.6	0.09	0.05				Consistent with reach *velocity of 0.179 actually measured on flow meter, rest are estaimted based on no flow reading
13-Jul-20	14A	1	1	0.1	0.02	0.05	0.02	0.07	0.05	0.3	0.11	0.05	0.4	0.17	0.05																						
13-Jul-20	14B	1	1	0.2	0.01	0.05	0.3	0.03	0.05	0.4	0.07	0.05	0.5	0.01	0.05	0.6	0.04	0.05	0.7	0.03	0.05	0.8	0	0													Consistent with reach *velocity estimated based on no rotation of flow meter (no depth, slow)
13-Jul-20	14	2	1	0.3	0.01	0	0.4	0.04	0.001	0.5	0.05	0.003	0.6	-0.06	0	0.7	0.05	0.06	0.8	0.03	0.06	0.9	0.08	0.06	1	0.12	0.03	1.1	0.07	0.001							Consistent with reach *velocity estimated fron bouyant object
17-Jul-20	20	1	1	0.1	0.09	0	0.3	0.9	0.01	0.5	0.11	0.01	0.7	0.08	0.01	0.9	0.1	0.01	1.1	0.08	0.01	1.3	0.1	0.01	1.4	0.05	0										Consistent *velocity estimated from bouyant object
17-Jul-20	20	1	2	1.5	0.03	0	1.6	0.03	0.05	1.8	0.07	0.05	1.9	0.08	0.05	2	0.08	0.07	2.1	0.08	0.07	2.2	0.09	0.05	2.3	0.11	0.01	2.4	0.1	0.01	2.6	0.1	0				Consistent, estimated from bouyant object
17-Jul-20	20	1	3	0.6	0.01	0.05	0.7	0.05	0.05	0.8	0.06	0.05	0.9	0.07	0.05	1	0.1	0.05	1.1	0.12	0.05	1.2	0.13	0.05	1.3	0.16	0.05	1.5	0.18	0.05	1.8	0.02	0.05				*Velocity estimated
17-Jul-20	20	1	4	0	0	0	0.1	0.13	0.05	0.2	0.17	0.05	0.3	0.12	0.05	0.4	0.12	0.05	0.5	0.18	0.05	0.6	0.16	0.05	0.7	0.15	0.05	0.9	0	0							Boulder 25%, muck 75%, *velocity estimated from bouyant object, boulder banks
17-Jul-20	21	1	1	0	0	0	0.1	0.04	0.05	0.2	0.2	0.05	0.3	0	0																						Substrate consistent, *velocity

																																					estimated from bouyant object
17-Jul-20	21	2	1	0	0.03	0.05	0.1	0.06	0.17	0.2	0.05	0.175	0.3	0.04	0.1	0.35	0	0																			
17-Jul-20	22	1	1	0	0.19	0.05	0.1	0.16	0.05	0.2	0.14	0.05	0.3	0.12	0.05	0.4	0.1	0.05	0.5	0.1	0.05	0.6	0.11	0.05	0.7	0.14	0.05	0.8	0.18	0.05	1	0.16	0.05				*Velocity estimated
17-Jul-20	22	1	2	0	0	0.05	0.1	0	0.05	0.2	0.02	0.05	0.3	0.09	0.05	0.4	0.14	0.05	0.5	0.14	0.05	0.6	0	0.05													*Velocity estimated
16-Jul-20	23	1	1	0.6	0	0	1	0.06	0.01	1.4	0.1	0.01	1.8	0.11	0.01	2.2	-0.07	0	2.6	-0.03	0	3	0.2	0.05	3.4	0.12	0.05	3.8	0.12	0.05	4.1	0	0				Large boulder 60%, muck 40%, *velocity estimated from bouyant object
16-Jul-20	23	1	2	1.4	0.03	0	1.7	0.18	0.01	2	0.2	0.01	2.3	0.22	0.9	2.6	0.18	0.9	2.9	0.12	0.7	3.2	0.13	0.6	3.5	0.2	0.01	3.7	0.02	0							Muck 80%, boulder 20%, estimated from bouyant object
16-Jul-20	23	2	3	1.2	0.04	0.001	1.5	0.06	0.005	1.8	0.11	0.01	2.1	0.14	0.02	2.4	0.29	0.04	2.7	0.14	0.04	3	0.07	0.02	3.3	0.12	0.02	3.6	0.15	0.005	4.1	0.05	0.001				Muck 80%, boulder 20%, estimated from bouyant object
16-Jul-20	23	2	1	0.03	0.01	0	0.6	0.07	0.01	0.9	0.08	0.01	1.2	0.16	0.02	1.4	0.18	0.03	1.6	0.11	0.05	1.9	0.15	0.03	2.2	0.09	0.02	2.5	0.07	0.01	2.9	0.04	0				85% muck, 15% boulder, *velocity estimated from bouyant object
16-Jul-20	23	2	2	1.9	0.02	0	2.2	0.14	0.001	2.5	0.34	0.02	2.8	0.09	0.01	3.1	-0.01	0	3.4	0.004	0.001	3.7	0.13	0.01	4	0.16	0.01	4.3	0.26	0	4.6	0.01	0				85% muck, 15% boulder, *velocity estimated from bouyant object
16-Jul-20	23	2	3	0.1	0.08	0.001	0.5	0.195	0.005	0.9	0.23	0.01	1.3	0.23	0.01	1.7	0.26	0.01	2.1	0.28	0.01	2.5	0.17	0.005	2.9	0.1	0.005	3.3	0.09	0.001	3.7	0.01	0.001				85% muck, 15% boulder, *velocity estimated from bouyant object
16-Jul-20	23	3	1	1.1	0	0	1.4	0.1	0.001	1.7	0.05	0.005	2	0.19	0.01	2.3	0.24	0.01	2.6	0.12	0.01	2.9	0.2	0.01	3.2	0.27	0.01	3.5	0.14	0.005	4.1	0.01	0				30% boulder, 70% muck, *velocity estimated from bouyant object
16-Jul-20	23	3	2	0.2	0.01	0	0.4	0.06	0.01	0.6	0.23	0.05	0.8	-0.08	0	1	0.26	0.1	1.2	0.25	0.05	1.4	0.11	0.1	1.6	0.21	0.05	1.8	0.26	0.01	2.2	0.11	0.01				60% boulder, 40% muck, *velocity estimated from bouyant object
16-Jul-20	23	3	3	1.4	0.01	0	1.6	0.09	0.005	1.8	0.13	0.005	2	0.14	0.01	2.2	0.13	0.01	2.4	0.15	0.01	2.6	0.09	0.01	2.8	0.07	0.005	3.1	0.09	0.005	3.5	0.01	0				*Velocity estimated from bouyant object
27-Jul-20	23	3	4	0.3	0.12	0.05	0.6	0.19	0.05	0.9	0.27	0.05	1.2	0.22	0.05	1.5	0.23	0.05	1.8	0.18	0.05	2.1	0.18	0.05	2.4	0.4	0.05	2.7	0.39	0.05	2.9	0.18	0.05				100% Detritus
27-Jul-20	23	3	5	1.75	0.15	0.05	2	0.16	0.05	2.25	0.18	0.05	2.5	0.42	0.05	2.75	0.19	0.05	3	0.12	0.05	3.25	0.19	0.05	3.5	0.22	0.05	3.75	0.15	0.05	4	0.03	0.05				100% Detritus
27-Jul-20	23	3	6	2.6	0.04	0.05	2.8	0.03	0.05	3	0.1	0.05	3.2	0.12	0.05	3.4	0.12	0.05	3.6	0.14	0.05	3.8	0.12	0.05	4	0.09	0.05	4.2	0.04	0.05	4.4	0.1	0.05				100% Detritus
27-Jul-20	23	3	7	0.1	0	0	0.2	0.14		0.3	0.21	0.43	0.4	0.13	0.21	0.5	0.17	0.22	0.6	0.16	0.16	0.7	0.06		0.8	0.1	0.19	0.9	0.2	1	0.13						Boulder substrate some rubble *Only recorded velocity measurements that could be taken with meter
27-Jul-20	23	3	8	1.3	0.07	0.05	1.6	0.09	0.05	1.9	0.13	0.05	2.1	0.17	0.05	2.4	0.15	0.05	2.7	0.18	0.05	3	0.25	0.05	3.3	0.3	0.05	3.6	0.3	0.05	3.9	0.23	0.05				100% Detritus
27-Jul-20	23	3	9	1.3	0.07	0.05	1.6	0.35	0.05	1.9	0.37	0.05	2.2	0.47	0.05	2.5	0.47	0.05	2.8	0.39	0.05	3.1	0.38	0.05	3.4	0.31	0.05	3.7	0.18	0.05	4	0.04	0.05				100% Detritus
27-Jul-20	23	3	10	1.35	0.23	0.05	1.6	0.25	0.05	1.85	0.35	0.05	2.1	0.39	0.05	2.35	0.37	0.05	2.6	0.32	0.05	2.85	0.45	0.05	3.1	0.23	0.05	3.35	0.26	0.05	3.6	0.7	0.05				100% Detritus
21-Jul-20	23	3	11	1.3	0.7	0.05	1.5	0.11	0.05	1.7	0.18	0.05	1.9	0.21	0.05	2.1	0.16	0.05	2.3	0.2	0.05	2.5	0.06	0.05	2.7	0.15	0.05	2.9	0.08	0.05	3.1	0.05	0.05				100% Detritus
21-Jul-20	23	3	12	2.25	0.06	0.05	2.4	0.07	0.05	2.55	0.12	0.05	2.7	0.13	0.05	2.85	0.12	0.05	3	0.11	0.05	3.15	0.06	0.05	3.3	0.06	0.05	3.45	0.06	0.05	3.6	0.12	0.05				100% Detritus
21-Jul-20	23	3	13	0.8	0.15	0.05	1	0.19	0.05	1.2	0.24	0.05	1.4	0.42	0.05	1.5	0.49	0.05	1.6	0.35	0.05	1.8	0.28	0.05	2	0.29	0.05	2.2	0.21	0.05	2.4	0.06	0.05				50% boulders, 50% detritus
21-Jul-20	23	3	14	0.75	0.17	0.05	0.9	0.25	0.05	1.05	0.17	0.01	1.2	0.27	0.02	1.35	0.14	0.04	1.5	0.13	0.094	1.65	0.1	0.04	1.8	0.2	0.02	1.95	0.14	0.01	2.1	0.09	0.01				50% boulders, 50% detritus
21-Jul-20	23	3	15	0.75	0.12	0.05	1	0.15	0.05	1.25	0.18	0.05	1.5	0.19	0.05	1.75	0.14	0.05	2	0.17	0.05	2.25	0.11	0.05	2.5	0.14	0.05	2.75	0.09	0.05	3	0.08	0.05	3.25	0.02	0.05	50% boulders, 50% detritus
21-Jul-20	23	3	16	1.75	0.21	0.05	2	0.24	0.05	2.25	0.31	0.05	2.5	0.39	0.05	2.75	0.5	0.05	3	0.34	0.05	3.25	0.31	0.05	3.5	0.27	0.05	3.75	0.39	0.05	4	0.25	0.05				
16-Jul-20	26	1	1	0.15	0.24	0.05	0.3	0.39	0.05	0.45	0.39	0.05																									100% muck

16-Jul-20	26	1	2	N/A - no depth	<0.1m	N/A - no velocity																															wetland moss/veg
16-Jul-20	26	2	1	0.6	0.04	0.05	0.7	0.09	0.05	0.8	0.08	0.05	0.9	0.09	0.13	1	0.15	0.13	1.1	0.14	0.12	1.2	0.16	0.05	1.3	0.19	0.05	1.4	0.25	0.05							Muck 60%, boulder 40%, velocities other than 0.05 are measured with velocity meter
16-Jul-20	26	2	2	0.5	0.31	0.05	0.3	0.3	0.11	0.45	0.29	0.05																									Muck 100%, 0.11m/s measured with velocity meter
16-Jul-20	26	2	3	0.5	0.05	0.05	0.7	0.18	0.05	0.9	0.27	0.05	1.1	0.15	0.05	1.3	0.21	0.05	1.5	0.2	0.05	1.7	0.1	0.05	1.9	0.07	0.05										100% Muck/detritus
16-Jul-20	26	2	4	0.1	0.14	0.05	0.2	0.13	0.05	0.3	0.15	0.05	0.4	0.24	0.05	0.5	0.23	0.05	0.6	0.23	0.1	0.7	0.19	0.1	0.8	0.05	0.05	0.9	0.11	0.05	1	0.11	0.05	1.1	0.11	0.05	Muck 100%, 0.10m/s measured with velocity meter
16-Jul-20	26	2	5	0.15	0.07	0.05	0.3	0.09	0.05	0.45	0.17	0.1	0.6	0.23	0.1	0.75	0.24	0.1	0.9	0.23	0.05	1.05	0.3	0.05	1.2	0.24	0.05	1.35	0.2	0.05							Muck 100%
16-Jul-20	26	2	6	0.1	0.18	0.05	0.2	0.27	0.05	0.3	0.3	0.05	0.4	0.29	0.05	0.5	0.2	0.05	0.6	0.24	0.05	0.7	0.28	0.05	0.8	0.24	0.05	0.9	0.14	0.05	1	0.25	0.05	1.1	0.2	0.05	Muck 100%
16-Jul-20	26	2	7	0.5	0.12	0.05	0.6	0.23	0.05	0.7	0.18	0.05	0.8	0.16	0.05	0.9	0.03	0.05	1	0.07	0.05	1.1	0.14	0.05	1.2	0.2	0.05	1.3	0.32	0.05	1.4	0.34	0.05	1.5	0.3	0.05	Muck 100%
16-Jul-20	26	2	8	0.1	0.35	0.05	0.2	0.29	0.05	0.3	0.38	0.05	0.4	0.3	0.05	0.5	0.34	0.05	0.6	0.28	0.05	0.7	0.26	0.05	0.8	0.2	0.05	0.9	0.13	0.05	1	0.2	0.05	1.1	0.31	0.05	Boulder 70%, muck 30%
16-Jul-20	26	2	9	0.15	0.09	0.05	0.3	0.25	0.05	0.45	0.26	0.05	0.6	0.25	0.05	0.75	0.2	0.05	0.9	0.2	0.05	1.05	0.32	0.05	1.2	0.21	0.05	1.35	0.37	0.05							Boulder 80%, muck 20%
16-Jul-20	26	2	10	0.4	0.63	0.05	0.8	0.67	0.05	1.2	0.71	0.05	1.6	0.72	0.05	2	0.72	0.05	2.4	0.75	0.05	2.8	0.81	0.05	3.2	0.82	0.05	3.6	0.68	0.05	4	0.59	0.05				Boulder 50%, muck 50%, * could not wade another transect past T10 - too deep
22-Jul-20	12	1	1																																		
30-Sep-20	25	1	1	N/A - no depth	<0.01 m	N/A - no velocity																															Muck/detritus
30-Sep-20	25	1	2	0.3	0.02	0.05	0.4	0.04	0.05	0.5	0.11	0.05	0.6	0.14	0.05	0.7	0.11	0.05	0.8	0.07	0.05	0.9	0.03	0.05													Muck/detritus

APPENDIX H: BASELINE FISH AND FISH HABITAT: 2015-2017 TECHNICAL REPORT

Baseline Fish and Fish Habitat
2015 – 2017 Technical Report

Name of Project:

Beaver Dam Gold Project
Location: Marinette, Nova Scotia
Prepared for: Atlantic Mining Nova Scotia

Report Prepared by:

McCallum Environmental Ltd.

2 Bluewater Road, Suite 115
Bedford, Nova Scotia
B4B 1G7

Date: March 2021

Executive Summary

Atlantic Mining NS Corp. (AMNS) is proposing to construct, operate, decommission and reclaim the Beaver Dam Project (the Project), which is an open pit cold min in Marinette, Nova Scotia. The Project includes the transportation of ore to the Touquoy Mine Site for processing. The Project Area (PA) incorporates three separate components: the Beaver Dam Mine Site, the Haul Road, and the Touquoy Mine Site.

This Baseline Fish and Fish Habitat Technical Report was prepared as background information for the Environmental Impact Assessment for the Beaver Dam Mine Project. Fish and fish habitat surveys have been completed with the key objectives of facilitating avoidance of fish habitat where practicable, understanding the potential project interactions with fish and fish habitat, and to facilitate regulatory approvals for impacts to fish and fish habitat wherever necessary. This was achieved by completing a review of background desktop resources in combination with field studies to identify potential environmental constraints and sensitivities. This report outlines the methods and results of initial baseline fish and fish habitat characterization conducted by MEL biologists at waterbodies, wetlands, and linear watercourses identified as being potentially fish bearing throughout the Project Area through 2015-2017.

Scoping of the baseline field program was completed through consultation with DFO under the previous version of the *Fisheries Act* which defined "Serious Harm to Fish", prior to the 2019 amendments. The baseline fish and fish habitat program outlined in this report was completed to support a general understanding of fish species and relative abundance within the Study Area. The field program included fish habitat surveys within field-delineated watercourses and wetlands, electrofishing within linear watercourse reaches, trapping within linear watercourses and waterbodies, and benthic invertebrate surveys. Water quality measurements were recorded *in-situ* during fish and fish habitat surveys.

Temperatures recorded in aquatic features during baseline surveys ranged from 13.5^{0}C to 23.43 ^{0}C. Overall, the aquatic features within the Study Area are characterized by moderately acidic conditions, with most pH levels recorded within the SA falling below recommended CCME guidelines for freshwater habitat (CCME, 1999). Most DO levels recorded within Study Area largely fell within the CCME ranges suitable for both cold and warm water fishes (CCME, 1999). Abundance and taxon richness within the benthic invertebrate communities sampled were low to moderate, but the presence of pollution-intolerant species at most sites suggests that DO and water quality is acceptable, as these groups (EPT) generally are associated with aquatic habitat having good water quality.

Electrofishing and trapping surveys confirmed the presence of 10 fish species in the Study Area that would be expected within the West River Sheet Harbour and Tangier River secondary watersheds. As a result of fishing efforts, a total of 145 individuals were captured, with American eel, brook trout, and banded killifish being the most frequently captured species within linear watercourses, while yellow perch, banded killifish, and golden shiner were most abundant in waterbodies (Crusher Lake and open water section of Cameron Flowage/Killag River).

Fish habitat characterizations were conducted for each linear watercourse and wetland within the Study Area confirmed or assumed to provide fish and fish habitat. Fish habitat has been assumed present within all 35 linear watercourses and associated wetlands with surface water features along the Haul Road. Of the 29 linear watercourses assessed for fish and fish habitat within and downgradient of the Beaver Dam Mine Site, nine have been designated as non-fisheries resources. Twenty-seven (27) wetlands within the

Study Area are accessible to fish. These aquatic features are considered to provide suitable habitat for spawning, young of year, juvenile, and adult life stages for various species throughout the Study Area.

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McCallum Environmental Ltd.

List of Acronyms

ACCDC	Atlantic Canadian Conservation Data Centre
CCME	Canadian Council of Ministers of the Environment
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
DFO	Fisheries and Oceans Canada
DO	Dissolved oxygen
KM	Kilometer
M	Meters
CM	Centimeter
MEL	McCallum Environmental Ltd.
NSDAF	Nova Scotia Department of Fisheries and Aquaculture
NSE	Nova Scotia Environment
NSESA	Nova Scotia Endangered Species Act
NSTDB	Nova Scotia Topographic Database
NSSA	Nova Scotia Salmon Association
SARA	Species at Risk Act
SOCI	Species of Conservation Interest
S-Rank	Status rank
TDS	Total Dissolved Solids
WC	Watercourse
WL	Wetland
WRSH	West River Sheet Harbour
YOY	Young of Year

List of Scientific Names

American eel	*Anguilla rostrata*
Atlantic salmon	*Salmo salar*
banded killifish	*Fundulus diaphanus*
brook stickleback	*Culaea inconstans*
brook trout	*Salvelinus fontinalis*
brown bullhead	*Ameiurus nebulosus*
creek chub	*Semotilus atromaculatus*
golden shiner	*Notemigonus crysoleucas*
lake chub	*Couesius plumbeus*
rainbow smelt	*Osmerus mordax*
ninespine stickleback	*Pungitius pungitius*
northern redbelly dace	*Chrosomus eos*
white sucker	*Catostomus commersonii*
yellow perch	*Perca flavescens*

1.0 INTRODUCTION

The Beaver Dam Gold Project ("The Project") proposed by Atlantic Mining NS (AMNS) involves the development of an open pit gold mine in Marinette, Nova Scotia. The Project will involve production and transportation of ore to the Touquoy Mine Site for processing. The Project Area (PA) incorporates three separate components: the Beaver Dam Mine Site, the Haul Road, and the Touquoy Mine Site (Figure 1, Appendix A).

In support of registering a combined federal Environmental Impact Statement (EIS) with the Impact Assessment Agency of Canada (IAAC) and provincial Environmental Assessment Registration Document (EARD) with Nova Scotia Environment (NSE), McCallum Environmental Ltd (MEL) was retained to complete baseline fish and fish habitat surveys within the Beaver Dam Mine Site and along the Haul Road. Fish and fish habitat surveys have been completed with the key objectives of facilitating avoidance of fish habitat where practicable, understanding the potential project interactions with fish and fish habitat, and to facilitate regulatory approvals for impacts to fish and fish habitat wherever necessary. This was achieved by completing a review of background desktop resources in combination with field studies to identify potential environmental constraints and sensitivities. This report outlines the methods and results of initial baseline fish and fish habitat characterization conducted by MEL biologists at waterbodies, wetlands, and linear watercourses identified as being potentially fish bearing throughout the PA through 2015-2017.

1.1 Regulatory Context

Throughout this report, fish habitat is described in the context of watercourses. The Nova Scotia *Environment Act* defines a watercourse as:

(i) the bed and shore of every river, stream, lake, creek, pond, spring, lagoon or other natural body of water, and the water therein, within the jurisdiction of the Province, whether it contains water or not; and,

(ii) all groundwater.

In addition to the above-mentioned definition and in accordance with the Guide to Altering Watercourses (NSE, 2015), the watercourse parameters listed in this document were used to aid in determining the presence of a watercourse. This guide indicates that at least two of the following characteristics are needed to be present in order for a water feature to be determined a watercourse:

- Presence of mineral soil channel;
- Sand, gravel and/or cobbles evident in a continuous pattern over a continuous length with no vegetation;
- Indication of water flowing in a path sufficient to erode a channel/pathway;
- Presence of pools, riffles and/or rapids;
- Presence of aquatic animals and plants.

The *Fisheries Act* defines fish as "(a) parts of fish, (b) shellfish, crustaceans, marine animals and any parts of shellfish, crustaceans or marine animals, and (c) the eggs, sperm, spawn, larvae, spat and juvenile stages of fish, shellfish, crustaceans and marine animals;", and fish habitat as "waters frequented by fish and any other areas on which fish depend directly or indirectly to carry out their life processes, including spawning grounds and nursery, rearing, food supply and migration areas".

Under the previous version of the *Fisheries Act* (up to August 27, 2019), and through consultation with DFO, it was determined that the Project was not expected to result in Serious Harm to Fish. Therefore, the scoping and assessment of the original baseline fish and fish habitat program presented in this report was completed to support a general understanding of fish species and relative abundance within the SA.

Under the current *Fisheries Act*, activities which result in the harmful alteration, disruption or destruction (HADD) of fish habitat are prohibited. Permission may be granted to HADD of fish habitat under Section 35(2) of the *Act.* In anticipation of potential HADD of fish habitat as a result of the Project, a comprehensive fish and fish habitat program was conducted from 2019-2020, the results of which are presented in a separate, updated technical report (MEL, 2020).

1.2 Study Area

The Project Area (PA) includes three components: the Touquoy Mine Site, the Beaver Dam Mine Site and Haul Road (Figure 1). This report is focused on initial baseline work completed from 2015-2017 within the Beaver Dam Mine Site and Haul Road components of the PA, and supplementary baseline surveys completed in Summer 2019 and Fall 2020. Throughout this report, the Beaver Dam Mine Site and Haul Road components of the PA are referred to as the Study Area (SA) for baseline fish and fish habitat work (see Figure 2, Appendix A). For further information regarding Touquoy Mine Site and specifically the baseline conditions of the Moose River, which is the ultimate receiving environment for discharge from the pit at Touquoy post-closure, refer to the EARD (CRA, 2007a) and Focus Report (CRA, 2007b).

The Beaver Dam Mine Site is located at the Beaver Dam Mines Road, in Marinette, approximately 18 km northwest of Sheet Harbour, Nova Scotia (Figure 1, Appendix A), on private land owned by the Northern Timber Nova Scotia Corporation. The Haul Road component of the SA incorporates approximately 191 hectares. This component of the PA is proposed for road upgrades and new road construction to facilitate transportation of ore to the Moose River Mine at Touquoy for processing. The Project is centered at coordinates 521480 m east and 4990180 m north (UTM Zone 20 NAD83).

The Beaver Dam Mine Site is described as having low topographic relief with average elevations of approximately 140 masl and scattered drumlins reaching approximately 165 to 175 masl. Drainage in the area is generally southeast along a number of poorly drained streams, shallow lakes, and wetlands that flow out into Cameron Flowage (130 masl) and the Killag River; however, a drainage divide is present inside the southern boundary of the mine site that drains water to the south through Cope Brook (southwest), Paul Brook (south-central), and Tent Brook (southeast). In general, the Beaver Dam Mine Site contains a mixture of disturbed and undisturbed habitats, with historic mining activities and timber harvesting representing the dominant disturbance regime. Soils are generally nutrient poor and acidic which supports softwoods such as spruce and balsam fir. Herbaceous layers are often dominated by ericaceous shrubs and bryophytes such as Shreber's moss, which indicates nutrient poor soils.

