Atlantic Gold

Appendix J.3

draft Fish Habitat Offset Plan – May 2021
Completed for the Updated 2021 Beaver Dam Mine EIS

Draft Fish Habitat Offset Plan

Beaver Dam Project
Project # ONS2002

Prepared for:

Atlantic Mining NS Inc.
409 Billybell Way, Mooseland, Middle Musquodoboit, Nova Scotia, Canada B0N 1X0

May 2021
Rev 3

Draft Fish Habitat Offset Plan

Beaver Dam Mine Project
Atlantic Mining Nova Scotia Inc.

Project # ONS2002

Prepared for:

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Executive Summary

Atlantic Mining NS Inc. (AMNS) is proposing the construction, operation, decommissioning, and reclamation of an open pit gold mine in Marinette, Nova Scotia. The Beaver Dam Mine Project (the Project) would have an ore production rate of approximately 2MT per year, over a five-year period. Ore from the Project would be crushed and transported approximately 31 km by road to the Moose River (Touquoy) mine for processing. While mitigation measures are being developed to minimize Project effects, the location of the ore body and the required infrastructure is likely to cause the Harmful Alteration, Disruption, or Destruction (HADD) of fish habitat (directly and indirectly). Any HADD of fish habitat will require authorization under Section 35 of the *Fisheries Act*.

As part of the early project planning and site assessment efforts, multiple site layouts were considered for both project efficiencies and the avoidance of impacts to fish frequented waters. Although components such as the open pit are fixed due to the orebody, other project footprints such as stockpiles, effluent discharge, and road networks have some flexibility in their location. To this end, the Project team reviewed multiple locations and site plans for these features, before selecting the proposed arrangement. Extensive field investigations have not identified fish presence within the footprint of the Proposed Waste Rock Storage Area (WRSA) and ECCC has confirmed that there are no current triggers for Schedule 2 of the MDMER.

This document has been prepared to provide descriptions of existing aquatic habitat within and near the Project that can potentially be altered, disrupted or destructed by the Project and to outline preliminary offset measures proposed to compensate for any Harmful Alteration Disruption or Destruction (HADD) of fish habitat determination. The intent is to demonstrate that mitigation and avoidance measures have been considered to minimize the overall impact on fish and fish habitat and that fish habitat offsetting designs are being developed for the Project that can meet the requirements of the *Fisheries Act*. The document provides Fisheries and Oceans Canada (DFO) with information to determine the direct habitat losses as well as any possible serious alterations (as defined in the *Fisheries Act*) due to indirect effects. The habitat alterations and preliminary offsetting options described will serve as the basis for ongoing consultation with DFO, Indigenous Groups and stakeholders and to ultimately support an application for authorization of HADD of fish habitat as required by the *Fisheries Act*.

It is worth noting that the highest species utilization was by species that prefer the somewhat disturbed, fine sediment, slower and warmer habitats observed at the Project site. While most preliminary offsets are focussed on providing similar habitat to those affected by the Project; some offset options are included that are focussed on nearby Southern Upland salmonid populations. This species has high social, recreational, and economic importance. As a result, a portion of the offset designs are outside the Project watershed and focussed on habitat more utilized and suitable for salmonids including the Musquodoboit River.

Although the final offset measures and locations need to be further developed in discussion with DFO, AMNS agrees to carry out at its own cost and expense and to the satisfaction of DFO, a Fish Offset Plan. Measures will be located in Nova Scotia and will be designed to enhance fish habitat and to rehabilitate/enhance habitat for Atlantic salmon (*Salmo salar*) and other fish species in other rivers such as the Musquodoboit River.

Habitat Affected / Altered

Regardless of the fish species found to utilize the individual waterbodies, habitats directly and indirectly affected by the Project have been quantified by aerial extent as square metres (m^2) and are provided to DFO for determination of HADD to fish habitat.

Efforts have been made to minimize residual effects on fish and fish habitat and to avoid impact wherever possible. While direct losses of fish habitat as a result of the Project will require offset, the extent of offsetting required for indirect altered habitat will be determined by DFO, recognizing that while alterations will occur, not all habitats will be completely lost and its use/suitability will also not be completely lost. Also note, while the overall change in water temperature within Cameron Flowage is not predicted to increase more than 0.5°C over baseline because of the shift from baseflow input to surface water input from the North Settling Pond, if groundwater upwelling(s) are confirmed, a portion of the west shoreline would be altered and therefore a portion of the estimated total area of Cameron Flowage may be included in the fish habitat altered. The values in the table acknowledge the possible extent of habitat alteration to date but does not confirm that it is considered harmful. **Table** A provides a summary fish habitat quantity that may be lost or altered by the project to date; as well as mitigation measures expected to reduce overall residual habitat losses.