The Haul Road will be developed on land owned by Northern Timber, the Nova Scotia Department of Lands and Forestry (NSDL&F), and other private enterprises and landowners. The general course of the Haul Road already exists in the form of forestry roads and seasonal access roads; however, deviations that result in new road construction to fulfill safe design standards will encroach on Crown and private land. The Haul Road mirrors the landscape described for the Beaver Dam Mine Site area in that it is a patchwork of forests in varying stages of regrowth with abundant watercourses, wetlands and generally low relief.

1.2.1 *Surface Water*

The West River Sheet Harbour (WRSH) and Tangier River Secondary boundary runs through the center of the PA along the Haul Road. The haul road component of the SA extends west into the Tangier River secondary watershed (1EL-2). The SA sits within ten tertiary watersheds: four within the Beaver Dam Mine Site (Killag River, Tent Brook, Paul Brook and Cope Brook) and six along the Haul Road footprint (Tent Brook, Keef Brook, Jack Lowe Brook, Little River, Sandy Pond, and Morgan River watersheds). Tertiary watersheds are shown on Figure 2, Appendix A.

The Beaver Dam Mine Site lies within the WRSH Nova Scotia secondary watershed, which is directly east of the Musquodoboit River and Tangier River secondary watersheds. The watershed occupies an area of roughly 576 km^2, a moderately sized watershed in the province. The area is characterized by rolling till plains, drumlin fields, extensive rockland, and numerous freshwater lakes, streams, bogs and wetlands having relatively low relief, hummocky type terrain. Forests are predominantly coniferous of red and black spruce. According to Neily and colleagues (2005), the site is in the Eastern Ecoregion of the Acadian Ecozone, the only ecozone in Nova Scotia. The Eastern Ecoregion is underlain by quartzite and slate of the Meguma Super Group with granitic intrusives. A variety of landforms are found in this ecoregion, including rolling till plains, drumlin fields, extensive rockland, and wetlands. The bedrock is highly visible in those areas where the glacial till is very thin, exposing the ridge topography. This inland area is somewhat removed from the immediate climatic influence of the Atlantic Ocean and is characterized by warmer summers and cooler winters (Neily et al., 2005).

The WRSH drainage basin discharges to the WRSH and its tributaries, from north to south. Elevations within the catchment vary from approximately 135 to 165 masl in the headwater areas and gradually decrease to sea level at the final outlet located at Sheet Harbour. The headwaters of the drainage basin are located along the topographic divide separating the Musquodoboit River Valley to the northwest. The Killag River and Cameron Flowage are the main mapped linear watercourses of the Beaver Dam Mine Site, and Crusher Lake and Mud Lake are the major mapped lakes. The complex system of streams, lakes, bogs and wetlands is a direct result of the underlying bedrock geology of greywacke and slate found in the region. These relatively impermeable and poorly jointed rocks result in slow groundwater recharge and most of the excess surface water is retained on the surface, often called a 'deranged' drainage pattern. The basin ultimately drains to the south via the West River Sheet Harbour, and discharge peaks are likely attenuated to a large extent by the numerous lakes and wetlands through which runoff is routed.

The Tangier River secondary watershed originates south of the community of Pleasant Valley, near Upper Musquodoboit. The drainage basin is approximately 283 km^2 in size, with a maximum elevation at its northern headwaters at approximately 195 masl which gradually decrease to sea level towards the south, at the final outlet located in Tangier, NS. The Tangier River drainage basin shares similar characteristics to the West River Sheet Harbour drainage basin, with abundant streams, lakes, and wetlands as a result of underlying bedrock within the Eastern Ecoregion. The Morgan River is main mapped linear watercourse along with Haul Road within this drainage basin and is a major tributary to the Tangier River. The Morgan River originates at from headwater lakes (including First and Second Essen Lakes) and south of the community of Pleasant Valley, then drains south/southeast across the Haul Road and into River Lake, east of the Haul Road, and then joins the main Tangier River to the southeast of the PA. The Tangier River drains from Tangier Grand Lake to the Atlantic Ocean at Tangier, Nova Scotia.

1.2.2 *Fish and Fish Habitat*

Prior to the start of the field program, available desktop databases were evaluated to identify mapped waterbodies and watercourses within the Beaver Dam Mine Site and the Haul Road. A baseline field evaluation followed in the spring and summer of 2015 and 2016 to confirm the presence of the identified water features within and surrounding the SA. No mapped waterbodies were identified within the Haul Road.

A desktop evaluation for priority fish species revealed that four priority species have been identified within 5 km of the SA. These include Atlantic salmon (*Salmo salar*), American eel (*Anguilla rostrata)*, alewife (*Alosa pseudoharengus)* and brook trout (*Salvelinus fontinalis)* (ACCDC, 2021). Priority fish species identified as having an elevated potential to be located within the PA, based on habitat preferences, and broad geographic range, include American eel, Atlantic salmon, brook trout, brook stickleback (C*ulaea inconstans*), and landlocked rainbow smelt (*Osmerus mordax).*

A desktop review was conducted for fish species within major watercourses and waterbodies within the SA. The West River Sheet Harbour, contiguous with the Killag River, is known to support Atlantic salmon, brook trout, American eel, brown bullhead, yellow perch, lake chub, creek chub, banded killifish, ninespine stickleback, golden shiner, and white sucker (Halfyard, 2007; NSFA, 2016). A portion of the Haul Road lies within the Tangier River secondary watershed. Fish species known to occur within this watershed include white sucker, brook trout, white perch, yellow perch, banded killifish, rainbow trout, golden shiner, stickleback sp., alewife, northern redbelly dace, and brown bullhead (Alexander et al, 1986). Nova Scotia Fisheries & Aquaculture (2019) have also recorded common shiner and smallmouth bass in this watershed. Atlantic salmon are considered extirpated from the Tangier River (DFO, 2009).

Atlantic salmon (Nova Scotia Southern Uplands population) are expected to potentially inhabit watercourses within and adjacent to the SA. Atlantic salmon are divided into unique populations based on genetic distinction and range. For the purposes of this discussion, we are considering only the Southern Uplands (SU) Population, as outlined by DFO in the Recovery Potential Assessment for the Southern Uplands population of Atlantic salmon (DFO, 2013).

The SU Population of Atlantic Salmon has experienced significant reductions over the last few decades, with adult abundance declining from 88% to 99% from observed abundances in the 1980s (DFO, 2013). Current adult and juvenile abundance has been assessed as critically low in most rivers, and there is strong evidence for river-specific extirpations – only 54% of rivers in the SU region were found to contain salmon in 2000 and only 38% were found to contain salmon in 2008 (Bowlby et al., 2013). The main contributing factors to these declines are considered to be degradation of freshwater habitat, acidification, and poor marine survival (Bowlby et al., 2014).

2.0 FIELD PROGRAM METHODOLOGY

This section summarizes the methods used for the original evaluation of fish and fish habitat conducted by MEL biologists at waterbodies, wetlands, and linear watercourses identified as being potentially fish bearing throughout the SA. Linear watercourses were identified and described across the Beaver Dam Mine Site (Summer 2015) and the Haul Road (Spring 2016), and two waterbodies within the Beaver Dam

Mine Site (Crusher Lake and Mud Lake) were described for physical parameters in the summer of 2015. Wetland delineation and evaluation were completed in 2015 (Beaver Dam Mine Site) and 2016 (Haul Road). Since the completion of the baseline field program, the infrastructure arrangement at the Beaver Dam Mine Site has been adjusted. The Beaver Dam Mine Site and Haul Road layouts presented on Figures 3 and 4, Appendix A, reflect the most recently proposed infrastructure footprints. All aquatic features discussed in this report are relevant to current infrastructure layouts and the PA. As a result of the micro-siting of infrastructure, additional supplementary baseline surveys were conducted in July and August 2019, and December 2020 to delineate and characterize additional surface water features within and downgradient of the SA, which have been included in this report. In addition, a comprehensive fish and fish habitat field program was conducted from 2019-2020, the results of which are presented in a separate technical report (MEL, 2020).

Watercourses were documented using an SXBlue II Global Positioning System (GPS) receiver unit capable of sub-meter accuracy with a handheld SXPad field computer. Blue flagging tape was used to mark the locations of all watercourses. Watercourses were mapped to the edge of the SA within the Beaver Dam Mine Site and Haul Road and provided a specific watercourse identification number. Each watercourse, when identified in the footprint, was described for physical parameters including: bank full width; wetted width; water depth; structure (pool, riffle, run, flat, others); fish habitat potential; overhanging and in-stream vegetation; substrate; and bank stability. Waterbodies observed at the Beaver Dam Mine Site were described for physical characteristics including width and overall size, depth, littoral zone description, shoreline characterization, and substrate.

Each of watercourse was evaluated for the presence of fish habitat and potential ability to support fish species during initial assessment and identification. Once this was completed, fishing locations and methods were established within reaches of linear watercourses and waterbodies. Field assessments to complete electrofishing and supporting fish collection were conducted on September 17-18, 2015 at linear watercourses within the Beaver Dam Mine Site. Additional field assessments were also completed between June 20-27, 2016 within linear watercourses along the Haul Road, Crusher Lake and Cameron Flowage within the Beaver Dam Mine Site. Field surveys included: preliminary fish habitat surveys; electrofishing within linear watercourse reaches; trapping within linear watercourses and waterbodies; in-situ water quality surveys; and benthic invertebrate surveys. The specific methods for each fish and fish habitat survey are described below.

2.1 Electrofishing (DFO Licence #341208)

Electrofishing sampling sites were established in representative aquatic habitats with high potential to support fish along the Haul Road and within the Beaver Dam Mine Site. The purpose of the electrofishing surveys was to determine fish species presence and abundance within watercourses and associated wetlands within the SA. Sixteen electrofishing sites were selected; nine within the Beaver Dam Mine Site and seven along the Haul Road. These locations are shown on Figures 3 and 4, Appendix A. Fishing was completed under Fisheries and Oceans Canada Fishing License # 341208.

Fisheries and Oceans Canada's Interim Policy for the Use of Backpack Electrofishing Units (2003) was reviewed and followed by all members of the electrofishing crew. This document provides a detailed list of standard equipment, safety, training, and emergency response procedure requirements for electrofishing. Each electrofishing crew consisted of two individuals, one of which (the crew lead) was a qualified person as defined under the DFO Interim Electrofishing Policy. The crew lead is responsible for operating the backpack electrofisher according to their training and the Policy, and for communicating safety policies and electrofishing procedures to the second crew member.

Standardized data collection forms developed by the New Brunswick Aquatic (NB) Resources Data Warehouse, the NB Department of Natural Resources and Energy, and the NB Wildlife Council (2002, updated 2006) were adapted for use for field data collection during electrofishing surveys. Field data collected included the physical and chemical parameters of the electrofishing site, along with electrofishing methods and settings, and results of electrofishing surveys. The Electrofishing Site Form (NB Aquatic Resources Data Warehouse, NB Department of Natural Resources and Energy, NB Wildlife Council, 2002, updated 2006) was completed to identify and describe the physical and chemical characteristics of the reach to be sampled. This site description helped the electrofishing crew determine the appropriate settings on the electrofishing unit based on physical parameters of the watercourse, conductivity, and species expected to be present. Survey effort (in electrofishing seconds) was recorded on the Electrofishing Site Form as well. Water quality measurements were recorded in the field with a Horiba U22 Multi-parameter probe or YSI 650 MDS & 600 QS Multi-Probe.

Fish were sampled within the isolated sampling areas using a Halltech Battery Backpack Electrofisher (HT-2000) with unpulsed direct current (DC). The operator waded upstream to eliminate the effects of turbidity caused by bottom sediment and probed the anode into likely fish habitat within the site. A second crew member walked ahead of the operator to net any stunned fish using a D-frame landing net (1/8" mesh). All captured fish were held in a live well containing ambient stream water, which was kept out of the sun and fish were checked regularly for signs of stress. At the conclusion of each pass, fish in the live well were identified (species confirmation) and measured (total length in mm). Condition, sex, and maturity, when known, were also recorded for individual fish using the Individual Fish Measurement Form (NB Aquatic Resources Data Warehouse, NB Department of Natural Resources and Energy, NB Wildlife Council, 2002, updated 2006). After recuperating, all fish were released upstream and outside of the sampling site.

2.1.1 *Beaver Dam Mine Site*

Electrofishing sites within the Beaver Dam Mine Site employed an "open" site and a single pass - no barrier nets were used to increase the chance of capturing fish migrating into the sampling reach.

Single-pass surveys provide a representative index of species diversity (Reid et al., 2009). Single-pass electrofishing can be used to detect spatial and temporal trends in abundance and species richness given standardized effort, but may not be representative of absolute population densities (Bertrand et al., 2006). Single pass surveys were completed within watercourses in the Beaver Dam Mine Site during electrofishing surveys in 2015.

This method allows for calculation of catch per unit effort, a more qualitative but standardized quantification of species richness and identification of trends). CPUE is usually assumed to be proportional to abundance and therefore included in stock assessment as a relative index of abundance. CPUE expresses how many fish (all species) are caught by a unit of effort (Hinton and Maunder, 2003).

CPUE=Catch (fish)/Effort (time in seconds)

CPUE was calculated to provide qualitative species abundance estimates for the one-pass electrofishing methodology completed within the Beaver Dam Mine Site in 2015, using electrofishing effort standardized to 300 seconds of effort (Scruton and Gibson, 1995). Electrofishing locations are showed on Figure 3, Appendix A

Table 2-1: Electrofishing Locations – Beaver Dam Mine Site

Electrofishing Location	Stream Order	Tertiary Watershed	Survey Dates	Survey Location Coordinates	
				Easting	Northing
WC4	1	Killag River	September 17, 2015	521326	4989831
WC5 (top- near WL2)	1	Killag River	September 17, 2015	521801	4989674
WC5 (lower- near WL14)	3	Killag River	September 17, 2015	521776	4990444
WC3 (top- near WL2)	1	Killag River	September 18, 2015	521993	4989901
WC3 (lower- near WL20)	2	Killag River	September 18, 2015	521905	5990241
WC12	1	Killag River	September 18, 2015	522202	4990328
WC13	2	Killag River	September 18, 2015	522748	4990230
WL56	N/A	Killag River	September 18, 2015	522054	4990353
WL59*	N/A	Killag River	September 18, 2015	522679	4990224

*Electrofishing effort severely limited by water depths.

2.1.2 *Haul Road*

Electrofishing along the Haul Road was performed in select watercourses with the goal of representing each tertiary watershed. Prior to each sampling event, sampling sites located within linear watercourses along the Haul Road were blocked off with barrier nets (1/8” mesh) that were secured to the streambed at either end of the 100 m linear reach of watercourse in order to prevent the loss of stunned or frightened fish. This created a “closed” system from which quantitative population estimates could be calculated. Barrier nets have a floating top line, and were anchored to the shoreline with rebar or rocks and to the substrate with rocks.

Two passes of electrofishing were performed within each sampling site along the Haul Road. All fish were recorded by species and counted separately per pass. For all electrofishing locations within the Haul Road, the two-pass depletion method was used to quantitatively estimate population size of fish species found in the sampled watercourses. This depletion method can be used when the stream is very small, it is expedient to collect all data within a short time period, such as one day, and the population being estimated is relatively small (roughly less than 2,000 individuals (Lockwood and Schneider, 2000).

Using this data, population estimates and variance of population estimated was calculated. The formulas (Heimbuch et al., 1997) are provided below:

Population estimate $N=C_1^2/(C_1-C_2)$
Variance of $N= C_1^2C_2^2(C_1+C_2)/(C_1-C_2)^4$
Standard error of $N=\sqrt{\text{Variance of } N}$

N=*Population estimate*
C_1=*number of fish removed in first pass*
C_2=*number of fish removed in second pass*

Details of electrofishing locations and survey dates along the Haul Road are provided in Table 2-2. Electrofishing locations are shown on Figure 4, Appendix A.

Table 2-2. Electrofishing Locations - Haul Road

Electrofishing Location	Stream Order	Tertiary Watershed	Survey Dates	Survey Location Coordinates	
				Easting	Northing
WC-B	2	Tent Brook	June 16, 2016	522717	4988574
WC-H	3	Keef Brook	June 20, 2016	522581	4985918
WC-N	4	Keef Brook/ Jack Lowe Brook	June 20, 2016	522804	4988460
WC-O	2	Little River	June 22, 2016	521959	4983878
WC-V	2	Little River	June 16, 2016	517415	4982555
WC-AA	2	Sandy Pond	June 23, 2016	516522	4979704
WC-AH	4	Morgan River	June 23, 2016	514339	4978579

2.2 Trapping (DFO Licence #341208)

Fish collection was completed in June 2016 to support and supplement electrofishing efforts completed in 2015 within linear watercourses in the Beaver Dam Mine Site. Two representative survey locations, site A and site B, within Cameron Flowage and Crusher Lake were chosen to complete fish collection. For the purpose of fish collection, Cameron Flowage is described as a lentic system, as sample methods normally selected for most lotic systems (i.e. electrofishing) are not feasible in a system of this depth and width. At each lentic sampling location, MEL biologists placed a fyke net, eel pot, and two minnow traps to capture and record fish presence to support fish species identification and relative abundance of fish species present. Fyke nets were placed in the shallow inshore littoral zone at sites and were fixed in place by stakes driven into the substrate of the waterbody through each wing of the net. Eel pots were also placed near the fyke nets within the littoral shelf of the two waterbodies. These eel pots were baited with cat food. Finally, two minnow traps were also placed and baited with cat food at each location to further support the collection of smaller fish and aid in species identification within the SA.

Minnow traps were also placed in deeper pools within select watercourses along the Haul Road during electrofishing surveys in 2016 to support the collection and identification of smaller fish in locations where electrofishing was not possible to due water depth.

All captured fish were held in a live well containing ambient lake water, which was kept out of the sun and fish were checked regularly for signs of stress. Fish in the live well were identified to species and measured (total length in mm). After recuperating, all fish were released back into the watercourse or waterbody.

The suite of survey methods (electrofishing and fish collection with eel pots, fyke nets, and/or minnow traps) was selected based on ability to identify the breadth of species diversity present throughout various habitat types available in the SA. All gear types have certain limitations, including but not limited to catch selectivity and sampling efficiency. The best fish collection studies employ a variety of gear types to sample as many habitat types as possible, thus ensuring the widest possible range of fish species and sizes are collected (Portt, Coker, Ming and Randall, 2006).

CPUE was determined for each trap type based on trapping effort, which was calculated as total catch per wetted hour. For trapping, the catch consists of how many fish were caught in a certain piece of fishing equipment. In the field, each fish was recorded and counted. The effort consists of the wetted time, which is equivalent to the time each piece of equipment was present in the waterbody. The start time and the end time were recorded for each piece of fishing equipment as they were placed and removed from the waterbody (Hinton and Maunder, 2003). CPUE was calculated for each fish collection method (fyke, minnow trap, eel pot) deployed along the Haul Road and in Cameron Flowage and Crusher Lake in 2016.

Details of survey dates, trap types and locations area provided Table 2-3. Trap locations are shown on Figure 3 and 4, Appendix A.

Table 2-3: Trapping Locations and Details

Trapping Location	**Tertiary Watershed**	**Survey Date**	**Trap Type**	**Survey Location Coordinates**		**Survey Time**
				Easting	**Northing**	
Crusher Lake A	Killag River	June 27, 2016	Fyke Net	521617	4990137	4hr 26mins
			Eel Pot	521579	4990165	4hr 44mins
			Minnow Trap 1	521577	4990161	4hr 26mins
			Minnow Trap 2	521573	4990171	4hr 25mins
Crusher Lake B	Killag River	June 27, 2016	Fyke Net	521566	4990193	4hr 25mins
			Eel Pot	521563	4990196	4hr 23mins
			Minnow Trap 1	521563	4990186	4hr 23mins
			Minnow Trap 2	521569	4990189	4hr 23mins
Cameron Flowage A	Killag River	June 24, 2016	Fyke Net	522708	4990370	4hr 55mins
			Eel Pot	522708	4990378	4hr 17mins
			Minnow Trap 1	522718	4990368	4hr 58mins
			Minnow Trap 2	522705	4990365	4hr 11mins
Cameron Flowage B	Killag River	June 24, 2016	Fyke Net	522743	4990338	5hr 08mins
			Eel Pot	522728	4990345	4hr 52mins
			Minnow Trap 1	522753	4990318	5hr 05mins

Trapping Location	Tertiary Watershed	Survey Date	Trap Type	Survey Location Coordinates		Survey Time
				Easting	Northing	
			Minnow Trap 2	522729	4990352	5hr 08mins
WC-B	Tent Brook	June 20, 2016	Minnow Trap 1	522691	4988578	2hr 18mins
			Minnow Trap 2	522697	4988568	2hr 18mins
			Minnow Trap 3	522700	4988555	2hr 17mins
WC-N	Keef Brook/Jack Lowe Brook	June 22, 2016	Minnow Trap 1	521856	4983929	2hr 02mins
			Minnow Trap 2	521867	4983925	2hr 07mins
			Minnow Trap 3	521877	4983920	2hr 11mins
WC-V	Little River	June 16, 2016	Minnow Trap 1	517417	4982555	2hr 25mins
			Minnow Trap 2	517429	4982564	2hr 26mins

2.3 Water Quality

Water quality was measured at each representative linear section of watercourse selected for electrofishing within the SA in September 2015 (Beaver Dam Mine Site) and June 2016 (Haul Road). Water quality measurements were also collected from Cameron Flowage during fish collection surveys. All water quality measurements were collected using a Horiba multi-probe (W-22XD) or YSI 650 MDS & 600 QS Multi-Probe water quality instrument. Parameters recorded include dissolved oxygen (DO) (mg/L), water temperature (°C), pH, and specific conductivity (µS/m).

2.4 Benthic Macroinvertebrate Sampling

Benthic macroinvertebrate sampling was completed within the SA from June 22-24, 2016 using the national standardized CABIN protocol (Environment Canada, 2012). Sampling was completed at each electrofishing reach in watercourses within the Haul Road footprint (seven locations) and at three electrofishing locations within the Beaver Dam Mine Site footprint where confirmed fish presence was known, for a total of ten samples within the SA. Benthic sampling was completed to support fish habitat evaluation as a baseline measurement, as biological parameters may detect impacts to the aquatic ecosystem that the physical and chemical parameters cannot, such as changes in water quantity, presence of invasive species, and habitat degradation. Benthic macroinvertebrates are common inhabitants of streams and lakes and are important in moving energy through food webs. Benthic macroinvertebrate communities are good indicators of localized conditions. Many benthic macroinvertebrates have limited migration patterns or a sessile mode of life, so they are particularly well-suited for assessing local, site-specific conditions and impacts (Barbour et al., 1999).

A site description, water chemistry, substrate characteristics, and channel measurements were recorded at each sampling location. The traveling kick net method (CABIN) was used to sample for macroinvertebrates. Using a 400 µm mesh kick net, the sampler shuffled upstream in a zigzag pattern for the standardized sampling effort (three minutes). The sample was then transferred to the sample jars and preserved with a 70% isopropanol solution. The samples were recorded, labeled, and sent to Envirosphere Consultants Ltd. for analysis. MEL provided ten samples to Envirosphere Consultants Ltd. in Windsor, Nova Scotia on July 7, 2016 for biological analysis (identification and assessment for biological species composition and abundance).

2.4.1 *Laboratory Methods: Sub-Sampling*

Prior to sorting, samples and sub-samples were rinsed on a 0.5 mm 20 cm diameter circular sieve to remove preservative. To ensure a reasonable processing time, three of the fourteen samples were then sub-sampled at 50% or 75% to ensure processing efficiency. Sub-sampling involved dividing the sample in four, by weight. The sample was spread evenly in the sieve and divided into fourths, with quarters transferred in their entirety into plastic trays. The trays with contents were weighed and verified to be within 0.5 to 1.0 g of each other to ensure even distribution of the material. Two or three of the four trays were randomly selected for sorting and identification and the others held until the final sample analysis was completed to allow an opportunity for further analysis if necessary to ensure adequate counts for interpretation. Final counts and biomass for the sub-samples were extrapolated to 100% based on the sub-sample percentage (i.e., 50%). Sub-sampling can affect measures of animal abundance and biomass by increasing variability and may lead to slightly reduced estimates of taxon richness compared to whole samples.

2.4.2 *Sorting and Identification*

Samples and sub-samples were examined at 6-6.4 times magnification on a stereomicroscope, with a final brief check at 16 times magnification. Organisms were removed and subsequently stored in labeled vials in 70% isopropyl alcohol. Sorting efficiency for lab personnel is checked periodically by re-sorting samples to ensure average recovery levels of 90% or better. Wet weight biomass (grams per sample) was estimated for each sample by weighing animals to the nearest milligram at the time of sorting and after blotting to remove surface water.

Organisms were identified to an appropriate taxonomic level, typically to genus, using conventional literature for the groups involved. Organisms were identified by Valerie Kendall (M.Env.Sc.) and verified by Heather Levy (B.Sc. Honours) of Envirosphere Consultants Ltd. Sorting of animals from the samples, identification, total number of animals of each type (taxonomic group), as well as total abundance, were determined for each sample. These numbers were used to calculate several indices of benthic community health, which can be compared between sites and, with time, at each site. Indices calculated are all commonly used in studies of this kind and include: EPT Ratio (ratio of abundance of mayflies (Ephemeroptera), caddisflies (Trichoptera), and stoneflies (Plecoptera), to total numbers of organisms); Total Abundance (number of animals in the sample and per unit area); and Taxon Richness (number of taxa per sample). Abundance in kick net samples was expressed on a per sample basis. All organisms present were included in estimates.

All electrofishing, trapping, water quality, and benthic sampling locations are shown on Figures 3 and 4, Appendix A.

2.5 Fish Habitat Surveys

The potential for each watercourse and wetland to support fish was evaluated across the SA. The SA presented in this report includes the full extent of the current 2021 EIS submission for completeness, though it is recognized that some aquatic habitats were delineated outside of the 2015-2017 timeframe, as the Projects' infrastructure layout shifted to reduce impacts to fish habitat (primarily wetlands and watercourses within the footprint and buffer area of the proposed Wasterock Storage Area. In total, thirty-five linear watercourses were identified within the Haul Road, 24 linear watercourses were identified within the Beaver Dam Mine Site, and three additional watercourses were identified outside and downgradient of the Beaver Dam Mine Site (WC23, WC26, and WC27). Two waterbodies (Crusher lake, Mud Lake) and one primary watercourse (Cameron Flowage/Killag River) were identified within the Beaver Dam Mine Site, all of which were expected to support fish. No waterbodies were identified along the Haul Road Study Area. Two hundred and twenty-seven (227) wetlands were evaluated across the Beaver Dam Mine Site and Haul Road. Fish habitat potential was determined at each location during field identification/evaluation and collection of physical characteristics of each watercourse/wetland.

The original qualitative descriptions of fish habitat presented in the Revised EIS (Atlantic Gold, 2019) were based on the *Standard Methods Guide for Freshwater Fish and Fish Habitat Surveys in Newfoundland and Labrador: Rivers and Streams* (Sooley et al., 1998), with the descriptions provided for fish of the Salmonidae family, using the Atlantic salmon as the indicator species. Characterization of fish habitat within watercourses, waterbodies and wetlands within the SA have since been updated to consider all fish species confirmed or potentially present within each aquatic features and support for their various life stages.

In anticipation of potential harmful alteration, disruption, or destruction (HADD) of fish habitat as a result of the Project and the development of an offsetting plan, detailed fish habitat surveys were conducted in Summer 2020 using updated classification and quantification methods (DFO, 2012a). These surveys were performed within selected watercourses within and downgradient of the Beaver Dam Mine Site predicted to be directly and indirectly affected by Project Development. During detailed habitat assessments, the entire length of each watercourse predicted to be impacted was delineated into individual reaches defined by discrete homogeneous units (e.g., riffle, run, pool, flat, etc.), with key habitat features (gradient, substrate types, water depth, velocity ranges, etc.) measured within each reach. The results of these surveys are presented in an updated technical report (MEL, 2020), and supersede the results for only those select aquatic features related to the Beaver Dam Mine Site presented herein. However, original baseline data for all watercourses (including those with expected impacts) have been presented in this report, as the data still considered to provide valuable baseline descriptions of watercourses throughout the SA.

Aquatic features along the Haul Road were not re-evaluated as the original fish habitat characterizations are considered valid descriptions for each specific crossing location. Fish habitat at each Haul Road crossing location is considered a discrete habitat unit based on the short length of each watercourse described. The data collected during the original baseline surveys presented herein can be used to quantify fish habitat using updated methods (DFO, 2012a).

3.0 RESULTS

3.1 Fish Surveys

As a result of fishing efforts (i.e. all electrofishing and trapping surveys) completed in 2015 and 2016 within the SA, a total of ten species and 145 individual fish were captured across eleven of the eighteen survey locations, including:

- WC4
- WC5 (lower – near WC14)
- WC12
- WC13
- Wetland 56
- Cameron Flowage
- Crusher Lake

- WC-N
- WC-V
- WC-AA
- WC-AH

Within the Beaver Dam Mine Site, no fish were captured in the upper reaches of WC5 located south of Crusher Lake, or within the two reaches fished along WC3 which drains north through the central portion of the Beaver Dam Mine Site. No fish were captured through electrofishing within WL59, but fish were observed within the deeper flooded areas of the wetland. Along the Haul Road, no fish were captured in WC-B, WC-H, or WC-O. The results of the electrofishing and trapping surveys within the SA are presented on Figures 3 and 4, Appendix A.

Table 3-1 through Table 3-3 outline a summary of fish species captured through all electrofishing and trapping surveys within the SA, listed in order of abundance. Representative photographs of fish survey locations and species captured are presented in Apprndix B, and individual data for fish captured at each sampling site within the SA are presented in Appendix C.

Table 3-1. Fish Species Captured via electrofishing within the Beaver Dam Mine Site

Species	SRank	SARA/COSEWIC/NSESA	Total #	% Catch
banded killifish	S5	COSEWIC: Not at Risk	11	26
ninespine stickleback	S5	N/A	11	26
brook trout	S3	N/A	10	23
northern redbelly dace	S5	N/A	9	21
lake chub	S5	N/A	1	2
brown bullhead	S5	N/A	1	2
Total			**43**	

Table 3-2. Fish Species Captured via trapping within Crusher Lake and Cameron Flowage

Species	SRank	SARA/COSEWIC/NSESA	Total #	% Catch
Crusher Lake				
banded killifish	S5	COSEWIC: Not at Risk	6	43
golden shiner	S4	N/A	5	36
brown bullhead	S5	N/A	3	21
Total			**14**	

Species	SRank	SARA/COSEWIC/NSESA	Total #	% Catch
Crusher Lake				
Cameron Flowage				
yellow perch	S5	N/A	18	67
golden shiner	S4	N/A	5	19
white sucker	S5	N/A	2	7
brown bullhead	S5	N/A	2	7
Total			**27**	

Table 3-3. Fish Species Captured within Watercourses along the Haul Road

Species	SRank	SARA/COSEWIC/NSESA	Total #	% Catch
American eel	S2	COSEWIC: Threatened	36	59
brook trout	S3	N/A	8	13
banded killifish	S5	COSEWIC: Not at Risk	6	10
white sucker	S5	N/A	5	8
lake chub	S5	N/A	3	5
golden shiner	S4	N/A	2	3
yellow perch	S5	N/A	1	2
Total			**61**	

3.1.1 *Fish Species Observed*

Within the Beaver Dam Mine Site, banded killifish, ninespine stickleback, brook trout, and northern redbelly dace were the most commonly captured species, while only one individual lake chub and brown trout were captured. Banded killifish, golden shiner, and brown bullhead were confirmed in Crusher Lake, while yellow perch was the most commonly captured species in Cameron Flowage. Along the Haul Road, American eel was the most frequently captured, followed by brook trout, banded killifish, and white sucker. Lake chub, golden shiner, and yellow perch were also confirmed, though in low abundance. While Atlantic salmon were not detected during field evaluations, a description of the species is provided below as they are known to inhabit the West River Sheet Harbour watershed.

3.1.1.1 Atlantic Salmon

Atlantic salmon (Nova Scotia Southern Uplands population) were not observed within the SA during fishing surveys but are expected to potentially inhabit watercourses within and adjacent to the SA.

SU Atlantic salmon have been found along the entire coast of Nova Scotia, from the Bay of Fundy to Cape Breton. Atlantic salmon spawn in fresh water from October to November and spend one to four years as juveniles in fresh water. The majority of juveniles migrate to the sea after two years of being in fresh water. In spring, the salmon leave the rivers and by mid-summer migrate to the Atlantic Ocean. They spend one to three years in the Atlantic Ocean before returning as adults to fresh water to spawn. The majority of adults leave the rivers in spring after spawning and recondition out at sea before spawning in freshwater again (Bowlby et al., 2014).

Within the freshwater environment, Atlantic salmon are found in cool, clear, well-oxygenated waters that support a reliable food source of aquatic invertebrates. Gravel and cobble are the preferred substrates for spawning (Bowlby et al., 2013), with redd sites typically located in well aerated areas - a riffle above a pool, or at the tail of pools on the upstream edge of riffles with depths of 10-70 cm (Grant and Lee, 2004). Young of year (YOY) will remain near the redd for a few months, after which point they disperse downstream, occupying areas of faster velocities as they increase in size (Grant and Lee, 2004). Juveniles can be found occupying a variety of habitats. In summer and fall, they are typically found in moderate velocity runs with clean, rocky substrate free of sand, silt, and detritus (Rimmer et al., 1983). Older parr are usually found in riffles, whereas deeper pools are the preferred habitat during low water levels, high temperatures, and winter freeze (Grant and Lee, 2004). The SU Population of Atlantic salmon has been assessed as endangered by COSEWIC (2010) and is considered provincially critically imperiled by the ACCDC (S1).

3.1.1.2 American Eel

Suitable habitat for eel is varied. As a catadromous species, eel spend the majority of their lives in freshwater, moving to the Sargasso Sea to spawn. Once hatched, American eel larvae drift back to the coast, undergoing several phases of metamorphosis. By the time they reach freshwater, young glass eel have developed pigment and are referred to as elvers (Scott and Crossman, 1973). In freshwater, elvers develop into yellow eels - immature adults and at which point sexual differentiation occurs. As growth proceeds, yellow eel metamorphose into silver eel, or mature adults that are now physiologically prepared to return to the sea to spawn (COSEWIC, 2012).

American eel are frequently found in watercourses that offer structural complexity and shade in the form of coarse woody debris, rocks, in-stream vegetation for daytime cover, and an available food source of forage fish, invertebrates, molluscs and vegetation. Migrating elvers are bottom dwellers and spend most of their time burrowed or hidden, including directly into soft bottom sediments (Tomie, 2011). In freshwater, yellow eel continue their migration upstream into rivers, streams, and muddy or silt bottomed lakes (Scott and Crossman, 1998). Like elvers, yellow eel are primarily nocturnal, spending most of the day under cover or buried in soft substrates. These soft substrates are particularly important for overwintering, where the eel hibernate by burying themselves into the bottoms of lakes and rivers (Smith and Saunders, 1995; Scott and Scott, 1998). Trautman (1981) also reported that eel partially or completely bury themselves in mud, sand and gravel during the day, emerging at dusk to begin feeding.

American eel has been assessed as threatened by COSEWIC (2012) and is considered provincially imperiled by the ACCDC (S2). American eel are not currently protected under SARA or NSESA. During the baseline fish and fish habitat field program, adult American eel were confirmed in watercourses along the Haul Road including WC-N, WC-V, and WC-AH. Juvenile eel were also observed in WC-N and WC-AH.

3.1.1.3 Banded Killifish

The banded killifish is a freshwater habitat generalist found within the quiet waters of lakes, ponds, and sluggish streams, tolerating a broad temperature, salinity, and DO range (COSEWIC, 2014). Adults tend to school in shallow water characterized by sand, gravel, or muddy substrate, with submerged aquatic plants (Scott and Crossman, 1973). The banded killifish is generally not considered a strong swimmer, and high velocities are thought to limit the species' movement within a watershed (DFO, 2011). Seasonal movement by the species has not been documented, and it is not considered migratory (COSEWIC, 2014).

Banded killifish spawning has been seldom documented; however, it is thought that aquatic vegetation within quiet shallows is a key component in spawning habitat as an attachment point for externally fertilized eggs (Richardson, 1939).

Banded killifish is considered provincially secure by the ACCDC (S5). During the baseline fish and fish habitat field program, banded killifish were captured within both the Beaver Dam Mine and along the Haul Road, including WC13, Crusher Lake, the flooded portion of Wetland 56, WC-N, and WC-AA,

3.1.1.4 Brook trout

Brook trout are known to inhabit a wide range of cool, freshwater environments, from small headwater streams to large lakes. Water temperature is a critical factor influencing brook trout distribution and production. Though typically not anadromous, brook trout require free passage along streams to move between areas of use, including spawning grounds, overwintering areas, and summer rearing areas.

In Nova Scotia, mature brook trout migrate to spawn in lakes or streams in the fall of the year. Brook trout spawning sites are usually near groundwater upwelling or spring seeps and within a lake or stream with gravel substrate (NSDAF, 2005). Optimal spawning conditions for brook trout include clean substrate 3-8 mm in size in shallow water with limited fines (<5%), and velocities of 25-75 cm/s (Raleigh, 1982).

YOY brook trout require cold water, stable, low velocities and an abundance of in-stream cover. Optimal temperature for juvenile growth is 10-16℃, while cover in the form rubble, vegetation, undercut banks, and woody debris should account for a minimum of 15% of total stream area (Raleigh, 1982). In winter, brook trout aggregate in pools beneath silt-free rocky substrate and close to point sources of groundwater discharge (Raleigh, 1982; Cunjak and Power, 1986). Adult fish use both pools and riffles, with more than 25% in-stream cover being optimal (Raleigh, 1982). Brook trout respond negatively to flashy or hydrologically dynamic systems, and require stable flow for all life stages (Raleigh, 1982).

Brook trout are considered provincially vulnerable by the ACCDC (S3), but have not been assessed by COSEWIC nor are they currently listed under SARA or NSESA. During the baseline fish and fish habitat field program, juvenile brook trout were captured in WC5 (north of Crusher Lake), WC12, and WC13 within the Beaver Dam Mine Site. Along the Haul Road, juvenile brook trout were confirmed in WC-N and WC-V. One individual adult brook trout was captured in WC-AH.

3.1.1.5 Brown Bullhead

Brown bullhead are bottom dwellers that prefer sluggish and warm water in slow-moving streams, ponds, and lakes with abundant aquatic vegetation. The species is resistant to increased levels of pollution and is tolerant of low oxygen concentrations and temperatures up to 31.6 °C (Scott and Crossman, 1973). Brown bullhead spawning occurs in late spring and summer when water temperatures reach 21°C (Scott and Crossman, 1973). Adhesive eggs are deposited into shallow nests that are excavated in mud or sand substrate, covered by at least 15 cm of water (Scott and Crossman, 1973).

Adults can be found in lakes and rivers with a variety of substrates but are typically associated with muddy bottoms. These fish are omnivorous night-feeders and will forage on all types of plant and animal materials that they locate with their barbels.

Brown bullhead are considered provincially secure by the ACCDC (S5). During the baseline fish and fish habitat field program, brown bullhead were confirmed within Crusher Lake and Cameron Flowage, and one juvenile was captured WC-13. No brown bullhead were captured within watercourses along the Haul Road.

3.1.1.6 Golden Shiner

Golden shiner are habitat generalists, primarily found schooling in well vegetated lakes with extensive shallows (Scott and Crossman, 1973). The species can tolerate a wide range of oxygen concentrations and temperatures (Murdy et al., 1997).

Spawning takes place from June to August, when temperatures reach 20°C, during which adhesive eggs are scattered over the substrate, attaching to filamentous algae or other aquatic vegetation (Scott and Crossman, 1973).

Golden shiner are considered provincially apparently secure by the ACCDC (S4). During the baseline fish and fish habitat field program, adult golden shiner were captured in Crusher Lake and Cameron Flowage, and WC-AA along the Haul Road.

3.1.1.7 Lake Chub

Lake chub are a common fish lakes and rivers, preferring cool, clear water and gravel bottomed streams and lake edges (Page and Burr, 2011). The species is mostly found in shallow water but may move into deeper areas to escape high temperatures (Scott and Crossman, 1973).

When inhabiting lakes and larger rivers, schools of lake chub will undergo spawning migrations to shallow areas of slow tributary streams in the spring, with seasonal movements occasionally being extensive (Scott and Crossman 1973; Stasiak, 2006a). During spawning, non-adhesive eggs are scattered over gravel or rocky substrate (Scott and Crossman, 1973; Stasiak, 2006a). YOY and juveniles prefer slow, shallow water. YOY are often found in submerged vegetation (Brown et al. 1970), while older juveniles have been found over a variety of substrates (Mecum, 1984).

Lake chub are considered provincially secure by the ACCDC (S5). During the baseline fish and fish habitat field program, one juvenile lake chub was captured in WC-13 within the Beaver Dam Mine Site. Along the Haul Road, adult lake chub were confirmed present in WC-N and WC-AA.

3.1.1.8 Ninespine Stickleback

Ninespine stickleback are found in both brackish waters and the shallow areas of freshwater lakes and ponds. In rivers and streams, they are generally found in sluggish, cool pools where there is plenty of aquatic vegetation.

Spawning takes place over the summer in fresh water, during which the male constructs a nest off the substrate by binding plant fragments together (Scott and Crossman, 1973). Spawning habitat is primarily characterized by shallow depths, low velocity, dense aquatic vegetation, and mud and silt substrates (McPhail and Lindsey, 1970; Scott and Scott, 1988)

Ninespine stickleback are considered provincially secure by the ACCDC (S5). During the baseline fish and fish habitat field program, ninespine stickleback were only captured in WC-4.

3.1.1.9 Northern Redbelly Dace

Northern redbelly dace have a strong habitat preference for quiet waters, including beaver ponds, bog ponds, small lakes, and sluggish areas of streams underlain by brown detritus or silt (Scott and Crossman, 1973). Preferred habitats are also characterized by a constant supply of cool groundwater, ensuring sufficient DO levels into the hotter summer months (Stasiak, 2006b).

Characteristics of small streams where this species generally occurs include water supplied by clear, cool springs or seeps, lack of a strong current, cover in the form of undercut banks, heavy vegetation, or brushy debris, and no large piscivorous fish populations (Stasiak, 2006b).

Spawning occurs in the spring to early summer (Scott and Crossman, 1973). Hubbs and Cooper (1936) documented non-adhesive eggs being deposited into dense mats of filamentous algae.

Northern redbelly dace are considered provincially secure by the ACCDC (S5). During the baseline fish and fish habitat field program, northern redbelly dace were captured in WC-5 north of Crusher Lake, WC-13, and the flooded portion of WL56. No northern redbelly dace were captured within watercourses along the Haul Road.

3.1.1.10 White Sucker

White sucker are generalist bottom dwellers found in warm, shallow water areas of lakes and quiet streams. They are most abundant in areas with aquatic vegetation and underwater debris that provide cover.

White sucker are active year-round, spawning in May-June when they migrate into small streams and tributaries with water temperatures of 10-18°C (NSSA, 2005). Preferred spawning habitat for white sucker is shallow gravel riffles of moderate water velocity. Lake populations sometimes spawn on gravel shoals where there is wave action (NSSA, 2005). The adults leave the spawning ground after a week or two and return to the river or lake from which they originated (Scott and Crossman, 1973).

YOY are typically found over sand and gravel substrates in moderate currents (Twomey, Williamson & Nelson, 1984). Older juveniles are typically found in shallow backwaters and riffles with moderate water velocities and sand/rubble substrate (Propst, 1982). In-stream cover in the form of rocky substrates, vegetation, and larger woody debris are important for all life stages of white sucker.

White sucker are considered provincially secure by the ACCDC (S5). During the baseline fish and fish habitat field program, juvenile white sucker were captured in Cameron Flowage, and in two watercourses along the Haul Road (WC-N and WC-AA).

3.1.1.11 Yellow Perch

Yellow perch are a schooling, shallow water fish that can adapt to a wide variety of warm or cool habitats. Most yellow perch do not appear to migrate, but some do in patterns which tend to be short and local (Brown et al., 2009). Adults and juveniles are found in large lakes, small ponds, or gentle rivers but are most abundant in clear, highly vegetated lakes (1-10 m depth) that have muck, sand, or gravel bottoms (Brown et al., 2009). They prefer summer temperatures of 21-24˚C.

Spawning occurs in the spring, with adults moving to lake shallows or low velocity areas of rivers with moderate vegetation. Within 2 months of emergence, YOY perch move to open water (Krieger, Terrell & Nelson, 1983).

Yellow perch are considered provincially secure by the ACCDC (S5). During the baseline fish and fish habitat field program, juvenile and adult yellow perch were captured in Cameron Flowage. Along the Haul Road, a single juvenile yellow perch was captured in WC-N.

3.1.2 *Electrofishing – Beaver Dam Mine Site*

The results of electrofishing surveys within the Beaver Dam Mine Site are presented in Table 3-4. When possible, relative abundance has been expressed through CPUE calculated as the number of fish captured per 300 seconds of electrofishing effort. Detailed results for individual fish captured and measured (lengths) have been provided in Appendix C.

Table 3-4. Summary of Electrofishing Efforts within the Beaver Dam Mine Site

Site	Survey Date	Fish Species Collected	Catch Per Species	Total Catch	Total Effort (seconds)	CPUE (fish/300 seconds)
WC4	September 17, 2015	Ninespine stickleback Unconfirmed fish species	11 1	12	838	4.29
WC5 (top- near WL2)	September 17, 2015	No fish	0	0	326	0
WC5 (lower- near WL14)	September 17, 2015	Brook trout Northern redbelly dace	1 3	4	102	11.76
WC3 (top- near WL2)	September 18, 2015	No fish	0	0	49	0
WC3 (lower- WL20)	September 18, 2015	No fish	0	0	119	0
WC12	September 18, 2015	Brook trout	3	3	195	3.25

Site	Survey Date	Fish Species Collected	Catch Per Species	Total Catch	Total Effort (seconds)	CPUE (fish/300 seconds)
WC13	September 18, 2015	Banded killifish Brook trout Brown bullhead Lake chub Northern redbelly dace	10 6 1 1 5	23	197	3.28
WL56	September 18, 2015	Banded killifish Northern redbelly dace	1 1	2	226	3.77
WL59	September 18, 2015	No fish	0	0	100	0

No fish were captured within either reach of WC3 or the upper reach of WC5. In addition, no fish were captured along the shoreline of WL59, though fish were visually observed in the deeper sections of the flooded wetland.

The highest total number of individuals and greatest species diversity was recorded in WC13 (23 individuals and 5 species), followed by WC4 (12 individuals and 2 species) and the lower reach of WC5 (4 individuals and 2 species). Brook trout was the only species (3 individuals) captured within WC12. One individual each of banded killifish and northern redbelly dace were recorded in the flooded portion of Wetland 56.

The total number of fish of each species was used to calculate CPUE. When calculated, CPUE was relatively consistent across sites (3.25-4.29) with the exception of the lower reach of WC5, which had a significantly higher CPUE (11.73). These numbers form a baseline estimate of catch per unit effort that can be compared between sites and, over time, at each of the watercourses within the Beaver Dam Mine Site. Multiple rounds of quantitative and qualitative electrofishing surveys were performed during Summer 2020 as part of a comprehensive fish and fish habitat program. The results of those surveys are presented in an updated technical report (MEL, 2020).

No fish species at risk (SAR) were captured within the Beaver Dam Mine Site during electrofishing surveys. One species of conversation interest (SOCI), Brook trout (S3), was captured in three of the nine electrofishing reaches in the Beaver Dam Mine Site (lower reach of WC-5, WC12, and WC13).

3.1.3 *Electrofishing- Haul Road*

The results of electrofishing surveys within watercourses along the Haul Road are presented in Table 3-5. Quantitative estimates of abundance were calculated per species using the two-pass depletion method. When practical, population estimates, variance, and standard errors of population estimates have been provided per species for each individual survey. Population estimates were not able to be calculated for those surveys resulting in no catch. Detailed results for individual fish captured and processed (lengths) have been provided in Appendix C.

Table 3-5. Summary of Electrofishing Efforts along the Haul Road

Species	Watercourse	N*	Variance of N	Standard Error
American eel	N	25	25.926	5.092
	V	N/A*	N/A*	N/A*
	AH	16.2	26.957	5.192
Banded killifish	N	N/A*	N/A*	N/A*
	AA	N/A*	N/A*	N/A*
Brook trout	N	N/A*	N/A*	N/A*
	V	8	24	4.899
	AH	N/A*	N/A*	N/A*
Golden shiner	AA	N/A*	N/A*	N/A*
Lake chub	N	N/A*	N/A*	N/A*
	AA	1	0	0
White sucker	N	N/A*	N/A*	N/A*
	AA	1	0	0
Yellow perch	N	1	0	0

*N = population estimate - two pass estimates fail if the catch on the second pass equals or exceeds that on the first pass (Heimbuch et al., 1997).

Within the seven electrofishing locations in the Haul Road, a total of 60 individual fish were captured at four watercourse locations including: WC-N (West River Sheet Harbour), WC-V (tributary draining into Lake Alma), WC-AA (tributary between Mink and Brady Lake), and WC-AH (tributary draining to the Morgan River). No fish were captured in WC-B (Tent Brook) or WC-H (Keef Brook). Both are located at the top of the Tent Brook and Keef Brook tertiary watersheds, respectively. As well, no fish were captured within WC-O, a tributary located within the upper reaches of the Little River tertiary watershed.

WC-N (West River Sheet Harbour) had the greatest species diversity, with six of the seven species captured along all Haul Road watercourses. American eel was the most abundant species captured with a population estimates of 25, while numbers of banded killifish, brook trout, lake chub, white sucker, and yellow perch were much lower. WC-AA had the second greatest species diversity with four species (banded killifish, golden shiner, lake chub, and white sucker), but very low catch rates across the board. American eel was the most abundant species captured in WC-AA, with a population estimate of 16.2. WC-V and WC-AH accounted for two species each, with American eel and brook trout confirmed present in both systems. It is important to note that population estimates for each species and watercourse presented in Table 3-5 represent snapshots in time – estimates have been calculated based on discrete sampling events and do not demonstrate population trends.