It is understood that Table A provides the maximum potential areas of alteration, and that the final HADD determination will be made by DFO taking into account that in many cases the habitat indirectly impacted may not be harmfully altered.

Preliminary Offset Options

Offsetting alternatives provided have been developed consistent with DFO's guidance Policy for Applying Measures to Offset Adverse Effects on Fish and Fish Habitat Under the *Fisheries Act*; however, preferred offsetting options will be further refined based on discussions with DFO and stakeholders during the detailed offset planning process. It is also possible that alternative approaches not listed could be integrated into any Final Authorization Application (via an updated offsetting Plan) if required and available. Offset plans should enable DFO and others to assess the alternatives for feasibility and acceptability. Several options have been considered feasible by the Project team at this stage and, based on habitat needs of target fish species and experience on similar offset designs, have a high degree of successful implementation.

Options considered and ranked included the **rehabilitation / restoration of degraded aquatic habitats** caused by channelization of small tributary streams and draining of former wetland areas. Restoration methods are well-known and can be very successful if used in the proper location. Locations along the Musquodoboit River have been identified through consultations with local landowners and agreements to rehabilitate these areas are underway. Additional options in other rivers are also being pursued and could be available as discussions continue, including those indirectly affected by the Project. These would include physical habitat enhancement works.

Complementary Measures to **improve existing fisheries knowledge** in areas of interest to Indigenous communities could provide information for future habitat rehabilitation options, additional habitat utilization, and/or species distributions / movement patterns in Nova Scotia, particularly in areas near the Project. The exact format of complementary measures would depend on consultations between AMNS representatives and local Indigenous communities. While complementary measures are typically limited to a maximum of 10% of the offset plan, this option can provide additional avenues for alternative offset options. This alternative was ranked as fourth highest, behind specific, targeted habitat rehabilitation/enhancements, due to its flexibility and ability to align with specific interests of stakeholders.

Table A: Summary of Potential Habitat Alterations and Mitigations for Beaver Dam Project

Habitat Measure	Project Area	Habitat Type	Habitat Units (m^2)	Habitat / Condition Description
Habitat that may be Altered, Disrupted or Destructed	Infrastructure Footprint Direct Habitat Descruction	Mine Site Streams	652.80	Riffle, pool, rapid, and run habitats dominated by intermittent reaches, heavy vegetation, and high summer water temperatures and low dissolved oxygen levels.
		Mine Site Open Water	38,790.64	Waterbodies dominated by muck/detritus substrates, most formerly disturbed by historic mining activities.
		Haul Road Stream	184.50	Small streams
		Haul Road Open Water	2,245.80	Small open water within wetlands
	Indirect Downstream Potential Alteration	Mine Site Streams	7,728.88	Pool and run habitat with varying substrates and cover. Water quality ranging from low to suitable. Some high water in summer and low pH but overall better condition than those in direct footprint.
		Open Water	-	n/a
Total			**49,602.62**	
Mitigation	Regained Habitat Connectivity	Stream	-	17 locations along haul road have unpassable culverts. Replacment will mitigate habitat fragmentation but has not been quantified.
	Groundwater Upwelling Station	Stream	3,300	If groundwater upwelling location idenfied in Cameron Flowage, groundwater pump or modification to the North Pond outflow will be installed. **Note:** This is not considered offseting.
Total			**3,300**	

Engagement

Engagement is a key component of AMNS's approach to the planning and implementation of its projects and other business activities. Several engagement initiatives have been undertaken in relation to the Project, with further engagement in progress or being planned. This includes discussions with relevant government departments and agencies, Indigenous communities and stakeholder organizations.

The Environmental Impact Statement documents describe previous and ongoing engagement initiatives related to the Project with Indigenous groups and the public. To continue open communications on the Project, AMNS is committed to meeting with and/or providing information to stakeholders at the appropriate time to discuss any offsetting plans.

Summary

Efforts have been made to minimize residual effects of the Project on fish and fish habitat and to avoid HADD wherever possible, however; portions of Project infrastructure will result in the HADD of existing fish habitat that is currently utilized by resident fish species. It is understood that the final HADD determination will be made by DFO; however, this preliminary quantification is provided to show that the offset concepts described can be designed to meet HADD quantity expectations. Table B provides a summary of the proposed preliminary offsets.