No fish species at risk (SAR) were captured within watercourses along the Haul Road. Two species of conservation interest (SOCI) were captured within the Haul Road during electrofishing surveys: American eel (COSEWIC Threatened) and brook trout (S3). Brook trout (n=7) and American eel (n=36) were confirmed at Watercourse N (West River Sheet Harbour), Watercourse V (Tributary to Lake Alma), and Watercourse AH (Tributary to the Morgan River).

3.1.4 *Trapping – Beaver Dam Mine Site*

The results of trapping efforts within the Beaver Dam Mine Site are presented in Table 3-6. Relative abundance has been expressed through CPUE per trap type. Detailed results for individual fish captured and processed (lengths and weights) have been provided in Appendix C.

Table 3-6. Summary of Trapping Efforts within the Beaver Dam Mine Site

Site	Survey Date	Fish Species Collected	Total Catch	Total Effort Per Trap Type (hours)	Total Catch Per Trap Type	CPUE (fish/hour of trapping)
Crusher Lake A	June 27, 2016	Banded killifish Golden shiner	6 2	FN- 4.43 hrs EP- 4.73 hrs MT1- 4.43 hrs MT2- 4.42 hrs	0 8 0 0	0 1.69 0 0
Crusher Lake B	June 27, 2016	Brown bullhead Golden shiner	3 3	FN- 4.42 hrs EP- 4.38 hrs MT1- 4.38 hrs MT2- 4.38 hrs	3 2 0 1	0.68 0.46 0 0.23
Cameron Flowage A	June 24, 2016	Brown bullhead Golden shiner White sucker Yellow perch	2 5 1 7	FN- 4.92 hrs EP- 4.28 hrs MT1- 4.97 hrs MT2- 4.18 hrs	3 6 3 3	0.61 1.40 0.60 0.72
Cameron Flowage B	June 24, 2016	White sucker Yellow perch	1 11	FN- 5.13 hrs EP-4.87 hrs MT1- 5.08 hrs MT2- 5.13 hrs	1 3 8 0	0.20 0.62 1.57 0
WC-B	June 20, 2016	No fish	0	MT1- 2.30 hrs MT2- 2.30 hrs MT3- 2.28 hrs	0 0 0	0 0 0
WC-N	June 22, 2016	No fish	0	MT1- 2.03 hrs MT2- 2.12 hrs MT3- 2.18 hrs	0 0 0	0 0 0
WC-V	June 16, 2016	Brook trout	1	MT1- 2.42 hrs MT2- 2.43 hrs	1 0	0.41 0

Fish collection was completed to support electrofishing and fish habitat surveys across the Beaver Dam Mine Site. The focus of fish collection efforts within the Beaver Dam Mine Site were Crusher Lake and Cameron Flowage, where fyke nets, minnow traps and eel pots were deployed at two locations within each waterbody to collect additional information about fish species and abundance within the SA.

Crusher Lake Fish Collection: A total of 14 individual fish of two species were captured through trapping efforts at Crusher Lake Site: banded killifish (n=6), brown bullhead (n=3), golden shiner (n=5).

No SAR/SOCI species were captured during fish collection efforts in Crusher Lake. However, brook trout were identified just north of Crusher Lake in WC-5, and are expected to be present in Crusher Lake, based on direct connectivity of WC-5 to Crusher Lake.

Cameron Flowage Fish Collection: A total of 27 individual fish of four species were captured through trapping efforts at Cameron Flowage: brown bullhead (n=2), golden shiner (n=5), white sucker (n=2) and yellow perch (n=18).

No SAR/SOCI species were identified during fish collection in Cameron Flowage.

Extensive trapping surveys were performed from September 2019 – September 2020 within select watercourses, waterbodies and wetlands within the Beaver Dam Mine Site. The results of those trapping surveys have been provided in an updated technical report (MEL, 2020).

3.1.5 *Trapping – Haul Road*

The results of trapping efforts within watercourses along the Haul Road are presented in Table 3-7. Relative abundance has been expressed through CPUE per trap type.

Table 3-7. Summary of Trapping Efforts along Haul Road Watercourses

Site*	Survey Date	Fish Species Collected	Total Catch	Total Effort Per Trap Type (hours)	Total Catch Per Trap Type	CPUE (fish/hour of trapping)
WC-B	June 20, 2016	No fish	0	MT1- 2.30 hrs MT2- 2.30 hrs MT3- 2.28 hrs	0 0 0	0 0 0
WC-N	June 22, 2016	No fish	0	MT1- 2.03 hrs MT2- 2.12 hrs MT3- 2.18 hrs	0 0 0	0 0 0
WC-V	June 16, 2016	Brook trout	1	MT1- 2.42 hrs MT2- 2.43 hrs	1 0	0.41 0

*Watercourses H, O, AA, and AH did not have enough depth in pooling water to allow for deployment of minnow traps.

Minnow traps were deployed where possible during electrofishing surveys within the Haul Road watercourses to supplement fish habitat and electrofishing surveys. Limited water depths and a lack of deeper pools in the discrete watercourses reaches overlapping the Haul Road SA resulted in limited fish collection opportunities. Where minnow traps were deployed, only one brook trout was captured in Watercourse V (tributary to Lake Alma). Brook trout were also captured during electrofishing surveys in this same watercourse, along with the American eel.

3.2 Water Quality

Water quality results are reported and discussed as it relates to the chemical characteristics required for suitable fish habitat. Where applicable, water quality sampling results are measured against the CCME Guidelines for the Protection of Freshwater Aquatic Life (FWALs). Summaries of water quality measurements recorded during electrofishing, trapping, and benthic invertebrate surveys are presented in Table 3-8 and Table 3-9 for aquatic features in the Beaver Dam Mine Site and the Haul Road, respectively.

Table 3-8. Summary of In-situ Water Quality Measurements recorded within the Beaver Dam Mine Site.

Site	Sampling Dates	Water Temp (°C)	pH	DO (mg/L)	TDS (g/L)
Electrofishing and Trapping Locations					
WC-3 (top- near WL2)	Sept 18, 2015	16.35	**4.66**	18.90	0.02
WC-3 (lower- near WL20)	Sept 18, 2015	18.71	**4.30**	18.45	0.02
WC-4	Sept 17, 2015	13.50	5.98	14.36	0.05

Site	Sampling Dates	Water Temp (ºC)	pH	DO (mg/L)	TDS (g/L)
WC-5 (top-near WL2)	Sept 17, 2015	17.87	5.10	19.99	0.05
WC-5 (lower- near WL14)	Sept 17, 2015	19.85	**4.16**	18.13	0.02
WC-12	Sept 18, 2015	14.13	5.54	14.11	0.05
WC-13	Sept 18, 2015	22.10	5.60	17.34	0.03
WL59	Sept 18, 2015	23.43	6.31	15.85	0.03
WL56	Sept 18, 2015	16.56	5.40	17.60	0.03
Trapping Locations					
Cameron Flowage	June 24, 2016	21.80	6.71	7.42	0.02
Benthic Sampling Locations					
WC-13	June 24, 2016	21.10	5.37	6.92	0.03
WC-4	June 24, 2016	13.80	6.55	9.28	0.02
WC-5	June 24, 2016	20.40	6.42	8.15	0.01

Note: Values in bold indicate parameters recorded as below CCME guidelines for the protection of aquatic life, including: DO levels not suitable for any life stage of warm or cold-water fish species (<5.5 mg/L) (1999), and pH levels below 5.0 (CCREM 1987).

Table 3-9. Summary of In-situ Water Quality Measurements recorded along the Haul Road.

Site	Sampling Dates	Water Temp (ºC)	pH	DO (mg/L)	TDS (g/L)
B	June 22, 2016	22.1	**4.61**	**3.9**	0.05
H	June 22, 2016	18.2	6.11	6.3	0.05
N	June 22, 2016	18.9	5.65	8.7	0.02
O	June 23. 2016	14.0	6.04	**5.3**	-
V	June 23. 2016	15.5	**3.43**	9.3	0.05
AA	June 23. 2016	20.5	5.39	6.6	-
AH	June 23. 2016	19.5	5.53	7.4	-

Note: Values in bold indicate parameters recorded as below CCME guidelines for the protection of aquatic life, including: DO levels not suitable for any life stage of warm or cold-water fish species (<5.5 mg/L) (1999), and pH levels below 5.0 (CCREM 1987). Missing measurements reflect equipment malfunctions in the field.

3.2.1 *Temperature*

Water temperature affects the metabolic rates and biological activity of aquatic organisms, thus influencing the use of habitat by aquatic biota. There are no CCME guidelines related to temperature and aquatic biota. Temperature preferences of fish vary between species, as well as with size, age, and season.

Salmonids are cold-water fish species, meaning they require cold water to live and reproduce. The optimal temperature range for these species (growth of juvenile) is 10-20˚C (The Stream Steward n.d.) to 16-20˚C (DFO, 2012b) (brook trout and Atlantic salmon, respectively). The Nova Scotia Trout Management Plan (NSDAF, 2005) identifies three classes of streams based on water quality and pH for trout species (including brook trout which is present within the FMS Study Area). Class A streams (cool) require the average summer temperature to be <16.5˚C. Class B streams (intermediate) temperature (average summer) ranges from 16.5-19˚C. Finally, Class C streams (warm) require temperatures above 19˚ or pH of <4.7 (NSDAF, 2005).

The identification, maintenance, protection, and enhancement of instream habitats of class A and class B waters can benefit the trout fishery. Average summer temperatures were not collected as part of baseline fish and fish habitat surveys completed within the SA. However, results shown in Table 3-8 and Table 3-9 can provide information relating to the generally quality of the streams present within the SA for trout. Streams with elevated temperatures in June (WC-B, AA, AH for example) would likely demonstrate average temperatures above 19℃ and be classified as warm streams (lower quality for trout). WC-3 and WC-V also have low pH indicating they are Class C (warm) streams. WC-4, WC-12 and WC-O indicate potential Class A streams (cool) based on temperature readings available (not confirmed average summer temperatures).

Other species documented within the SA have higher temperature ranges: Yellow Perch 21-24˚C (Brown et al., 2009), and white sucker 19-26˚C (Kelly, 2014). American eel have a broader temperature range and can tolerate temperatures from 4 to 25 ºC (Fuller et al., 2019).

Temperatures recorded in watercourses during electrofishing and fish collection in September 2015 and June 2016 ranged from 13.5^{0}C (WC-4 within Beaver Dam Mine Site) to 23.43 ^{0}C (Wetland 59 within Beaver Dam Mine Site). Generally, the range of temperatures within watercourses is within the required ranges for the species expected to inhabit aquatic features within the SA. The warmer temperatures identified in WC-13 and Wetland 59 in the Beaver Dam Mine Site, and WC-B and WC-AA within the Haul Road are above the optimal range for salmonids. For waterbodies, only discrete in-situ water quality measurements were taken from shore. As such, the records presented for Cameron Flowage and Wetland 56 and 59 are expected to represent the upper extent of the thermal range within each system at the time of assessment. It is likely that some of these features may provide areas of thermal refuge in areas comprising deeper water (e.g. Cameron Flowage).

3.2.2 *pH*

CCME FWALs establish that a range of pH from 6.5 to 9.0 is suitable within freshwater habitat. All watercourses measured in 2015 within the Beaver Dam Mine Site had pH levels below the range suitable for fish within freshwater habitat. In 2016, during a benthic sampling event, the pH in WC-4 was recorded slightly higher than in 2015 and just within the lower end of the acceptable CCME range at 6.55. The pH within Cameron Flowage was recorded at 6.71 in 2016. Levels of pH in all watercourses within the Haul Road SA reported below the range suitable for fish within freshwater habitat.

Levels of pH that were reported below the suitable range indicate the presence of acidification within watercourses across the SA. Kalff (2002) indicates that the loss of fish populations is gradual and depends on fish species, but decline is evident when pH is <6.5. Kalff further states that a 10-20% species loss is apparent when pH<5.5.

Juvenile rearing of Atlantic salmon requires freshwater pH >4.7. The Recovery Potential Assessment for Atlantic salmon completed by Fisheries and Oceans Canada indicates that acidification is an extreme threat to the Atlantic salmon population (Gibson and Bowlby, 2013). Yellow perch are found in Ontario lakes with a pH range from approximately 3.9 to 9.5. Yellow perch are relatively tolerant of low pH, but reproductive success is reduced in lakes with pH < 5.5 (Krieger, Terrell, & Nelson, 1983). White suckers have been collected from areas with a pH as low as 4.3 (Dunson and Martin, 1973, as cited in Twomey, Williamson, & Nelson, 1984), but Beamish (1974) reported sharp declines in white sucker populations in Canadian lakes when the pH was lowered to 4.5 to 5.0 as a result of acid precipitation.

Brook trout tolerate acidic conditions particularly well, compared with other species. They have been known to survive at pH 3.5, though only in unusual circumstances. Realistically, the lower limits are around pH 4.8 (Soil & Water Conservation Society of Metro Halifax, 2016). American eels are also more tolerant of low pH, although densities and growth rates may be adversely affected by direct mortalities or declining abundance of prey as productivity declines at low pH (Jessop, 1995).

The Nova Scotia Salmon Association (NSSA) is currently conducting a liming project in tertiary watersheds that are located within the SA. In order to offset the acidity of watercourses and improve water quality for Atlantic salmon, the project uses lime dosers (an automated system that combines powdered limestone with the watercourse) as well as helicopters that add lime to the soils within the Killag River tertiary watershed. Two lime dosers are currently in use, they are located within the West River Sheet Harbour (WC-N) and the Killag River (Figure 2, Appendix A). The West River Sheet Harbour lime doser, which was installed in September 2005, is located approximately 8.5 km upstream of the intersection between the Beaver Dam Mine Road and West River Sheet Harbour. The Killag River lime doser was installed in November 2017 and is located approximately 400 m downstream of the Beaver Dam Mine Site, downstream of where the Killag River crosses the Beaver Dam Mines Road. Catchment liming is ongoing within the Brandon Lake Tertiary Watershed (1EM-2G), adjacent to Keef Brook (WC-H). WC-H is located within the Haul Road SA as a throughflow through Wetland 79. WC-H eventually empties into the West River Sheet Harbour.

3.2.3 *Dissolved Oxygen*

The atmosphere and photosynthesis by aquatic vegetation are the major sources of DO in water (CCME 1999). However, the amount of oxygen available for aquatic life (i.e. the concentration of oxygen in water) is affected by several independent variables including water temperature, atmospheric and hydrostatic pressure, microbial respiration, and growth of aquatic vegetation; DO can vary daily and seasonally (CCME, 1999). The CCME FWALs establish a minimum recommended concentration of DO of 9.5 mg/L for early life stages of cold-water biota and 6.5 mg/L for other life stages. For warm-water biota, the CCME guidelines recommend 6.0 mg/L for early life stages, and 5.5 mg/L for all other life stages.

Within the Beaver Dam Mine Site, DO levels recorded across watercourses and waterbodies in 2015 were above the guidelines for both life stages of cold-water biota. DO levels recorded in the Beaver Dam Mine Site in 2016 (Cameron Flowage and benthic sampling sites) are considered suitable for other life stages of cold-water fishes. Along the Haul Road, most watercourses had DO levels suitable for other stages of cold-water fishes, with the exception of WC-B (3.9 mg/L) and WC-O (5.3 mg/L). These DO levels are considered limiting to both warm-water and cold-water fish species.

3.2.4 *Total Dissolved Solids*

Total Dissolved Solids (TDS) is a measurement of inorganic salts, organic matter and other dissolved materials in water. TDS causes toxicity through increases in salinity, changes in the ionic composition of the water and toxicity of individual ions. TDS field measurements within SA ranged from 0.01 to 0.05 g/L (10-50 mg/L TDS). A recent study by Weber-Scannell and Duffy (2007) reported a variety of studies that evaluated the effect of elevated TDS on freshwater aquatic invertebrates. These studies reported the commencement of effect at 499 mg/L, and most effects aren't observed until >1000 mg/L. Research is limited, but preliminary studies reported in Weber-Scannell and Duffy demonstrated survival rates of salmonid embryos to elevated TDS (38% survival when exposed to 2229 mg/L for Brook trout, and 35%

survival when exposed to 1395 mg/L). TDS levels measured within the SA are considered acceptable for aquatic life.

3.3 Benthic Invertebrate Community

The total number of animals of each type (taxonomic group), as well as total abundance, was determined for each sample collected from the watercourses within the SA. These numbers were used to calculate several indices of baseline benthic community health, which can be compared between sites and, with time, at each site. Indices calculated are all commonly used in studies of this kind and include: EPT Ratio (ratio of abundance of mayflies (Ephemeroptera), caddisflies (Trichoptera), and stoneflies (Plecoptera), to total numbers of organisms); Total Abundance (number of animals in the sample and per unit area); and Taxon Richness (number of taxa per sample). Abundance in kicknet samples was expressed on a per sample basis. All organisms present were included in estimates. A summary of results for each sample site (total abundance, taxon richness and EPT ratio for each watercourse) are presented in Table 3-10. Sediment descriptions for the ten samples (and associated sub-set samples) along with species identifications for each watercourse are presented in Appendix D.

Table 3-10. Summary of Benthic Invertebrate Community Parameters

Watercourse	Abundance (#/sample)	Taxon Richness	EPT: Total Ratio (%)
Beaver Dam Mine Site			
4	179	13	1.1
5	947	30	3.8
13	703	27	5.3
Haul Road			
B.a	205	22	7.3
B.b	210	12	0.5
B.c	253	10	1.6
B.d	181	15	2.8
H	269	21	5.2
N	110	23	26.4
V	279	20	16.1
AA	762	31	8.4
AH	203	18	24.1
O.a	163	18	36.2
O.b	410	19	50.2

Note: Samples consists of a 3-minute kick net.

Samples were dominated in numbers by Diptera larvae, principally midges (Chironomidae) at all sites, and by juvenile clams (Bivalves), predominantly Sphaeriidae at Watercourse 13. Caddisfly larvae (Trichoptera) occurred frequently at all sites with the exception of one (WC-B.b), and may fly larvae (Ephemeroptera) occurred at twelve of the fourteen sites. Aquatic beetle larvae (Coleoptera), dragonfly/damselfly larvae (Odonata), stonefly larvae (Plecoptera) and dobsonfly/fishfly larvae (Megaloptera) occurred frequently at most sites. Aquatic Hemiptera (i.e. Gerridae, Corixidae, etc.) also occurred in many of the sites, as well as crustaceans, including the amphipod *Hyalella azteca* (found only at Watercourse 13), and copepods & cladocera (found at a total of eight sites).

Taxon richness indicates the health of the community through its diversity, and increases with increasing habitat diversity, suitability, and water quality. Taxon richness equals the total number of taxa represented within the sample. The healthier the community is, the greater the number of taxa found within that community. Similarly, a high abundance may indicate a healthier waterbody.

The EPT index is named for three orders of pollution sensitive aquatic insects that are common in the benthic macroinvertebrate community: Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) and is commonly used as an indicator of water quality (i.e., the greater percentage of the total sample comprised of EPT organisms indicates a healthier site). Generally speaking, the EPT index increases with increasing water quality. However, there are many factors that regulate the distribution and abundance of benthic macroinvertebrates within aquatic environments (as well as biological condition within a waterbody), thus the results of this study only allow for the establishment of baseline conditions that can later be used in a monitoring program to identify potential changes to water quality within these specific environments.

As previously mentioned, there are several factors that regulate the distribution and abundance of benthic macroinvertebrates, including current speeds, temperature, altitude, season, substratum, vegetation, dissolved substances (e.g., oxygen), and pH (Hussain & Pandit, 2012). To illustrate the effects of some of these factors, temperature and pH will be discussed in relation to their effects on benthic macroinvertebrates.

The distribution and community structure of benthic macroinvertebrates is limited by their ability to live within a specific temperature range. Temperature affects their emergence patterns, growth rates (Sweeney & Schnack, 1977), metabolism (Angelier, 2003), reproduction (Vannote & Sweeney, 1980), and body size (Sweeney & Schnack, 1977).

Benthic macroinvertebrates vary in their sensitivity to pH (i.e., values below 5.0 and greater than 9.0 are considered harmful) (Yuan, 2004). However, studies have shown that low pH values are associated with lower diversity of benthic macroinvertebrates (Thomsen & Friberg, 2002), and cause decreased emergence rates (Hall, Likens, Fiance, & Hendrey, 1980), for example.

Overall abundance and taxon richness within SA were low to moderate (110-947 individuals/sample and 10-31 taxon, respectively), and EPT ratios low at eight of the sites (0.5-8.4%) and moderate (16.1-50.2%) at the remaining sites (Watercourse N, V, AH, O). The occurrence of EPT groups (Trichoptera, Ephemeroptera and Plecoptera) at most sites suggests that DO and water quality is acceptable, as these groups generally are associated with aquatic habitat having good water quality.

3.4 Fish Habitat Assessment

The potential for each watercourse and wetland to support fish was evaluated across the SA. In addition to the Killag River, 35 linear watercourses were identified within the Haul Road, and 28 linear watercourses were identified within and downgradient the Beaver Dam Mine Site. Two waterbodies (Crusher Lake, and Mud Lake) and one main watercourse system (Cameron Flowage/Killag River) were identified within the Beaver Dam Mine Site, all of which were expected to support fish. No waterbodies were identified within the Haul Road. Two hundred and twenty-nine (229) wetlands were evaluated across the SA. Fish habitat potential was determined at each location during field identification/evaluation and collection of physical characteristics of each watercourse/wetland.

3.4.1 *Beaver Dam Mine Site Watercourses*

A summary of key fish habitat characteristics within each linear watercourse surveyed within the Beaver Dam Mine Site are presented in Table 3-11. Only regulated watercourses confirmed or assumed to support fish and fish habitat have been included. Fisheries resources within the Beaver Dam Mine Site are presented on Figure 5, Appendix A.

Table 3-11. Summary of Key Diagnostic Features of Fish Habitat within Linear Watercourses within the Beaver Dam Mine Site

Watercourse	Tertiary Watershed	Stream Order	Section Length (m)[1]	Watercourse Characteristics										
				Channel Width (m)	Wetted Width (m)	Dominant Habitat Type	Other Habitats Present	Gradient[2]	Velocity[3]	Average Depth (m)	Substrate Composition (%)	In-stream Vegetation (%)	Overhanging Vegetation (%)	Coarse Woody Debris[4]
1	Tent Brook	1	60	0.6	0.45	Run	-	L-M	L	0.1	Boulder (80), Gravel (20)	20	80	M
2	Killag River	1	70	0.8	0.7	Run	-	M	L	0.15	Muck (80), Gravel (20)	40	80	H
3	Killag River	1-2	50	0.3	0.3	Riffle	Pool	L-M	L	0.05	Rubble (70), Sand (30)	40	80	L
4	Killag River	1	40	0.8	0.1	Flat	-	L	L	0.05	Cobble (80), Gravel (20)	40	>95	H
5 (upper)	Killag River	1	100	0.75	0.6	Flat	Run	M	M	0.05	Rubble (30), Sand (20), Silt (20), Boulder (15), Cobble (15)	15	100	M
5* (lower)	Killag River	2-3	266	1.0-3.0	0.5-2.0	Run	Riffle	M	M	0.2-0.6	Boulder (80), Rubble (10), Cobble (10)	20	100	H
6	Killag River	1	30	0.3	0.2	Run	-	M	M	0.05	Rubble (60), Cobble (40)	10	100	M
7	Killag River	1	100	0.5	0.4	Glide	Riffle, Pool	L-M	L	0.03	Cobble (40), Rubble (20), Muck (15), Gravel (10), Boulder (5)	25	100	M
8	Killag River	1	30	3.0	0.5	Glide	-	L	L	0.1	Silt (40), Muck (35), Rubble (15), Boulder (10)	70	75	L
9	Killag River	1	100	2.0	0.5	Glide	Pool, Riffle, Cascade	H	H	0.08	Boulder (50), Rubble (30) Cobble (13), Muck (7)	30	100	M
11	Kent Brook	1	250	1.5	1.5	Run	-	L	L	0.4	Muck (90), Rubble (5), Boulder (5)	40	70	H
12*	Killag River	1	40	1.0-4.0	0.5-4.0	Run	-	L	M	0.1	Silt (60), Gravel (40)	15	80	L
13*	Killag River	2	60	5.0	3.0	Run	Riffle, Pool	L	L	0.1	Rubble (60), Boulder (20), Silt (20)	80	100	L
14*	Killag River	1-2	150	1.2	1.0	Run	-	M	M	0.5	Cobble (60), Gravel (40)	0	100	M
17	Killag River	1	150	0.3-1.0	0.3-1.0	Flat	Run	L	L	0.2	Muck (90), Boulder (10)	5	20	M
23*	Cope Brook	1	1645	3.0-6.0	3.0-6.0	Flat	Run	L	L	0.35	Muck (85), Boulder (15)	55	80	H
24	Cope Brook	1	92	0.2	0.2	Run	-	L	L	0.1	Muck (60), Boulder (40)	0	60	M
25*	Killag River	1	39	0.75-3.0	0.75-3.0	Run	-	L	L	0.5	Muck (100)	10	40	L
26*	Killag River	1	803	2.5	0.5-3.0	Run	-	L	L	0.7	Muck (80), Boulder (20)	40	80	L
27*	Killag River	3	237	25.0	15.0	Flat	-	L	L	1.0	Muck (100)	25	2	L
28	Tent Brook	1	45	0.45-0.70	0.45-0.70	Flat	-	L	L	0.17	Muck (90), Cobble (10)	5	10	L
Killag River/ Cameron Flowage	Killag River	4	1700	7.5-76.8	7.3-76.8	Flat	Run, riffle, rapid	L	M	0.88 (up to 3.7 m)	Cobble, Boulder, Rubble and muck, variable amongst reaches	n/a	n/a	L

*Watercourses have been revaluated through quantitative habitat assessments during 2019-2020 field program (MEL, 2020).
[1]Linear extent of watercourse described.

[2]Gradient: H:>5% slope M: 2-5% slope L: <2% slope (estimated only).
[3]Velocity: H: flows at a speed at which the water is visually rough and irregular, creates eddies, heavier riffles to light rapids (>0.3 m/s) M: flows at a speed which creates smooth to moderate riffles (0.15-0.3 m/s) L: flows so slowly that the water is smooth and fine sediments are not held in suspension (<0.15 m/s).
[4]Coarse Woody Debris: H:10+ woody debris per 20 m reach, M: 10-5 woody debris per 20 m reach, L: less than 5 woody debris per 20 m section.

Of the 29 linear watercourses within and downgradient the Beaver Dam Mine Site, 19 watercourses have been confirmed or are assumed to support fish and fish habitat. Regulated watercourses within the Beaver Dam Mine Site that are considered non-fisheries resources include:

- WC10
- WC15
- WC16
- WC18
- WC19
- WC20
- WC21
- WC22
- WC24

These watercourses are hydrologically isolated, meaning there is no contiguous surface water connecting these watercourses with any upgradient or downgradient fish-bearing systems year-round. These watercourses are therefore considered inaccessible to fish. Watercourses 20-24, which fall within and downgradient of the waste rock storage infrastructure footprint, were re-evaluated and thoroughly assessed during the 2019-2020 field program (MEL, 2020). WC18, located east of the till stockpile, was also re-evaluated.

In anticipation of Fisheries Act authorizations (HADD), watercourses and waterbodies within the Beaver Dam Mine Site anticipated to be directly or indirectly impacted by Project development were reassessed during the 2019-2020 field program, which included quantitative detailed habitat mapping and multiple rounds of electrofishing and trapping surveys. Fish habitat within each watercourse and open water feature has been described based on every species and life stage confirmed or potentially present within each aquatic feature. Waterbodies within the Beaver Dam Mine Site (Crusher Lake and Mud Lake, plus ‘lentic’ like component of Cameron Flowage) have also been included in this updated assessment. The results presented in the Baseline Fish and Fish Habitat 2020 Technical Report (MEL, 2020) supersede the results presented in Table 3-11.

3.4.2 *Haul Road Watercourses*

A summary of key fish habitat characteristics within each linear watercourse observed along the Haul Road, including current crossing conditions, are presented in Table 3-12. All Haul Road watercourses have been confirmed or assumed to be potentially fish bearing. Haul road watercourses and wetlands are shown on Figures 6 through 9, Appendix A.

Table 3-12: Summary of Key Diagnostic Features of Fish Habitat within Linear Watercourses along the Haul Road

Watercourse	Tertiary Watershed	Stream Order	Section Length (m)[1]	Watercourse Characteristics											
				Channel Width (m)	Wetted Width (m)	Dominant Habitat Type	Other Habitats Present	Gradient[2]	Velocity[3]	Average Depth (m)	Substrate Composition (%)	In-stream Vegetation (%)	Overhanging Vegetation (%)	Coarse Woody Debris[4]	Current Crossing (condition)
A	Tent Brook	1	26	0.2-4	0.2-4	Flat	-	L	L	0.10-0.25	Muck (100)	20	65	L	Culvert (buried)
B (Tent Brook)	Tent Brook	2	40	0.2-4	0.2-4	Glide	Riffle, Run	L	L	0.10-0.20	Muck (90), Cobble (10)	10	95	M	Culvert (crushed)
C	Tent Brook	1	50	0.35-0.8	0.35-0.8	Flat	-	L	L	0.05-0.25	Muck (30), Silt (25), Cobble (20), Gravel (15), Rubble (10)	10	50	M	Culvert (functioning)
D	Tent Brook	1	25	0.25-0.8	0.25-0.65	Run	Riffle, Pocket	M	M	0.05-0.20	Cobble (50), Boulder (40), Muck (10)	0	45	L	None
E	Keef Brook	1	75	0.35-1.8	0.25-1.7	Run	Glide, Riffle, Pool	L	M	0.01-0.20	Cobble (80), Boulder (5), Gravel (15)	5	80	H	Culvert (blocked)
F	Keef Brook	2	83	0.7-1.7	0.6-1.5	Run, Pool	-	L	M	0.10-0.30	Muck (75), Gravel (25)	20	70	M	Culvert (crushed)
G	Keef Brook	1	71	0.5-3.5	0.4-3.5	Glide	Run	L	L	0.05-0.30	Muck (50), Gravel (25), Cobble (15)	75	10	M	Culvert (crushed)
H (Keef Brook)	Keef Brook	3	100	1.2-5	1-5	Run	Cascade, Riffle, Pool	M	H	0.02-0.40	Boulder (30), Cobble (40), Rubble (30)	0	60	M	Bridge
I	Keef Brook	1	64	0.3-1.5	0.3-1.5	Riffle-Run	Pool	L	L	0.05-0.15	Cobble (60), Rubble (20), Boulder (15), Gravel (5)	5	65	L	Culvert (buried)
J	Keef Brook	1	80	0.6-2	0.5-2	Run	Pool, Riffle	M	M	0.05-0.23	Muck (40), Cobble (30), Gravel (15)	0	70	M	Culvert (buried)
K	Keef Brook	1	55	0.4	0.3	Riffle	Pool	M	M	0.15	Boulder (40), Sand (40), Gravel (20)	5	100	L	None
L	Keef Brook	1	47	0.5	0.3	Run	Riffle, Pool	M	L-M	0.10-0.30	Cobble (50), Gravel (50)	0	90	L	Culvert (functioning)
M	Keef Brook	1	50	0.5-1.1	0.35-1	Run	-	L	L	0.02-0.45	Muck (90), Gravel (10)	5	95	H	Culvert (functioning)
N (West River Sheet Harbour)	Keef Brook / Jack Lowe Brook	4	113	12	12	Run	Cascade, Glide, Riffle	M	H	1.00	Cobble (30), Gravel (30), Rubble (25), Boulder (15)	10	40	L	Bridge
O	Little River	2	30	0.6-4.3	0.4-4	Glide	Riffle, Pool	L	L	0.15	Muck (65), Rubble (15), Boulder (10), Cobble (10)	7	30	M	None

Watercourse	Tertiary Watershed	Stream Order	Section Length (m)[1]	Watercourse Characteristics											
				Channel Width (m)	Wetted Width (m)	Dominant Habitat Type	Other Habitats Present	Gradient[2]	Velocity[3]	Average Depth (m)	Substrate Composition (%)	In-stream Vegetation (%)	Overhanging Vegetation (%)	Coarse Woody Debris[4]	Current Crossing (condition)
P	Little River	1	30	0.2-1.5	0.2-1.2	Run	Riffle, Pocket	M	M	0.10-0.35	Boulder (40), Cobble (30), Rubble (20), Gravel (10)	0	0	L	None
Q	Little River	1	35	0.6-1.6	0.6-1.6	Glide	Riffle	L	L	0.10-0.20	Gravel (35), Boulder (30), Cobble (30), Muck (5)	0	10	M	None
R	Little River	1	100	1-1.8	0.8-1.5	Pool	Glide, Riffle	L	L	0.15	Muck (90), Boulder (5), Cobble (5)	30	50	M	None
S	Little River	1	68	1-2	1-2	Glide	Run, Riffle	L	L	0.10-0.20	Gravel (40), Cobble (25), Muck (20), Rubble (15)	0	90	L	Culvert (hung)
T	Little River	2	52	1-2.6	1-2.6	Run	Pool, Riffle	L	M	0.01-0.19	Cobble (40), Rubble (20), Muck (20), Gravel (10), Boulder (10)	0	80	M	Culvert (buried)
U	Little River	1	56	0.5-1	0.5-1	Run	Riffle, Pool	L-M	L-M	0.06-0.40	Muck (50), Gravel (40), Cobble (10)	0	90	L	Culvert (functioning)
V	Little River	2	65	1.3-1.5	0.8-1.4	Run	Cascade, Riffle	M	H	0.02-0.17	Boulder (40), Gravel (30), Cobble (30)	5	90	L	Culvert (buried)
W	Little River	1	44	0.2-2	0.2-1.5	Run	Pool, Riffle	M	M	0.05-0.22	Muck (90), Rubble (10)	0	90	L	Culvert (hung)
X	Little River	1	70	0.3-1	0.25-0.8	Flat	Riffle	M	M	0.05-0.45	Muck (60), Cobble (40)	0	40	M	None
Y	Little River	1	70	0.3-1	0.25-0.8	Flat	Riffle	M	M	0.05-0.45	Muck (60) Cobble (40)	0	40	M	None
Z	Little River	1	90	0.3-2 (downstream), 25 (upstream)	0.3-2 (downstream), 25 (upstream)	Pool	Run, Riffle	L	L	0.12->0.40	Gravel (65), Muck (30), Cobble (5)	70	30	L	Culvert (buried)
AA	Sandy Pond	2	105	0.5-3.5	0.5-3.5	Run=100	-	L	M	0.20	Cobble (40), Muck (30), Gravel (25), Rubble (5)	10	80	M	Culvert (hung)
AB	Sandy Pond	1	40	0.25	0.2	Run	Pocket	M	M	0.10	Sand (100)	40	100	L	None
AC	Sandy Pond	1	60	0.5-6	0.5-4	Flat	Riffle, Pool	L	L	0.05-0.20	Boulder (40), Rubble (30), Sand (30)	10	50	L	None
AD (Morgan River)	Sandy Pond	3	130	13-17	12-16	Run	-	L	M	1.00+	Too deep to see substrate; Co, Ru, LB, SB	1	10	L	Bridge
AE	Morgan River	1	80	0.5-1.5	0.3-1.2	Run	Riffle, Pool	L	M	0.10	Cobble (55), Gravel (40), Rubble (5)	10	50	L	Culvert (buried)
AF	Morgan River	1	70	0.5-1.8	0.5-1.8	Flat	Pool, Riffle	L	L	0.20-0.30	Cobble (45), Gravel (30), Rubble (25)	40	70	M	None

Watercourse	Tertiary Watershed	Stream Order	Section Length (m)[1]	Watercourse Characteristics											
				Channel Width (m)	Wetted Width (m)	Dominant Habitat Type	Other Habitats Present	Gradient[2]	Velocity[3]	Average Depth (m)	Substrate Composition (%)	In-stream Vegetation (%)	Overhanging Vegetation (%)	Coarse Woody Debris[4]	Current Crossing (condition)
AG	Morgan River	1	65	0.4-1.1	0.4-0.9	Run	Riffle, Cascade	L	M	0.20-0.45	Rubble (40), Cobble (30), Boulder (30)	10	55	M	None
AH	Morgan River	4	100	2-7	2-6.5	Riffle	Pool	L	M	0.50-0.80	Cobble (40), Rubble (30), Gravel (20), Boulder (10)	30	30	L	None
AI	Little River	1	70	1.2	0.2	Pool	-	L	L	10	Muck (90), Ru (10)	0	10	L	None

[1]Linear extent of watercourse described.
[2]Gradient: H:>5% slope M: 2-5% slope L: <2% slope (estimated only).
[3]Velocity: H: flows at a speed at which the water is visually rough and irregular, creates eddies, heavier riffles to light rapids (>0.3 m/s) M: flows at a speed which creates smooth to moderate riffles (0.15-0.3 m/s) L: flows so slowly that the water is smooth and fine sediments are not held in suspension (<0.15 m/s).
[4]Coarse Woody Debris: H:10+ woody debris per 20 m reach, M: 10-5 woody debris per 20 m reach, L: less than 5 woody debris per 20 m section.

The capacity of each linear watercourse along the Haul Road to support fish has been assessed based on key fish habitat characteristics presented in Table 3-12. This determination has been supported by fish species confirmed within the watercourses through electrofishing and trapping surveys. All species captured within each secondary watershed along the Haul Road have been considered potentially present within all Haul Road watercourses, to be conservatively inclusive. Atlantic salmon has also been considered for watercourses within the West River Sheet Harbour secondary watershed – Atlantic salmon are considered extirpated from the Tangier River and are therefore not included in the assessment of those watercourses. It is important to note that fish habitat characterization was only performed on short sections of watercourse which overlapped the SA and is not considered representative of the fish habitat along the entire length of each watercourse. In addition, due to the linear nature of the Haul Road Footprint, connectivity to downgradient fish-bearing systems have been assumed for all watercourses in absence of confirmation of barriers to downstream fisheries resources. Descriptions of fish habitat by species and life stage for each linear watercourse are presented in Table 3-13.

Table 3-13. Fish Habitat Descriptions by Species and Life Stage - Haul Road

Species	Life Stage	Potential Habitat – Haul Road Watercourses
American eel	Juvenile	A, B, C, D, F, G, I, J, M, N, O, Q, R, S, T, U, V, W, X, Y, Z, AA, AB, AC, AD, AE, AF, AG, AH, AI
	Adult	A, B, C, D, E, F, G, I, J, M, N, O, Q, R, S, T, U, V, W, X, Y, Z, AA, AB, AC, AC, AD, AE, AF, AG, AH, AI
Atlantic Salmon	Spawning	N
	YOY	N
	Juvenile	H, N
	Adult	N
Banded killifish	Spawning	A, B, C, F, G, O, R, Z, AA, AD, AC, AF, AH
	YOY	A, B, C, F, G, O, R, Z, AA, AC, AD, AF, AH
	Juvenile	A, B, C, F, G, O, R, Z, AA, AC, AF
	Adult	A, B, C, F, G, O, R, Z, AA, AC, AF
Brook trout	Spawning	E, K, L, N, S, T, V, Z, AD, AE, AF, AH
	YOY	E, I, K, L, N, P, S, T, V, Z, AD, AD, AE, AF, AH
	Juvenile	E, H, I, K, L, N, P, Q, T, V, AD, AE, AF, AG, AH
	Adult	A, B, C, F, G, H, J, N, O, P, Q, R, T, V, X, Y, AA, AC, AD, AF, AG, AH
Golden shiner	Spawning	AA, AC, AF
	YOY	AA, AC, AF
	Juvenile	AA, AC, AF
	Adult	AA, AC, AF
Lake chub	Spawning	D, E, K, H, S, T, Z, AA, AD, AE, AF, AH
	YOY	A, B, C, F, G, O, R, Z, AA, AD, AC, AE, AF, AH
	Juvenile	A, B, C, E, F, G, O, R, Z, AA, AD, AC, AE, AF, AH
	Adult	A, B, C, F, G, O, R, Z, AA, AC, AD, AE, AF, AH
White sucker	Spawning	E, K, S, T, Z, AD, AE, AF, AH
	YOY	E, K, S, T, Z, AA, AB, AC, AD, AE, AF, AH
	Juvenile	E, I, K, S, T, Z, AA, AB, AC, AD, AE, AF, AH
	Adult	A, B, C, F, G, O, R, Z, AA, AC, AD, AF, AH
Yellow perch	Spawning	A, B, C, F, G, O, R, Z
	YOY	A, B, C, F, G, O, R, Z
	Juvenile	A, B, C, F, G, O, R, Z
	Adult	A, B, C, F, G, O, R, Z

During field assessments in Spring and Summer 2016, 34 watercourses were mapped and evaluated within the Haul Road. During the supplementary 2019 field evaluations, one new watercourse (WC-AI) and an extension of a previously identified watercourse (WC-O) were delineated along the Haul Road. These watercourses straddle six tertiary watersheds, and many are classified as first order streams, in high positions within the tertiary basins. Others, however, are second, third, and fourth order streams, positioned lower in the tertiary watersheds and broader secondary watersheds, and offer more substantial aquatic and fish habitat.

As noted, the majority of streams delineated along the Haul Road are small, first order tributaries located high in their respective watersheds. These streams can be generally described as falling into one of two categories.

Broadly speaking, the first category consists of low gradient, homogenous streams with low velocity, abundant in-stream vegetation, and soft substrates which provide suitable spawning habitat for generalist spawners, including banded killifish, golden shiner, and yellow perch. These streams also considered to support YOY, juvenile, and adult life stages of these species, and lake chub, as well as juvenile and adult American eel. These streams may also support adult life stages of white sucker and brook trout, but lack the habitat complexity to support earlier life stages of these species.

The second category of streams contain more complex habitat types (i.e. riffles, runs, pools), moderate velocities, and a variety of rocky substrates with limited fines. These streams likely support various life stages of brook trout, white sucker, and early life stages of lake chub which prefer abundant in-stream cover in the form of rocky substrate, undercut banks and woody debris. Some of these streams were also observed to have gravel substrate and shallow riffles and are considered to support brook trout and white sucker spawning.

Higher order streams (2^{nd}-4^{th} order) commonly contain more complex habitat, including both low velocity habitat types (flats, pools, glides), and moderate-high velocity types (runs, riffles, cascades), These streams likely support a more diverse range of species, including habitat generalist and specialists.

Two, higher order watercourses are likely to support habitat for Atlantic salmon: the West River Sheet Harbour (WC-N) and Keef Brook (WC-H). The West River Sheet Harbour is considered to provide suitable habitat for all life stages of Atlantic salmon, with clean gravel and cobble substrate in well aerated areas, to deeper holding pools for adults. Keef Brook is considered to provide suitable habitat for older juveniles, but high velocities, limited water depths, and a lack of gravel substrate limits habitat suitability for spawning, young of year, and adults.

It should be emphasized that the fish habitat characterizations described above are only applicable to the length of watercourse surveyed – the length of each watercourse surveyed was limited by the linear extent of the Haul Road SA.

3.4.3 *Wetlands*

Table 3-14 describes the fish habitat present within each wetland and its associated watercourse in the SA. Wetlands that were determined not to support fish habitat (i.e., no surface water connectivity and/or open water present within the wetland habitat) are not included in this table and are not discussed further in this section. In addition, wetlands with throughflow watercourses were not included if fish habitat was determined to the be confined to the watercourse channel.

Table 3-14. Wetland Fish Habitat within the SA

WL ID	Hydrological Regime	Associated Watercourse/ Waterbody	Fish Habitat Description
Beaver Dam Mine Site			
4	Throughflow	WC2 and WC3	Fish habitat within standing and open water in wetland. Shallow contiguous surface water in wetland may provide shelter and food sources for small forage species. However, no fish were captured in WC3 through electrofishing surveys. No fish collection was conducted in WC2.
8	Bi-directional non-tidal / Throughflow	WC4, WC5, and Crusher Lake	Open water observed in wetland and WC5 throughflow through wetland habitat. Along the southern shore of Crusher Lake. Deeper contiguous surface water may provide rearing, shelter and food for generalist species. Potential spawning habitat for generalist species confirmed in Crusher Lake (banded killifish, brown bullhead, golden shiner) observed along submerged vegetated wetland edge.
10	Lentic – bi-directional - non-tidal	Crusher Lake	Open water and vegetated habitat along lake edge. Deeper contiguous surface water may provide rearing, shelter and food for generalist species. Potential spawning habitat for generalist species confirmed in Crusher Lake (banded killifish, brown bullhead, golden shiner) observed along submerged vegetated wetland edge.
11	Throughflow	WC4	Fish habitat within standing and open water in wetland. Shallow contiguous surface water in wetland may provide shelter and food sources for small forage species confirmed in WC4 (ninespine stickleback, one unconfirmed species).
13	Throughflow	WC4	Currently small beaver dam at watercourse outlet causing localized flooding within the wetland. Shallow contiguous surface water in wetland may provide shelter and food sources for small forage species confirmed in WC4 (ninespine stickleback, one unconfirmed species).
15	Headwater - outflow	WC8	Open water observed in wetland with potential seasonal surface water connections to downstream resources. Shallow contiguous surface water in wetland may provide seasonal shelter and food sources for small forage species. No fish surveys conducted in WC8 as part of 2015 and 2016 field programs.
17	Lentic – bi-directional - non-tidal/throughflow	WC5 and Mud Lake	Open water observed in wetland and unconfined WC5 throughflow. Along the shores of Mud Lake. Inundated wetland habitat with deeper contiguous surface water may provide rearing, shelter and food for generalist species. Potential spawning habitat for generalist species observed along submerged vegetated wetland edge. No fish surveys conducted in Mud Lake as part of 2015 and 2016 field programs.
20	Throughflow	WC3	Open water observed in wetland with intermittent surface water connections to downstream resources. Shallow contiguous surface water in wetland may provide seasonal shelter and food

WL ID	Hydrological Regime	Associated Watercourse/ Waterbody	Fish Habitat Description
			sources for small forage species. However, no fish were captured in WC3 through electrofishing surveys.
29	Headwater - outflow (northern extent) Throughflow (southeastern extent)	WC10 and WC11	Open water and vegetated habitat along lake edge. Deeper contiguous surface water may provide rearing, shelter and food for generalist species. Potential spawning habitat for generalist species also likely along submerged vegetated wetland edge. No fish surveys conducted in system as part of 2015 and 2016 field programs.
44	Throughflow	WC5	Open water observed in wetland with confirmed surface water connections to downstream resources. Currently beaver dam at outlet causing extensive flooding within the wetland. Deeper contiguous surface water may provide rearing, shelter and food for generalist species. Beaver pond may provide shelter and food source for older brook trout. However, no fish captured in WC5 south of Crusher Lake. Brook trout confirmed south of Crusher Lake.
56*	Throughflow	WC12	Fish habitat present where standing water is present – drain system present. Shallow contiguous surface water in wetland may provide seasonal shelter and food sources for small forage species confirmed in wetland (banded killifish, northern redbelly dace). Potential spawning areas also available along inundated wetland edge. Seasonal, high flow access to brook trout possible through WC12.
59*	Throughflow	WC12, WC13, WC14	Open water observed in wetland with confirmed surface water connections to downstream resources. Inundated wetland habitat with deeper contiguous surface water may provide rearing, shelter and food for generalist species, particularly small forage fish. Potential spawning habitat for generalist species within inundated wetland vegetation. No fish species identified through electrofishing surveys but fish visually observed in deeper, open water areas.
61*	Throughflow/bi-directional non-tidal	WC13, WC25, and Cameron Flowage	Open water observed in wetland with confirmed surface water connection to downstream resources. Along the southeastern shore of Cameron Flowage. Deeper contiguous surface water may provide rearing, shelter and food for generalist species confirmed in Cameron Flowage and WC13 (banded killifish, brown bullhead, golden shiner, white sucker, northern redbelly dace, yellow perch). Potential spawning habitat for generalist species confirmed in Cameron Flowage and (brown bullhead, golden shiner, yellow perch) observed along submerged vegetated wetland edge.
62	Bi-directional non-tidal	Cameron Flowage	Open water observed in wetland with confirmed surface water connection to downstream resources. Along the mid-southern shore of Cameron Flowage. Deeper contiguous surface water may provide rearing, shelter and food for generalist species confirmed in Cameron Flowage and (brown bullhead, golden shiner, white sucker, yellow perch). Potential spawning habitat for generalist species confirmed in Cameron Flowage (brown bullhead, golden shiner, yellow perch) observed along submerged vegetated wetland edge.

WL ID	Hydrological Regime	Associated Watercourse/ Waterbody	Fish Habitat Description
Haul Road			
64	Throughflow	A	Open water observed in wetland. Deeper contiguous surface water may provide rearing, shelter and food for generalist species. Potential spawning habitat for generalist species observed within submerged vegetated wetland. No fish surveys conducted as part of 2015 and 2016 field programs.
66	Throughflow	B	Open water observed in wetland. Deeper contiguous surface water may provide rearing, shelter and food for generalist species. Potential spawning habitat for generalist species observed within submerged vegetated wetland (edge). No fish captured in throughflow watercourse (WC-B) through electrofishing efforts.
68	Throughflow	B and C	Shallow open water sections observed within wetland habitat. Shallow contiguous surface water in wetland may provide seasonal shelter and food sources for small forage species. Inundated wetland area falls outside SA. No fish captured in throughflow watercourse (WC-B) through electrofishing efforts.
69	Lentic/Throughflow	D	Fish habitat present in connected open water – riparian wetland. Inundated wetland habitat with deeper contiguous surface water may provide rearing, shelter and food for generalist species. Potential spawning habitat for generalist species observed along submerged vegetated wetland edge. No fish surveys conducted in waterbody or WC-D as part of 2015 and 2016 field programs.
73	Throughflow	n/a (Cope Pond)	Open water observed on west and east side of forestry road. No culvert, west side of road is currently impounded/inaccessible. Inundated wetland habitat on east side of road with deeper contiguous surface water may provide rearing, shelter and food for generalist species. Outlet stream falls outside of SA. No fish surveys conducted as part of 2015 and 2016 field programs.
74	Throughflow	F	Fish habitat potential in open water marsh habitat located east of exiting forestry road only. Inundated wetland habitat with deeper contiguous surface water may provide rearing, shelter and food for generalist species. Potential spawning habitat for generalist species also present within inundated wetland vegetation. No fish surveys conducted as part of 2015 and 2016 field programs.
76	Throughflow	G	Open water observed in wetland. Inundated wetland habitat with deeper contiguous surface water may provide rearing, shelter and food for generalist species. Potential spawning habitat for generalist species observed along submerged vegetated wetland edge. No fish surveys conducted as part of 2015 and 2016 field programs.
146	Headwater - outflow	Z	Open water behind blocked culvert within wetland habitat. Inundated wetland habitat with deeper contiguous surface water may provide rearing, shelter and food for generalist species. Potential spawning habitat for generalist species

WL ID	Hydrological Regime	Associated Watercourse/ Waterbody	Fish Habitat Description
			observed within submerged vegetated wetland. No fish surveys conducted as part of 2015 and 2016 field programs.
157	Lentic	Upper Kidney Lake/Big Pond	Fish habitat limited to inundated wetland immediately adjacent to Upper Kidney Lake located south of the forestry road, and Big Pond located north of the forestry road. No throughflow hydrological connection identified in wetland connecting the northern and southern lobes – no culvert. No fish surveys conducted as part of 2015 and 2016 field programs.
159	Throughflow	AA	Inundation caused by beaver activity has extended potential fish habitat throughout wetland. Inundated wetland habitat with deeper contiguous surface water may provide rearing, shelter and food for species confirmed within WC-AA (banded killifish, golden shiner, lake chub, and white sucker). Potential spawning habitat for generalist species observed along submerged vegetated wetland edge (golden shiner, banded killifish).
160	Throughflow	AA	Open water observed in wetland. Inundated wetland habitat with deeper contiguous surface water may provide rearing, shelter and food for species confirmed within WC-AA (banded killifish, golden shiner, lake chub, and white sucker). Potential spawning habitat for generalist species observed within submerged vegetated wetland (golden shiner, banded killifish).
168	Lentic/Throughflow	n/a (Johns Pond)	Culvert at forestry road collects ditch drainage and directs it north through wetland, surface water disappears underground. Channel forms towards Johns Pond, outside/north of SA. Fish habitat restricted to channel and inundated wetland immediately adjacent to Johns Pond. No fish surveys conducted as part of 2015 and 2016 field programs.

* Wetlands reassessed through detailed fish habitat assessments during 2019-2020 field program (see MEL, 2020 for updated results).

Fourteen wetlands are considered to provide potential fish habitat within the Beaver Dam Mine Site. Along the Haul Road, twelve wetlands have been determined to provide potential fish habitat. The Haul Road is linear by nature, so limited evaluation of each watercourse and associated wetland was completed. As a result, fish habitat conclusions especially within this area of the SA should be considered preliminary, as downstream connectivity was not confirmed. Open deep-water marsh habitat was documented in Wetlands 64, 74, 76, 146 (blocked culvert backing water up), 159 (beaver impoundment), and 160.

In addition to providing fish habitat within their associated watercourse and waterbodies, wetland habitat accessible to fish within the SA may generally provide suitable habitat for generalist species that prefer slack water, highly vegetated areas and soft, organic substrates for all or some life stages (i.e. American eel, golden shiner, ninespine stickleback, northern redbelly dace, yellow perch, brown bullhead, white sucker). Wetland habitat is generally considered to provide rearing, refuge, and food sources for these species.

Wetlands with associated fish habitat in open water features anticipated to be directly impacted by Project development within the Beaver Dam Mine Site (Wetlands 56, 59 and 61) were re-evaluated during Summer 2020 through detailed habitat assessments and additional fish surveys. The results of these most recent surveys (discussed in MEL, 2020) supersede those presented in Table 3-14.

4.0 SUMMARY OF BASELINE CONDITIONS

This Baseline Fish and Fish Habitat Technical Report was prepared as background information for the Environmental Impact Statement (EIS) for the Beaver Dam Mine Project. The purpose of this report was to describe existing baseline conditions of fish and fish habitat within the Beaver Dam Mine Site and Haul Road components of the Project through the reporting of baseline fish and fish habitat studies conducted in 2015, 2016, and 2019.

The SA was defined as an area of land encompassing aquatic features within the Beaver Dam Mine Site and along the Haul Road, including all field delineated linear watercourses, wetlands, and three waterbodies (Crusher Lake, Mud Lake, and Cameron Flowage). A comprehensive fish and fish habitat field program was conducted from 2019-2020, the results of which are presented in a separate and updated technical report (MEL, 2020).

This Technical Report presented the results of field studies conducted from 2015-2017 and published literature. It is anticipated that this information will support the registering of a combined federal EIS with IAAC and the provincial EARD by understanding the potential project interactions with fish and fish habitat, and to facilitate regulatory approvals for impacts to fish and fish habitat wherever necessary.

Electrofishing and trapping surveys confirmed the presence of fish species in the SA that would be expected within the West River Sheet Harbour and Tangier River watersheds, including American eel, banded killifish, brook trout, brown bullhead, golden shiner, lake chub, ninespine stickleback, northern redbelly dace, white sucker, and yellow perch. Atlantic salmon were not captured during these surveys but are known to inhabit the West River Sheet Harbour and its tributaries. A total of 145 individuals were captured, with American eel, brook trout, and banded killifish were the most frequently captured species within linear watercourses, while yellow perch, banded killifish, and golden shiner were most abundant in waterbodies (Cameron Flowage and Crusher Lake). Fish habitat characterizations were conducted for each linear watercourse and wetland within the SA confirmed or assumed to provide fish and fish habitat.

Overall, the aquatic ecosystem within the SA is characterized by moderately acidic conditions. Benthic macroinvertebrate abundance and taxa richness were low to moderate, but the presence of pollution-intolerant species at most sites suggests that DO and water quality is acceptable, as these groups (EPT) generally are associated with aquatic habitat having good water quality.

Low pH levels, elevated temperatures, and low DO concentrations may limit fish habitat quality within select systems, particularly within small, sluggish first order streams and shallow open water features that experience with low water depths during the summer months.

Fish habitat has been assumed present within all 35 linear watercourses and associated wetlands with surface water features along the Haul Road, as downstream connectivity was not confirmed. Of the 29 linear watercourses assessed within and downgradient of the Beaver Dam Mine Site for fish and fish habitat throughout baseline field studies, 9 have been designated as non-fisheries resources. Watercourses

10, 15, 16, 18, 19, 20, 21, 22, and 24 do not provide fish habitat and are considered inaccessible to fish. Twenty-seven (27) wetlands within the SA are accessible to fish.

5.0 CERTIFICATE

This document has been prepared by Environmental Scientist Amber Stoffer (MREM) and reviewed by the undersigned. If you have any questions or require any more information, please feel free to contact me.

Thank you,

<Original signed by>

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Senior Ecologist
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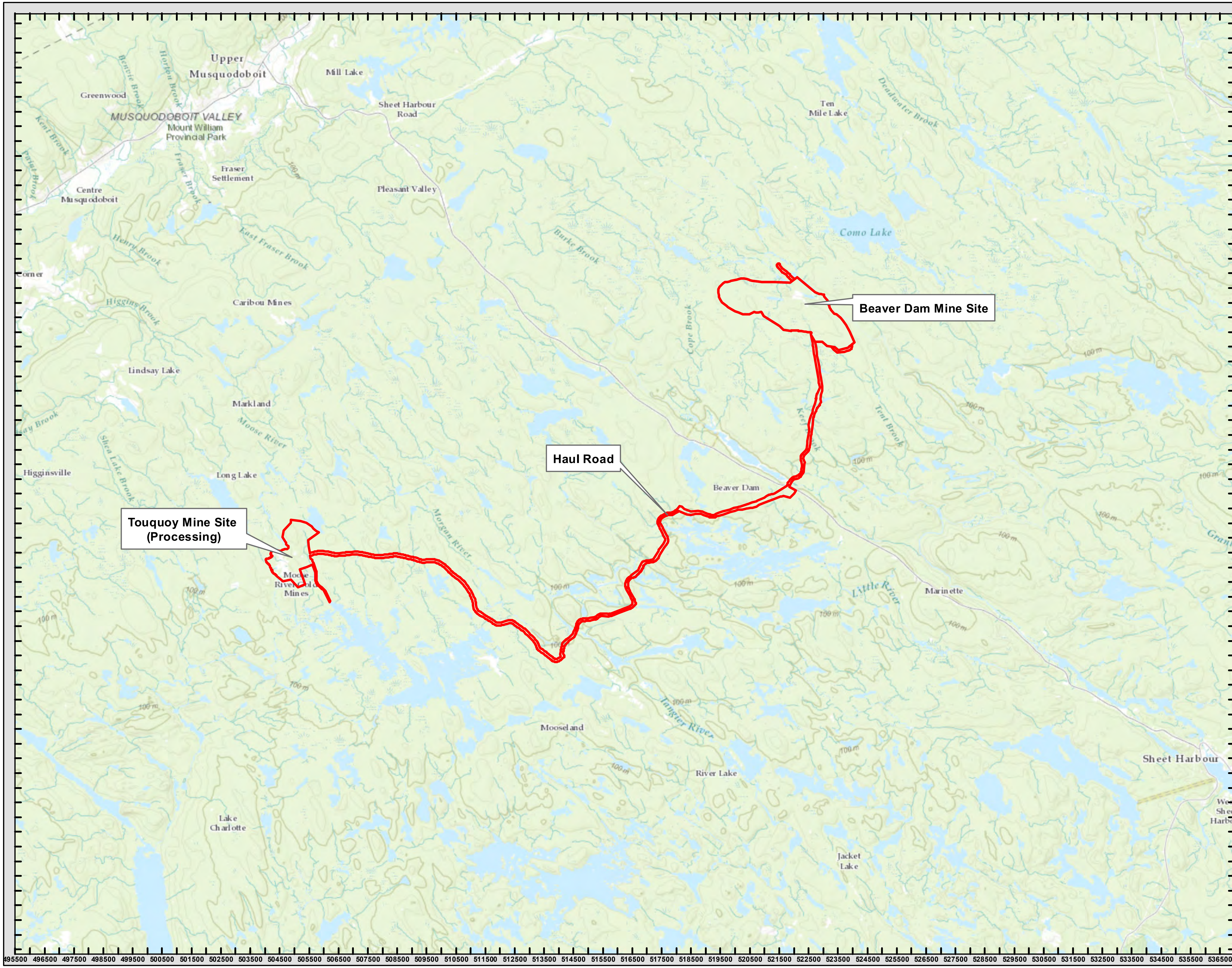
APPENDIX A. FIGURES



Prepared For:

Atlantic Gold

FIGURE 1

Project Location
Beaver Dam Mine Site

Marinette, NS

Project Area

Truro
NOVA SCOTIA
NOUVELLE-ÉCOSSE

Coordinate System: NAD 1983 CSRS UTM Zone 20N
Projection: Transverse Mercator
Datum: North American 1983 CSRS
Units: Meter

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1:120,000 Scale when printed @ 11" x 17"

Drawn By: AS

Date: 2021-01-08

McCallum Environmental Ltd.

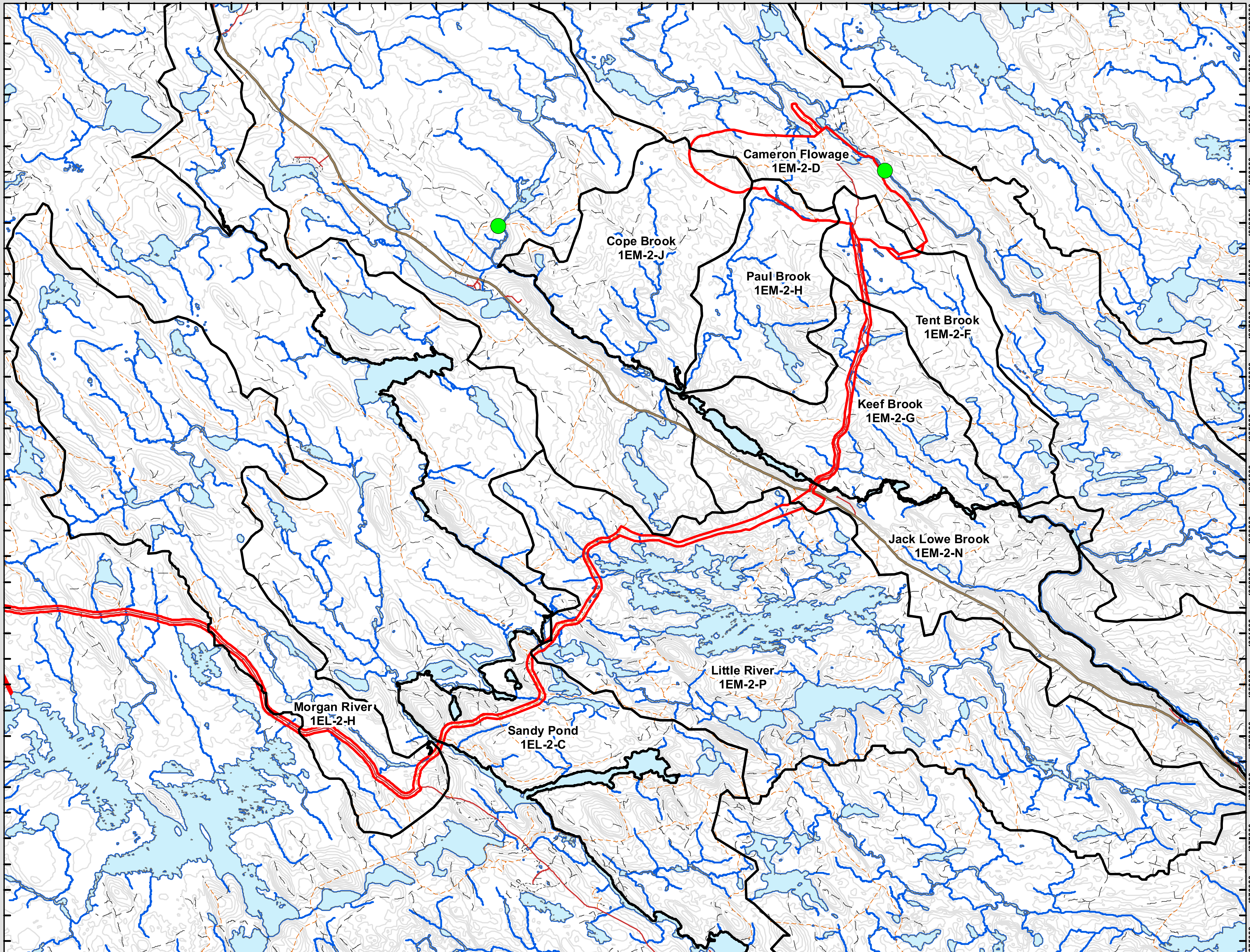

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FIGURE 2

Tertiary Watersheds
Beaver Dam Mine Site

Marinette, NS

Lime Doser
NSTDB Mapped Watercourses
Tertiary Watershed Boundaries
Study Area

Coordinate System: NAD 1983 CSRS UTM Zone 20N
Projection: Transverse Mercator
Datum: North American 1983 CSRS
Units: Meter

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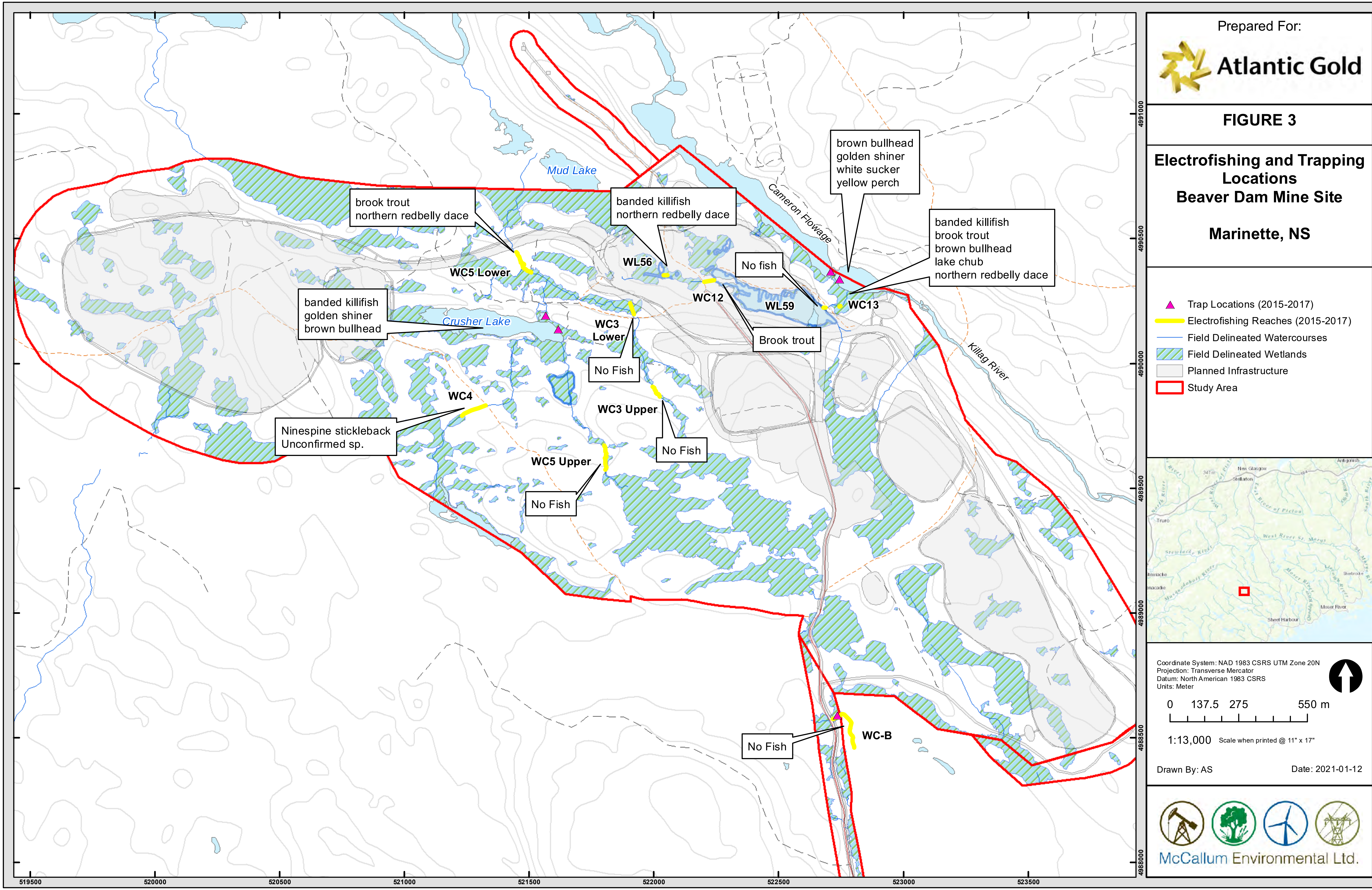
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FIGURE 3
Electrofishing and Trapping Locations
Beaver Dam Mine Site
Marinette, NS
Trap Locations (2015-2017)
Electrofishing Reaches (2015-2017)
Field Delineated Watercourses
Field Delineated Wetlands
Planned Infrastructure
Study Area
Mud Lake
Crusher Lake
Cameron Flowage
Killag River
brook trout
northern redbelly dace
WC5 Lower
banded killifish
northern redbelly dace
WL56
WC12
No fish
WL59
Brook trout
brown bullhead
golden shiner
white sucker
yellow perch
banded killifish
brook trout
brown bullhead
lake chub
northern redbelly dace
WC13
banded killifish
golden shiner
brown bullhead
WC3
Lower
No Fish
WC4
Ninespine stickleback
Unconfirmed sp.
WC3 Upper
No Fish
WC5 Upper
No Fish
WC-B
No Fish
519500
520000
520500
521000
521500
522000
522500
523000
523500
4991000
4990500
4990000
4989500
4989000
4988500
4988000
Coordinate System: NAD 1983 CSRS UTM Zone 20N
Projection: Transverse Mercator
Datum: North American 1983 CSRS
Units: Meter
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1:13,000 Scale when printed @ 11" x 17"
Drawn By: AS
Date: 2021-01-12
McCallum Environmental Ltd.

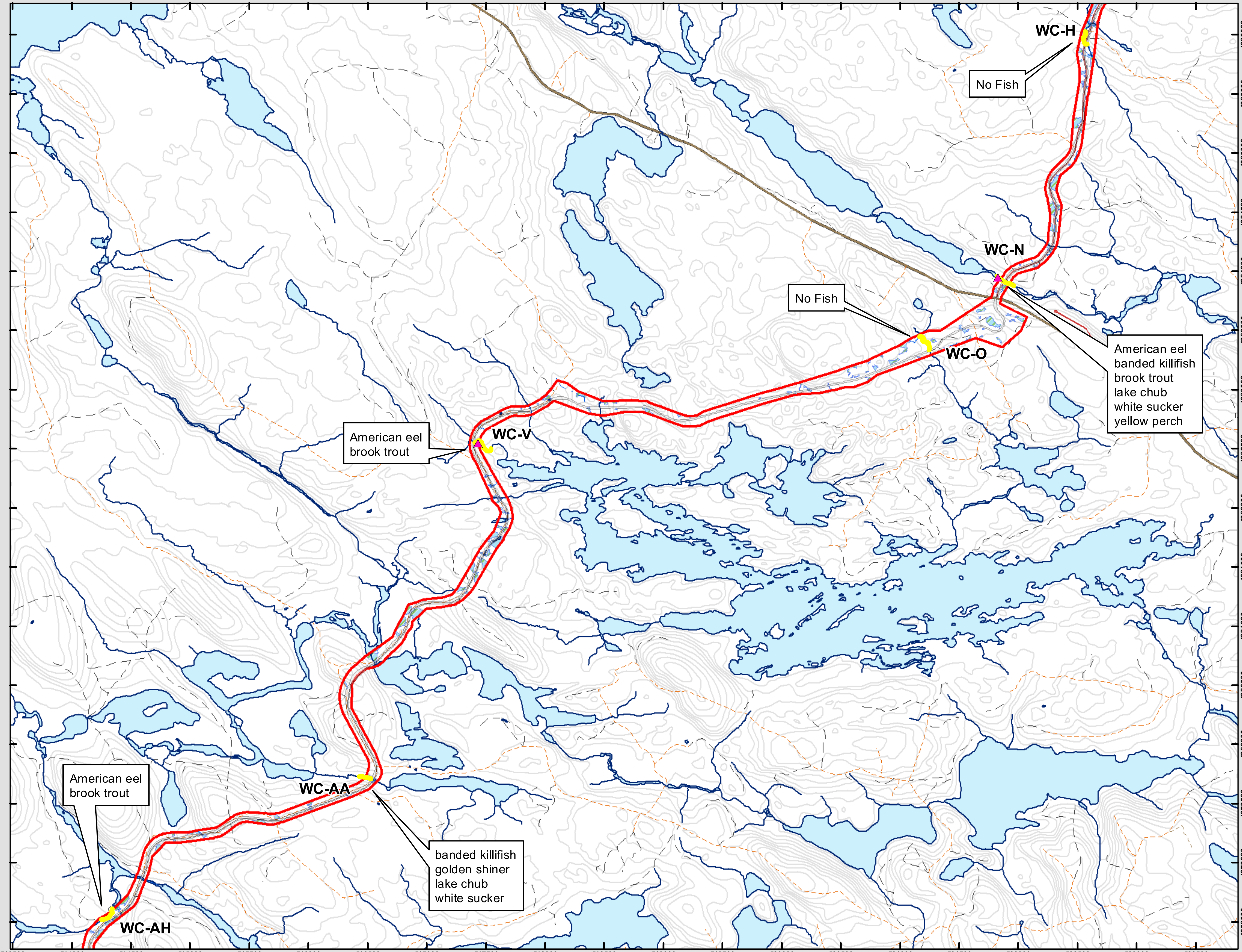

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FIGURE 4

Electrofishing and Trapping Locations
Haul Road

Marinette, NS

- Trap Locations (2015-2017)
- Electrofishing Reaches (2015-2017)
- NSTDB Watercourses
- Field Delineated Watercourses
- Field Delineated Wetlands
- Study Area

Coordinate System: NAD 1983 CSRS UTM Zone 20N
Projection: Transverse Mercator
Datum: North American 1983 CSRS
Units: Meter

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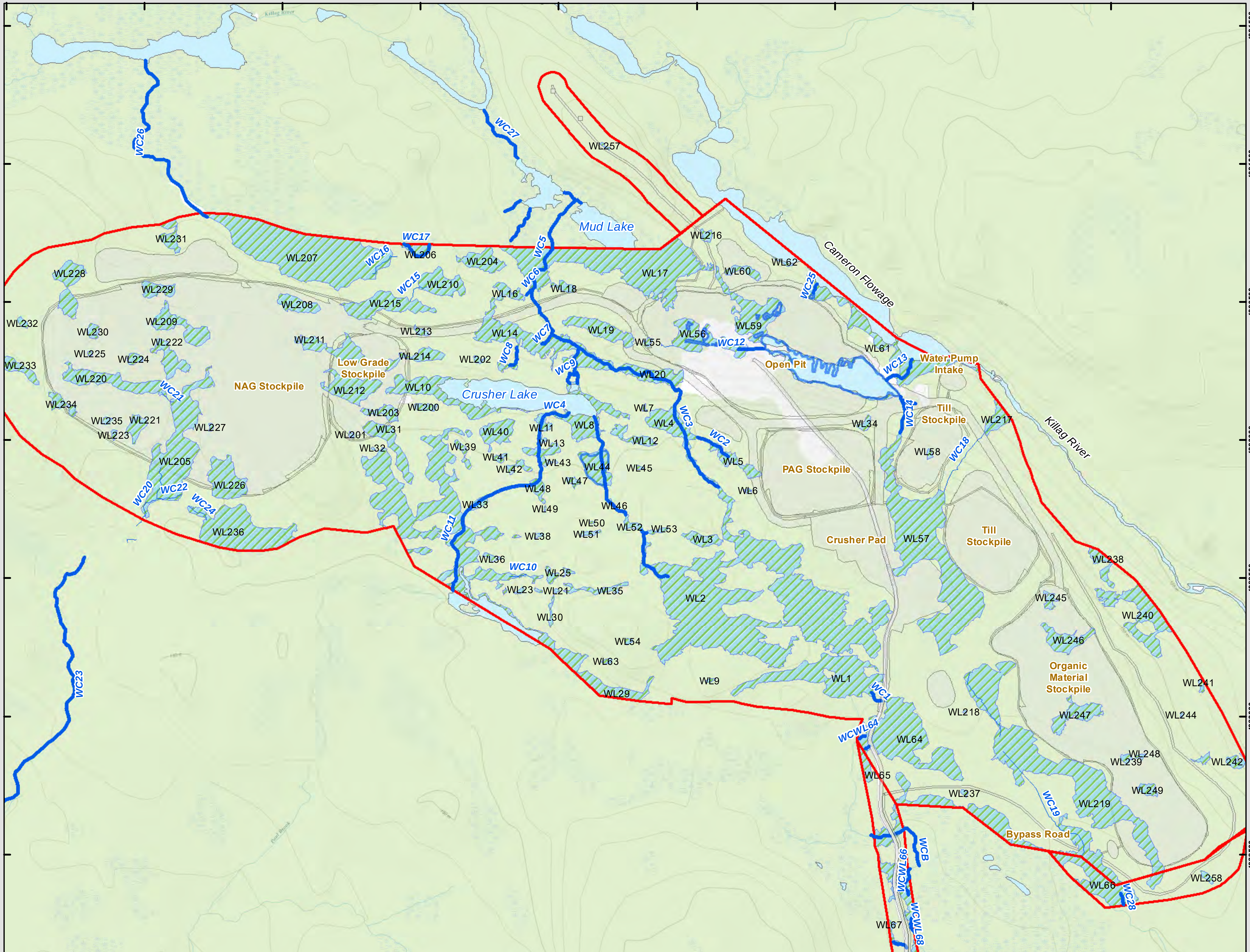

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FIGURE 5

Wetlands and Watercourses Beaver Dam Mine Site

Marinette, NS

- Known or Assumed Fisheries Resources
- Field Delineated Watercourses
- Field Delineated Wetlands
- Planned Infrastructure
- Study Area

Coordinate System: NAD 1983 CSRS UTM Zone 20N
Projection: Transverse Mercator
Datum: North American 1983 CSRS
Units: Meter

0 137.5 275 550 m

1:13,000 Scale when printed @ 11" x 17"

Drawn By: AS

Date: 2021-01-12

McCallum Environmental Ltd.

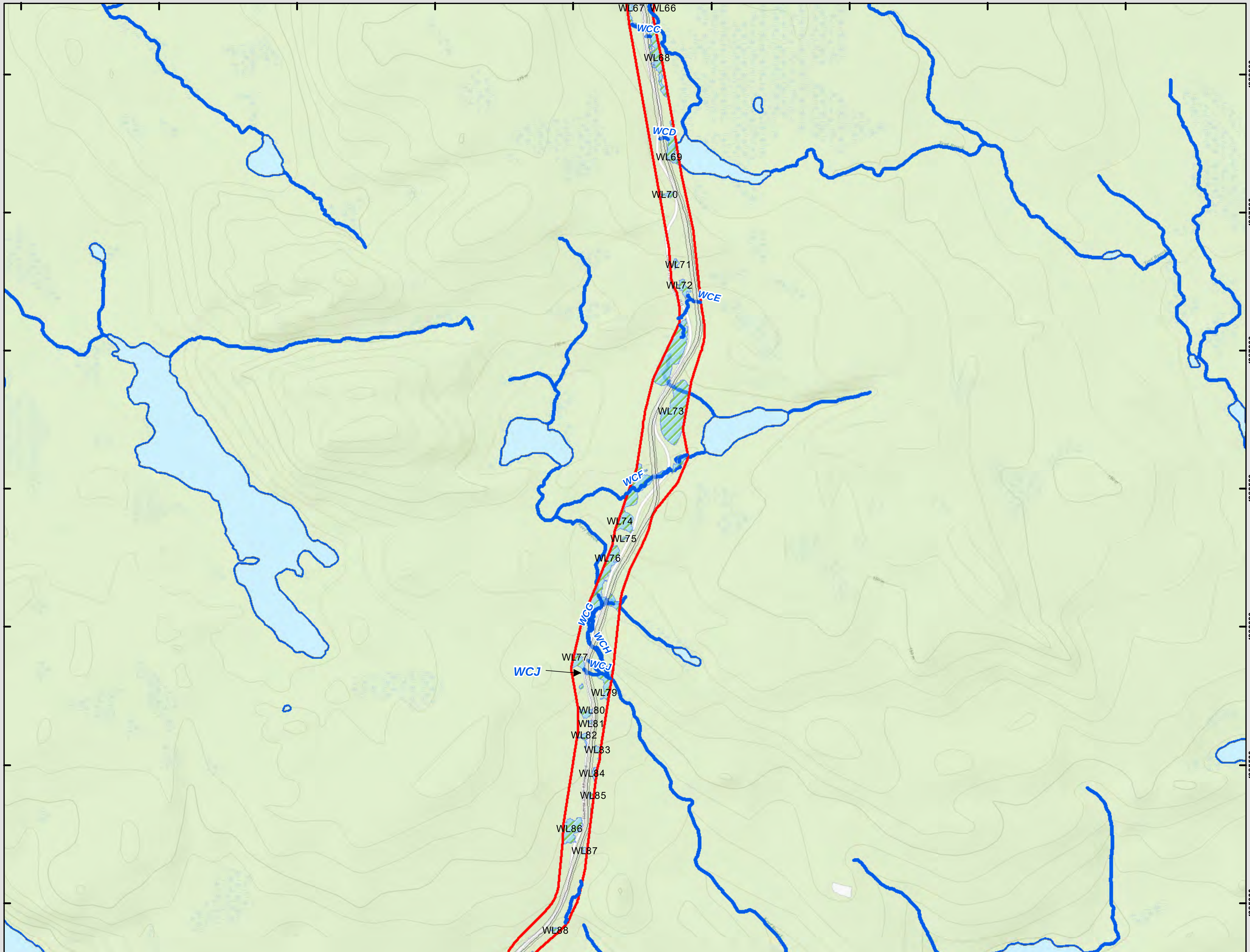

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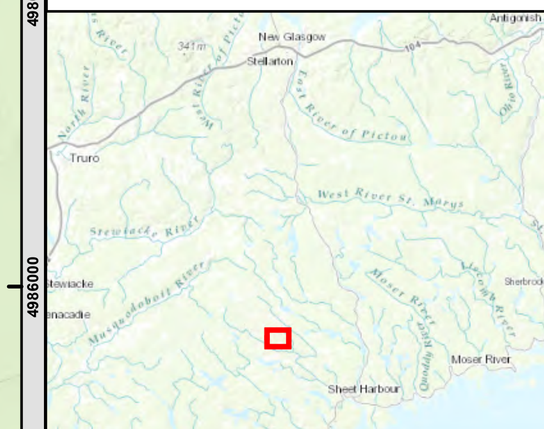
FIGURE 6

Wetlands and Watercourses Haul Road - Part 1

Marinette, NS

- Known or Assumed Fisheries Resources
- Field Delineated Watercourses
- Field Delineated Wetlands
- Study Area



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Projection: Transverse Mercator
Datum: North American 1983 CSRS
Units: Meter

0 137.5 275 550 m

1:13,000 Scale when printed @ 11" x 17"

Drawn By: AS

Date: 2021-01-08

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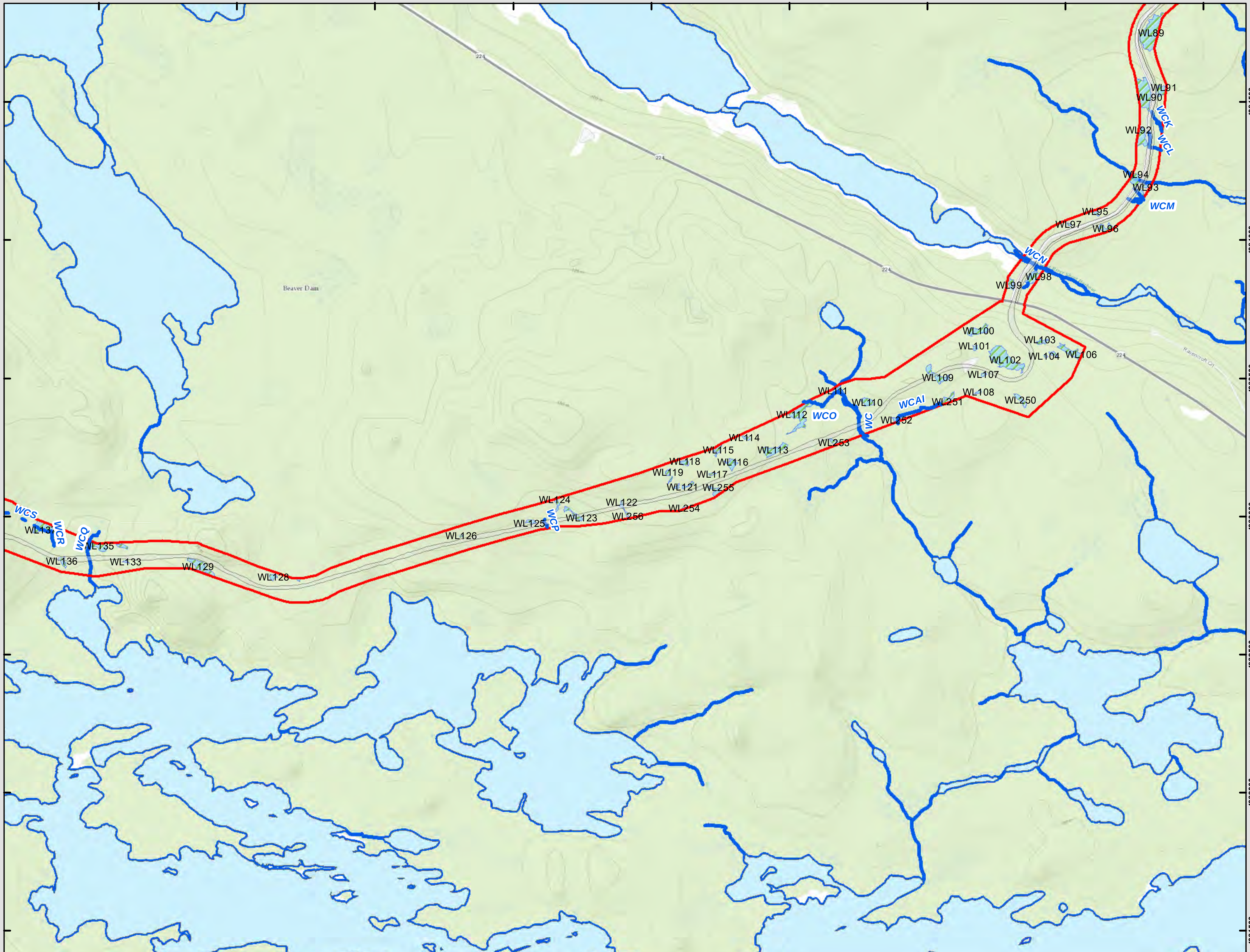
FIGURE 7

Wetlands and Watercourses Haul Road - Part 2

Marinette, NS



Known or Assumed Fisheries Resources

Field Delineated Watercourses

Field Delineated Wetlands

Study Area

Coordinate System: NAD 1983 CSRS UTM Zone 20N
Projection: Transverse Mercator
Datum: North American 1983 CSRS
Units: Meter

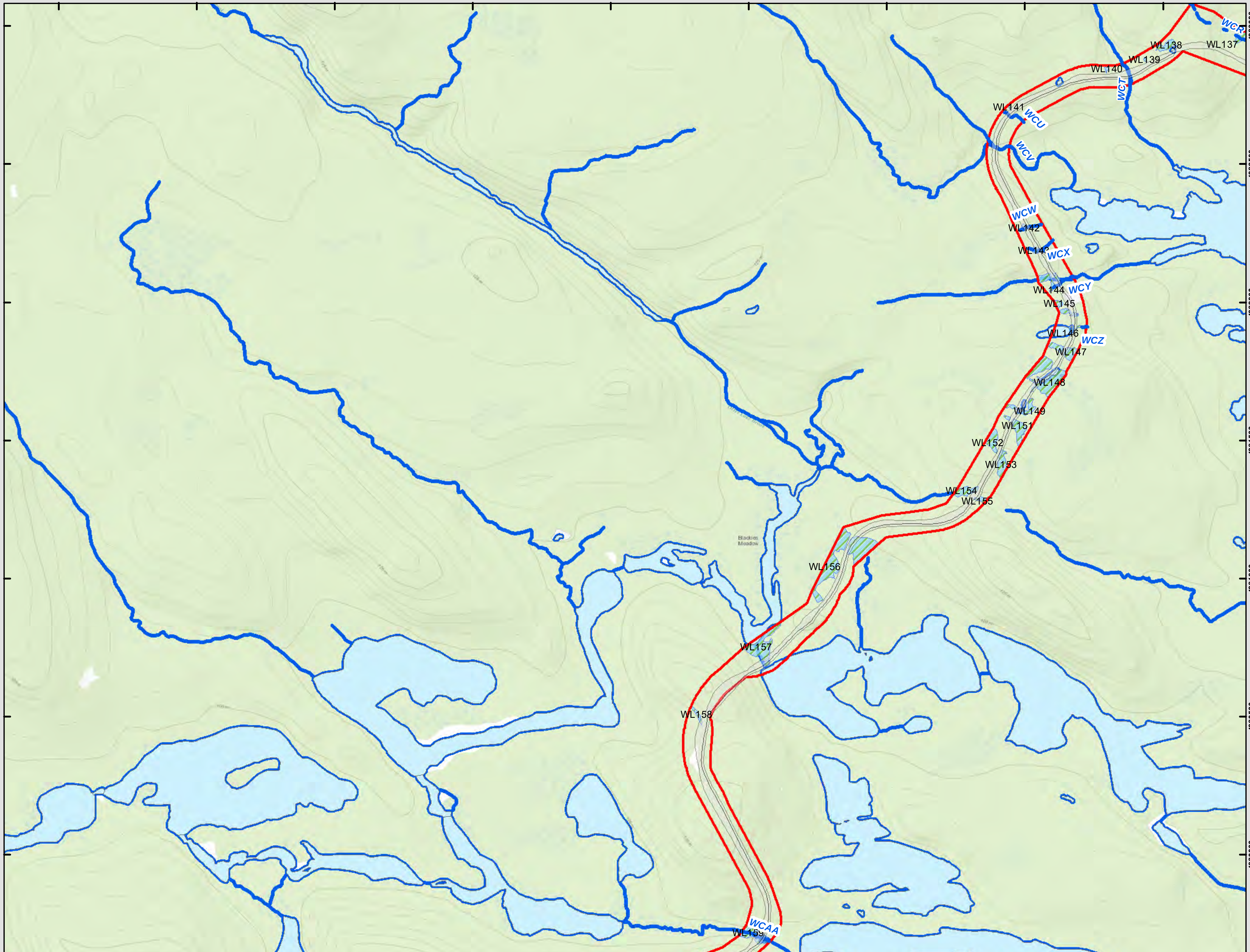
0 137.5 275 550 m

1:13,000 Scale when printed @ 11" x 17"

Drawn By: AS

Date: 2021-01-08

McCallum Environmental Ltd.



Prepared For:

Atlantic Gold

FIGURE 8

Wetlands and Watercourses Haul Road - Part 3

Marinette, NS

Known or Assumed Fisheries Resources

Field Delineated Watercourses

Field Delineated Wetlands

Study Area

Coordinate System: NAD 1983 CSRS UTM Zone 20N
Projection: Transverse Mercator
Datum: North American 1983 CSRS
Units: Meter

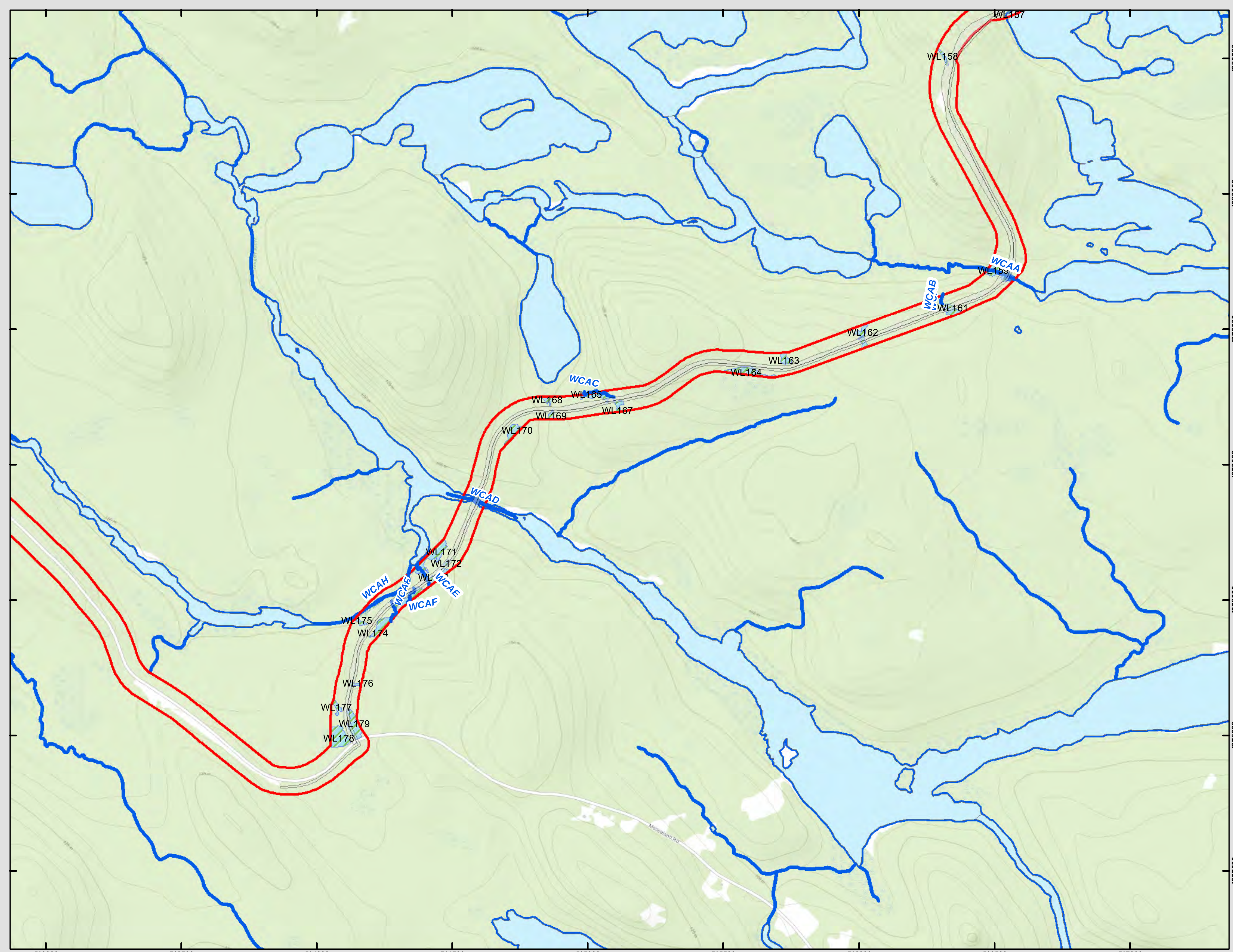
0 137.5 275 550 m

1:13,000 Scale when printed @ 11" x 17"

Drawn By: AS

Date: 2021-01-08

McCallum Environmental Ltd.



Prepared For:

Atlantic Gold

FIGURE 9

Wetlands and Watercourses Haul Road - Part 4

Marinette, NS

- Known or Assumed Fisheries Resources
- Field Delineated Watercourses
- Field Delineated Wetlands
- Study Area

Coordinate System: NAD 1983 CSRS UTM Zone 20N
Projection: Transverse Mercator
Datum: North American 1983 CSRS
Units: Meter

0 137.5 275 550 m

1:13,000 Scale when printed @ 11" x 17"

Drawn By: AS

Date: 2021-01-08

McCallum Environmental Ltd.

APPENDIX B. PHOTOGRAPH LOG


Photo 1: WC4 electrofishing reach.


Photo 2: WC5 (top-near WL2) electrofishing reach.


Photo 3: WC5 (lower-near WL14) electrofishing reach.


Photo 4: WC3 (lower- near WL 20) electrofishing reach.


Photo 5: WC12 electrofishing reach.


Photo 6: WC13 electrofishing reach.


Photo 7: WL56 electrofishing reach.


Photo 8: WL59 electrofishing reach.

Photo 9: WC-B electrofishing reach and trapping location.

Photo 10: WC-H electrofishing reach.

Photo 11: WC-N electrofishing reach and trapping location.

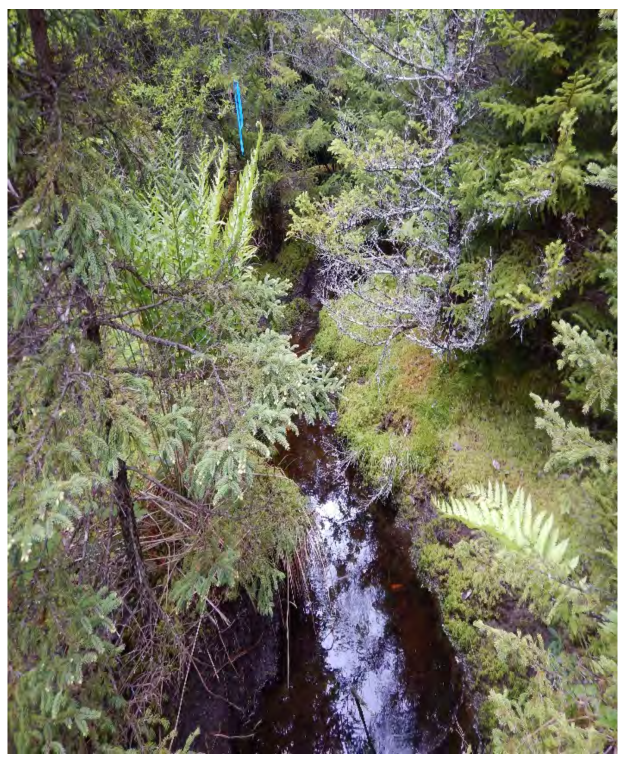


Photo 12: WC-O electrofishing reach.


Photo 13: WC-V electrofishing reach and trapping location.


Photo 14: WC-AA electrofishing reach.


Photo 15: WC-AH electrofishing reach.

Photo 16: Crusher Lake trapping location.

Photo 17: Cameron Flowage trapping location.

Photo 18: American Eel.

Photo 19: Banded Killifish.

Photo 20: Brook Trout.

Photo 21: Brown Bullhead.

Photo 22: Golden Shiner.

Photo 23: Lake Chub.

Photo 24: Ninespine Stickleback.

Photo 25: Northern Redbelly Dace.

Photo 26: White Sucker.

Photo 27: Yellow Perch.

APPENDIX C. INDIVIDUAL FISH DATA

Survey Date	Site	Capture Method	Species	Fork Length (cm)	Total Length (cm)
September 17, 2015	WC-4	Electrofishing	Ninespine stickleback	-	4.0
September 17, 2015	WC-4	Electrofishing	Ninespine stickleback	-	5.0
September 17, 2015	WC-4	Electrofishing	Ninespine stickleback	-	3.0
September 17, 2015	WC-4	Electrofishing	Ninespine stickleback	-	3.0
September 17, 2015	WC-4	Electrofishing	Ninespine stickleback	-	3.0
September 17, 2015	WC-4	Electrofishing	Ninespine stickleback	-	3.0
September 17, 2015	WC-4	Electrofishing	Ninespine stickleback	-	3.0
September 17, 2015	WC-4	Electrofishing	Ninespine stickleback	-	2.5
September 17, 2015	WC-4	Electrofishing	Ninespine stickleback	-	2.5
September 17, 2015	WC-4	Electrofishing	Ninespine stickleback	-	2.5
September 17, 2015	WC-4	Electrofishing	Ninespine stickleback	-	2.5
September 17, 2015	WC-4	Electrofishing	Unconfirmed Fish Species	-	3.3
September 17, 2015	WC-5 (lower)	Electrofishing	Brook trout	13.0	15.0
September 17, 2015	WC-5 (lower)	Electrofishing	Northern redbelly dace	6.0	8.0
September 17, 2015	WC-5 (lower)	Electrofishing	Northern redbelly dace	6.0	8.0
September 17, 2015	WC-5 (lower)	Electrofishing	Northern redbelly dace	4.8	6.0
September 18, 2015	WC-12	Electrofishing	Brook trout	6.0	7.0
September 18, 2015	WC-12	Electrofishing	Brook trout	6.0	7.0
September 18, 2015	WC-12	Electrofishing	Brook trout	4.8	6.0
September 18, 2015	WL56	Electrofishing	Banded killifish	3.0	4.0
September 18, 2015	WL56	Electrofishing	Northern redbelly dace	3.0	4.0
September 18, 2020	WC-13	Electrofishing	Brook trout	14.0	17.0
September 18, 2020	WC-13	Electrofishing	Brook trout	10.0	12.0
September 18, 2020	WC-13	Electrofishing	Brook trout	4.0	5.0
September 18, 2020	WC-13	Electrofishing	Northern redbelly dace	5.0	6.0

Survey Date	Site	Capture Method	Species	Fork Length (cm)	Total Length (cm)
September 18, 2020	WC-13	Electrofishing	Banded killifish	6.5	7.5
September 18, 2020	WC-13	Electrofishing	Northern redbelly dace	5.0	6.0
September 18, 2020	WC-13	Electrofishing	Brook trout	5.0	6.0
September 18, 2020	WC-13	Electrofishing	Banded killifish	5.0	6.0
September 18, 2020	WC-13	Electrofishing	Banded killifish	8.0	9.0
September 18, 2020	WC-13	Electrofishing	Brook trout	4.2	5.0
September 18, 2020	WC-13	Electrofishing	Banded killifish	6.0	7.0
September 18, 2020	WC-13	Electrofishing	Banded killifish	6.0	7.0
September 18, 2020	WC-13	Electrofishing	Banded killifish	5.0	6.0
September 18, 2020	WC-13	Electrofishing	Lake chub	4.0	4.5
September 18, 2020	WC-13	Electrofishing	Banded killifish	6.0	7.0
September 18, 2020	WC-13	Electrofishing	Banded killifish	6.0	7.0
September 18, 2020	WC-13	Electrofishing	Banded killifish	5.2	6.0
September 18, 2020	WC-13	Electrofishing	Brook trout	5.0	6.0
September 18, 2020	WC-13	Electrofishing	Brown bullhead	5.0	6.0
September 18, 2020	WC-13	Electrofishing	Northern redbelly dace	4.0	5.0
September 18, 2020	WC-13	Electrofishing	Northern redbelly dace	4.0	5.0
September 18, 2020	WC-13	Electrofishing	Northern redbelly dace	4.5	5.5
September 18, 2020	WC-13	Electrofishing	Banded killifish	3.5	4.0
June 22, 2016	Haul Road N	Electrofishing	Yellow perch	8.0	8.5
June 22, 2016	Haul Road N	Electrofishing	White sucker	17.0	18.0
June 22, 2016	Haul Road N	Electrofishing	Banded killifish	7.25	7.5
June 22, 2016	Haul Road N	Electrofishing	Lake chub	8.5	9.0
June 22, 2016	Haul Road N	Electrofishing	American eel	-	21.0
June 22, 2016	Haul Road N	Electrofishing	American eel	-	18.0

Survey Date	Site	Capture Method	Species	Fork Length (cm)	Total Length (cm)
June 22, 2016	Haul Road N	Electrofishing	American eel	-	12.0
June 22, 2016	Haul Road N	Electrofishing	American eel	-	29.0
June 22, 2016	Haul Road N	Electrofishing	American eel	-	15.0
June 22, 2016	Haul Road N	Electrofishing	American eel	-	31.0
June 22, 2016	Haul Road N	Electrofishing	American eel	-	27.0
June 22, 2016	Haul Road N	Electrofishing	American eel	-	30.0
June 22, 2016	Haul Road N	Electrofishing	American eel	-	25.0
June 22, 2016	Haul Road N	Electrofishing	American eel	-	20.0
June 22, 2016	Haul Road N	Electrofishing	American eel	-	10.0
June 22, 2016	Haul Road N	Electrofishing	American eel	-	11.0
June 22, 2016	Haul Road N	Electrofishing	American eel	-	15.0
June 22, 2016	Haul Road N	Electrofishing	American eel	-	19.0
June 22, 2016	Haul Road N	Electrofishing	American eel	-	35.0
June 22, 2016	Haul Road N	Electrofishing	White sucker	24.0	25.0
June 22, 2016	Haul Road N	Electrofishing	Banded killifish	7.0	7.5
June 22, 2016	Haul Road N	Electrofishing	White sucker	17.0	18.0
June 22, 2016	Haul Road N	Electrofishing	Brook trout	6.5	7.0
June 22, 2016	Haul Road N	Electrofishing	American eel	-	45.0
June 22, 2016	Haul Road N	Electrofishing	Lake chub	7.5	8.0
June 22, 2016	Haul Road N	Electrofishing	American eel	-	30.0
June 22, 2016	Haul Road N	Electrofishing	American eel	-	27.0
June 22, 2016	Haul Road N	Electrofishing	American eel	-	45.0
June 22, 2016	Haul Road N	Electrofishing	American eel	-	20.0
June 22, 2016	Haul Road N	Electrofishing	American eel	-	19.0
June 23, 2016	Haul Road V	Electrofishing	American eel	-	20.0

Survey Date	Site	Capture Method	Species	Fork Length (cm)	Total Length (cm)
June 23, 2016	Haul Road V	Electrofishing	Brook trout	10.0	10.5
June 23, 2016	Haul Road V	Electrofishing	Brook trout	6.0	6.25
June 23, 2016	Haul Road V	Electrofishing	Brook trout	14.5	15.0
June 23, 2016	Haul Road V	Electrofishing	Brook trout	19.5	20.0
June 23, 2016	Haul Road V	Electrofishing	Brook trout	5.25	5.0
June 23, 2016	Haul Road V	Electrofishing	American eel	-	31.0
June 23, 2016	Haul Road V	Minnow trap	Brook trout	6.75	7.0
June 23, 2016	Haul Road AA	Electrofishing	Banded killifish	-	8.0
June 23, 2016	Haul Road AA	Electrofishing	Golden shiner	7.0	8.0
June 23, 2016	Haul Road AA	Electrofishing	Lake chub	8.5	9.0
June 23, 2016	Haul Road AA	Electrofishing	White sucker	9.5	10.0
June 23, 2016	Haul Road AA	Electrofishing	White sucker	9.5	10.5
June 23, 2016	Haul Road AA	Electrofishing	Banded killifish	-	7.25
June 23, 2016	Haul Road AA	Electrofishing	Banded killifish	-	7.0
June 23, 2016	Haul Road AA	Electrofishing	Banded killifish	-	8.0
June 23, 2016	Haul Road AA	Electrofishing	Golden shiner	9.5	9.5
June 23, 2016	Haul Road AH	Electrofishing	Brook trout	19.0	20.0
June 23, 2016	Haul Road AH	Electrofishing	American eel	-	23.0
June 23, 2016	Haul Road AH	Electrofishing	American eel	-	35.0
June 23, 2016	Haul Road AH	Electrofishing	American eel	-	29.0
June 23, 2016	Haul Road AH	Electrofishing	American eel	-	14.0
June 23, 2016	Haul Road AH	Electrofishing	American eel	-	31.0
June 23, 2016	Haul Road AH	Electrofishing	American eel	-	17.0
June 23, 2016	Haul Road AH	Electrofishing	American eel	-	22.0
June 23, 2016	Haul Road AH	Electrofishing	American eel	-	10.0

Survey Date	Site	Capture Method	Species	Fork Length (cm)	Total Length (cm)
June 23, 2016	Haul Road AH	Electrofishing	American eel	-	17.0
June 23, 2016	Haul Road AH	Electrofishing	American eel	-	24.0
June 23, 2016	Haul Road AH	Electrofishing	American eel	-	32.0
June 23, 2016	Haul Road AH	Electrofishing	American eel	-	36.0
June 23, 2016	Haul Road AH	Electrofishing	American eel	-	20.0
June 24, 2016	Cameron Flowage A	Eel pot	Yellow perch	12.3	13.5
June 24, 2016	Cameron Flowage A	Eel pot	Yellow perch	10.2	12.0
June 24, 2016	Cameron Flowage A	Eel pot	Yellow perch	7.3	8.9
June 24, 2016	Cameron Flowage A	Eel pot	Yellow perch	8.7	10.2
June 24, 2016	Cameron Flowage A	Eel pot	Golden shiner	8.4	9.5
June 24, 2016	Cameron Flowage A	Eel pot	Yellow perch	10.2	11.9
June 24, 2016	Cameron Flowage A	Fyke net	Yellow perch	11.1	11.9
June 24, 2016	Cameron Flowage A	Fyke net	Yellow perch	12.1	12.9
June 24, 2016	Cameron Flowage A	Fyke net	White sucker	13.9	15.7
June 24, 2016	Cameron Flowage A	Minnow trap	Golden shiner	9.2	10.1
June 24, 2016	Cameron Flowage A	Minnow trap	Golden shiner	9.4	10.1
June 24, 2016	Cameron Flowage A	Minnow trap	Golden shiner	9.4	10.1
June 24, 2016	Cameron Flowage A	Minnow trap	Golden shiner	7.9	8.8
June 24, 2016	Cameron Flowage A	Minnow trap	Brown bullhead	-	10.0
June 24, 2016	Cameron Flowage A	Minnow trap	Brown bullhead	-	9.6
June 24, 2016	Cameron Flowage B	Eel pot	Yellow perch	11.2	11.7
June 24, 2016	Cameron Flowage B	Eel pot	Yellow perch	9.5	10.1
June 24, 2016	Cameron Flowage B	Eel pot	Yellow perch	7.8	9.1
June 24, 2016	Cameron Flowage B	Fyke net	Yellow perch	11.4	12.0
June 24, 2016	Cameron Flowage B	Minnow trap	Yellow perch	8.7	9.1

Survey Date	Site	Capture Method	Species	Fork Length (cm)	Total Length (cm)
June 24, 2016	Cameron Flowage B	Minnow trap	Yellow perch	9.6	9.9
June 24, 2016	Cameron Flowage B	Minnow trap	Yellow perch	8.5	9.0
June 24, 2016	Cameron Flowage B	Minnow trap	Yellow perch	8.9	9.3
June 24, 2016	Cameron Flowage B	Minnow trap	Yellow perch	12.5	12.9
June 24, 2016	Cameron Flowage B	Minnow trap	Yellow perch	8.4	9.1
June 24, 2016	Cameron Flowage B	Minnow trap	Yellow perch	7.2	7.6
June 24, 2016	Cameron Flowage B	Minnow trap	White sucker	13.0	13.4
June 27, 2016	Crusher Lake A	Eel pot	Banded killifish	-	8.9
June 27, 2016	Crusher Lake A	Eel pot	Banded killifish	-	8.5
June 27, 2016	Crusher Lake A	Eel pot	Banded killifish	-	7.4
June 27, 2016	Crusher Lake A	Eel pot	Banded killifish	-	8.8
June 27, 2016	Crusher Lake A	Eel pot	Banded killifish	-	8.4
June 27, 2016	Crusher Lake A	Eel pot	Banded killifish	-	8.7
June 27, 2016	Crusher Lake A	Eel pot	Golden shiner	7.9	8.5
June 27, 2016	Crusher Lake A	Eel pot	Golden shiner	8.0	8.4
June 27, 2016	Crusher Lake B	Eel pot	Golden shiner	8.5	9.0
June 27, 2016	Crusher Lake B	Eel pot	Brown bullhead	-	12.5
June 27, 2016	Crusher Lake B	Fyke net	Brown bullhead	-	11.5
June 27, 2016	Crusher Lake B	Fyke net	Brown bullhead	-	16.0
June 27, 2016	Crusher Lake B	Fyke net	Golden shiner	-	- (predated)
June 27, 2016	Crusher Lake B	Minnow trap	Golden shiner	7.3	8.0

APPENDIX D: BENTHIC INVERTEBRATE COMMUNITY DATA

Table 1. Sediment Characteristics at each Benthic Sampling Location (collected June 22-24, 2016)

Sample	Sediment Description
Beaver Dam Mine Site Footprint PA	
Watercourse 4	Abundant fines (mud) with organics (woody, plant and other organic debris) and occasional animal casings.
Watercourse 5	Fines and medium to fine sand with organics (woody, plant and other organic debris) and occasional animal casings.
Watercourse 13	Sand with organics (woody, plant and other organic debris) and occasional mollusk shells and animal casings.
Haul Road PA	
Watercourse B.a	Silt to fine sand with detritus, plant and woody debris and animal casings.
Watercourse B.b	Silt with minor amounts fine to medium sand, as well as, organics (woody, plant and other organic debris) and large amounts of animal casings.
Watercourse B.c	Silt with minor amounts fine sand, as well as, organics (woody, plant and other organic debris) and large amounts of animal casings.
Watercourse B.d	Silt with minor amounts fine to medium sand, as well as organics (woody, plant and other organic debris) and large amounts of animal casings.
Watercourse H (Keef Brook)	Abundant amounts of organics (plant, woody and other organic debris) with occasional silt and sand, as well as animal casings.
Watercourse N	Coarse sand to silt with organics (plant, woody and other organic debris).
Watercourse V	Medium to coarse sand with occasional fines and organics (plant, woody and other organic debris), as well as animal casings.

Watercourse AA	Medium to coarse sand and organics (plant, woody and other organic debris), as well as animal casings.
Watercourse AH	Medium to coarse sand and organics (plant, woody and other organic debris), as well as occasional animal casings.
Watercourse O.a	Medium to coarse sand and organics (plant, woody and other organic debris), as well as occasional animal casings. Sample material had a noticeable film coating it, before washing.
Watercourse O.b	Medium to coarse sand and organics (plant, woody and other organic debris). Sample material had a noticeable film coating it, before washing.
Grain size classes: cobble = 6.4 cm and larger; pebble/gravel = 4 mm to 6.4 cm; sand = 0.063 mm to 2 mm; silt = 0.004 mm to 0.063 mm; clay = <0.004 mm.	

Table 2. Total Abundance of Organisms (Part 1)

Location	**Watercourse**						
	4	**5**	**13**	**B.a**	**B.b**	**B.c**	**B.d**
Abundance	#	#	#	#	#	#	#
Diptera							
Certapogonidae-Probezzia/Bezzia sp	0	0	2	6	10	7	2
Chironomidae larvae	114	809	361	133	165	213	136
Chironomidae pupae	2	13	13	5	7	5	3
Diptera adult	0	1	0	1	0	1	0
Diptera larvae	0	2	0	0	0	0	1
Empididae larvae	0	0	0	0	0	0	0
Simuliidae larvae	1	6	5	1	0	0	0

Location	Watercourse						
	4	5	13	B.a	B.b	B.c	B.d
Abundance	#	#	#	#	#	#	#
Simuliidae pupae	0	3	0	0	1	0	0
Tipulidae larvae	0	0	0	0	1	0	0
Coleoptera							
Dytiscidae adult	2	0	0	0	0	0	0
Dysticidae larvae-Ilybius? sp	0	1	0	0	0	0	0
Dytiscidae larvae-Hydroporus/Hygrotus sp	1	0	0	0	0	0	0
Elimidae adult	1	0	0	0	0	0	0
Elmidae larvae-Stenelmis sp	0	8	9	0	0	0	0
Hydrophilidae adult	0	1	0	0	0	0	0
Ephemeroptera							
Ephemerellidae-Eurylophella sp	0	1	0	0	0	0	0
Ephemerellidae	0	0	1	0	0	0	0
Ephemeroptera-sp A	0	0	16	0	0	0	0
Ephemeroptera-sp B	0	0	4	0	0	0	0
Ephemeroptera-unidentified	0	1	12	5	1	3	2
Heptogeniidae	0	0	0	5	0	0	1
Leptophlebiidae-Paraleptophlebia? sp	0	0	1	0	0	0	0

Location	Watercourse						
	4	**5**	**13**	**B.a**	**B.b**	**B.c**	**B.d**
Abundance	#	#	#	#	#	#	#
Plecoptera							
Leuctridae-Leuctra sp	0	11	0	0	0	0	0
Perlodidae	0	0	0	1	0	0	0
Plecoptera-unidentified	0	8	0	0	0	0	0
Plecoptera-pupae	0	0	0	2	0	0	0
Trichoptera							
Hydropsychidae-Diplectrona sp	0	1	0	0	0	0	0
Hydropsychidae-Hydropsyche sp	0	1	1	0	0	0	0
Hydroptilidae-Oxytheria sp	0	0	0	1	0	1	1
Leptoceridae-Oecetis? sp	0	0	1	0	0	0	0
Limnephilidae Grammotaulius	1	0	0	0	0	0	0
Limnephilidae	0	0	0	0	0	0	1
Philopotamidae-Chimarra sp	1	1	1	0	0	0	0
Polycentropodidae	0	1	0	0	0	0	0
Polycentropodidae-Polycentropus	0	2	0	0	0	0	0
Trichoptera-unidentified	0	9	0	1	0	0	0
Odonata							
Aeshnidae-Aesha	0	1	3	0	0	0	0

Location	Watercourse						
	4	**5**	**13**	**B.a**	**B.b**	**B.c**	**B.d**
Abundance	**#**	**#**	**#**	**#**	**#**	**#**	**#**
Calopterygidae-Calopteryx	0	1	6	0	0	0	0
Coenagrionidae-Argia	0	0	1	0	0	0	0
Cordulegastridae-Cordulegaster	0	0	3	1	1	0	0
Odonata-unidentified	0	0	0	0	0	0	3
Megaloptera							
Corydalidae-Chauliodes sp	0	0	0	1	0	0	0
Corydalidae-Nigronia sp	0	6	1	0	0	0	0
Sialidae-Sialis sp	1	0	0	0	6	4	4
Collembola							
Collembola	0	0	0	1	0	1	0
Hemiptera							
Corixidae	0	0	0	2	0	0	2
Gerridae	1	1	0	3	0	1	1
Hemiptera-unidentified	0	1	0	6	0	0	0
Notonectidae	0	0	0	3	0	0	0
Pleidae-Neoplea	0	0	0	1	0	0	0
Vellidae-Rhagorelia	0	0	2	0	0	0	0
Vellidae-sp. A	0	1	0	0	0	0	0

Location	Watercourse						
	4	5	13	B.a	B.b	B.c	B.d
Abundance	#	#	#	#	#	#	#
Vellidae-sp. B	0	1	0	0	0	0	0
Hirudinea							
Helobdella stagnalis	0	0	1	0	0	0	0
Hydrachnidia							
Hydrachnidia sp. A	0	0	1	0	0	0	0
Hydrachnidia sp. B	0	0	1	0	0	0	0
Hydrachnidia sp. C	0	1	0	0	0	0	0
Hydrachnidia sp. D	0	0	0	0	1	0	0
Hydrachnidia sp. E	0	0	0	0	0	0	0
Hydrachnidia sp. F	0	0	0	0	0	0	0
Hydrachnidia sp. G	0	0	0	0	0	0	0
Oligochaeta							
Oligochaete	16	4	13	1	0	0	1
Nematoda							
Nematoda	0	0	0	1	1	0	0
Mollusca							
Hydrobiidae-Amnicola limosa?	0	0	23	0	0	0	0
Lymnaeidae-Fossaria? sp	0	0	1	0	0	0	0

Location	Watercourse						
	4	**5**	**13**	**B.a**	**B.b**	**B.c**	**B.d**
Abundance	**#**	**#**	**#**	**#**	**#**	**#**	**#**
Sphaeriidae	30	2	211	0	0	0	0
Crustacea							
Amphipoda-Hyalella azteca	0	0	9	0	0	0	0
Cladocera	0	0	0	24	14	16	22
Copepoda	8	48	0	0	2	0	1
Thysanoptera							
Thysanoptera-Thrip	0	0	0	0	0	0	0
Other							
Ant - terrestrial	0	0	0	0	0	1	0
Arachnida - terrestrial	0	0	0	2	0	0	1
Casts	2	5	31	56	10	20	6
A question mark (?) after a name indicates a lack of key features to further identify organisms.							

Table 3. Total Abundance of Organisms (Part 2)

Location	**Watercourse**						
	H	**N**	**V**	**AA**	**AH**	**O.a**	**O.b**
Abundance	**#**	**#**	**#**	**#**	**#**	**#**	**#**
Diptera							
Certapogonidae-*Probezzia/Bezzia* sp	1	0	0	8	0	0	0

Location	Watercourse						
	H	N	V	AA	AH	O.a	O.b
Abundance	#	#	#	#	#	#	#
Chironomidae larvae	198	60	41	494	69	88	154
Chironomidae pupae	10	1	3	16	6	7	26
Diptera adult	1	1	4	0	3	0	0
Diptera larvae	0	1	0	0	0	0	0
Empididae larvae	1	1	0	0	1	0	0
Simuliidae larvae	13	3	148	28	9	0	2
Simuliidae pupae	1	1	7	10	0	0	0
Tipulidae larvae	0	1	0	0	0	0	0
Coleoptera							
Dytiscidae adult	1	0	1	0	0	1	2
Dysticidae larvae-*Ilybius*? sp	0	0	4	0	0	0	6
Dytiscidae larvae-*Potamonectes*? sp	0	0	0	2	0	0	2
Gyrinidae? adult	0	0	1	0	0	0	0
Elmidae larvae-*Promoresia* sp	0	3	9	6	13	0	0
Elmidae larvae-*Stenelmis* sp	0	0	0	2	0	0	0
Elmidae larvae-unidentified	0	1	0	0	0	0	0
Ephemeroptera							
Baetidae	0	2	0	0	0	0	0
Ephemerellidae-*Eurylophella* sp	0	1	0	0	10	0	0
Ephemerellidae	1	0	0	6	0	0	0
Ephemeroptera-unidentified	0	1	0	8	0	10	18
Heptogeniidae	2	1	0	10	0	0	0
Heptogeniidae-*Stenonema* sp	0	0	0	0	8	0	0

Location	Watercourse						
	H	N	V	AA	AH	O.a	O.b
Abundance	#	#	#	#	#	#	#
Plecoptera							
Leuctridae	0	0	3	4	0	6	20
Nemouridae	3	0	16	0	0	0	0
Perlodidae	2	1	0	0	0	0	0
Plecoptera-unidentified	1	0	17	0	3	9	54
Plecoptera-pupae	0	0	1	0	0	2	0
Trichoptera							
Brachycentridae-*Brachycentrus*? sp	0	2	0	0	0	0	0
Brachycentridae-*Micrasema*? sp	0	0	0	4	6	0	0
Hydropsychidae-*Hydropsyche* sp	1	1	0	0	0	0	0
Hydropsychidae	0	4	0	0	0	0	0
Hydroptilidae-*Hydroptila* sp	0	10	0	0	4	0	0
Hydroptilidae-*Oxytheria* sp	0	0	0	0	0	15	86
Hydroptilidae-*Palaeaganetes* sp	0	0	0	0	0	3	2
Hydroptilidae	0	0	0	6	0	0	0
Leptoceridae-*Ceraclea* sp	0	1	0	0	0	0	0
Leptoceridae-*Oecetis*? sp	0	1	0	2	9	1	0
Leptostomatidae-*Lepidostoma* sp	2	0	7	2	5	1	10
Limnephilidae *Grammotaulius*? sp	0	0	1	0	0	0	0
Limnephilidae-sp A	0	0	0	0	0	9	8
Philopotamidae-*Chimarra* sp	0	0	0	18	3	0	0
Polycentropodidae-*Polycentropus* sp	0	0	0	0	0	2	6
Phrygeneidae?	0	0	0	0	0	1	2

Location	Watercourse						
	H	N	V	AA	AH	O.a	O.b
Abundance	#	#	#	#	#	#	#
Rhyacophilidae?	0	0	0	2	1	0	0
Trichoptera pupae	2	4	0	2	0	0	0
Odonata							
Aeshnidae-*Aesha* sp	0	0	0	0	0	0	2
Calopterygidae-*Calopteryx* sp	2	0	0	0	0	0	0
Coenagrionidae-*Argia* sp	0	0	0	0	1	0	0
Corduliidae	0	0	0	2	0	0	0
Megaloptera							
Corydalidae-*Nigronia* sp	0	0	0	2	0	0	0
Sialidae-*Sialis* sp	0	0	0	0	0	0	2
Collembola							
Collembola	16	0	11	4	0	1	2
Hemiptera							
Aphidae	0	0	0	2	0	0	0
Corixidae	0	0	0	8	0	0	0
Gerridae	9	0	1	8	0	0	0
Mesoveliidae	0	0	0	62	50	0	0
Hirudinea							
Hirundea sp A	0	0	0	2	0	0	0
Hydrachnidia							
Hydrachnidia sp. A	0	0	0	0	0	0	0
Hydrachnidia sp. B	0	0	0	0	0	0	0
Hydrachnidia sp. C	0	0	2	0	0	5	6

Location	Watercourse						
	H	**N**	**V**	**AA**	**AH**	**O.a**	**O.b**
Abundance	**#**	**#**	**#**	**#**	**#**	**#**	**#**
Hydrachnidia sp. D	0	0	0	0	0	0	0
Hydrachnidia sp. E	0	0	1	0	0	0	0
Hydrachnidia sp. F	0	0	1	0	0	0	0
Hydrachnidia sp. G	1	0	0	0	0	0	0
Oligochaeta							
Oligochaete	1	0	0	4	2	0	0
Nematoda							
Nematoda	0	0	0	0	0	0	0
Mollusca							
Sphaeriidae-*Sphaerium* sp	0	8	0	0	0	0	0
Sphaeriidae	0	0	0	6	0	0	0
Crustacea							
Cladocera	0	0	0	22	0	0	0
Copepoda	0	0	0	10	0	1	0
Thysanoptera							
Thysanoptera-Thrip	0	0	0	0	0	1	0
Other							
Arachnida - terrestrial	1	0	0	0	0	0	0
Casts	22	0	10	6	0	2	0
A question mark (?) after a name indicates a lack of key features to further identify organisms.							