Table B: Summary of Habitat Offset Options for Beaver Dam Project

Habitat Measure	Project Area	Habitat Type	Habitat Units (m²)	Description
Offsets	Pond Creation	Pond similar the Mine Site Open Water Habitat	**123,000 - 164,000**	Small ponds (3-4) of 41,000 m^2 in size within a rehabilitated wetland complex.
	Tributary Stream Rehabilitation	Small stream habitat similar to the Mine Site Streams	**1,500 - 2,000**	Small streams (3-4) of 500 m^2 in size within or near a rehabilitated wetland complex.
	Musquodoboit River Main Stem	Enhanced Riverine Spawning and Rearing Habitat	**1,000 – 2,000**	Sections of main stem with increased spawning/rearing habitat suitable for salmonids including Atlantic Salmon and Brook Trout.
	Tributary Stream Rehabilitation	Small onsite stream habitat	**800 – 1,000**	Small streams (WC-5, WC-23, WC-26, WC-27) of 200 m^2 in size within Project area.
Total Offset Options		**126,300 m^2 – 169,000 m^2**		

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List of Acronyms

AEMP	Aquatic Effects Monitoring Program
AMNS	Atlantic Mining NS Inc.
ATV	All Terrain Vehicle
BFI	baseflow index
CCME	Canadian Council of Ministers of the Environment
cfs	cubic feet per second
cm	centimeter
CUPE	Catch-per-Unit Effort
DFO	Fisheries and Oceans Canada
DO	dissolved oxygen
EIS	Environmental Impact Statement
EMS	Environmental Management System
EOM	end-of-mine
EPP	Environmental Protection Plan
FMS	Fifteen Mile Stream
GHD	GHD Limited
ha	hectares
HADD	Harmful Alteration, Disruption, or Destruction
HEU	Habitat Equivalent Units
HSI	Habitat suitability index
km	kilometer
km^2	square kilometer
LAA	Local Assessment Area
m	metre
m/s	metres per second
m^2	square meter
m^3/s	cubic metres per second
MAD	mean annual discharge
MDMER	Metal and Diamond Mining Effluent Regulations
MEL	McCallum Environmental Ltd.
mg/L	milligrams per liter
NS WAP	Nova Scotia Watershed Assessment Program
PA	Project Area
PC	post-closure
the Project	Beaver Dam Mine Project
UTV	Utility Terrain Vehicle
WPM	Wetted Perimeter Method
WRSA	Waste Rock Storage Area
YOY	year-of-young

1.0 Introduction

Atlantic Mining NS Inc. (AMNS) is proposing the construction, operation, decommissioning, and reclamation of an open pit gold mine in Marinette, Nova Scotia. The Beaver Dam Mine Project (the Project) would have an ore production rate of approximately 2MT per year over a five-year period. Ore from the Project would be crushed and transported approximately 31 km by road to the Moose River (Touquoy) mine for processing. Components of the Project include an open pit, material storage facilities (i.e., waste rock, topsoil and organic materials), mine haul roads, mine infrastructure for crushing, water management, hauling, truck maintenance, administration, and road upgrades (**Figure** 1).

While mitigation measures are being developed to minimize Project effects, the location of the ore bodies and the required infrastructure is likely to cause the permanent loss of fish and fish habitat. Any Harmful Alteration, Disruption, or Destruction (HADD) of fish habitat will require authorization under Section 35 of the *Fisheries Act*. Additionally, any deposit of mineral waste (overburden, waste rock, effluent) in waters frequented by fish will require waterbodies to be listed in Schedule 2 of the Metal and Diamond Mining Effluent Regulations (MDMER) in accordance with Section 36 of the *Fisheries Act*.

This draft Fish Habitat Offset Plan (the Plan) has been prepared to provide a description of the extent of possible effects on fish and fish habitat that could occur due to the Project both directly and indirectly; and to begin outlining the offset measures being considered to compensate for any HADD determination. The extent of impacts including potential indirect alteration has been quantified; however, final HADD determination will be completed by Fisheries and Oceans Canada (DFO) which will guide the final compensation plan design and quantification as required for an authorization under the *Fisheries Act*. This Plan is supported by and builds upon the previous studies and documentation completed by McCallum Environmental Ltd. (MEL), GHD Limited, and others. Detailed baseline aquatic habitat data has been collected by MEL personnel and where ongoing model and design work is applicable, it has been included, appended, or referenced. This Plan in also submitted in responses to Information Request #2 (IR2) CEAA-2-07 (CEAA 2019) and to support the Beaver Dam Mine Updated 2021 EIS (AMNS 2021).

Ongoing discussions with residents and farmers of the Musquodoboit River valley indicate a willingness to allow fish habitat remediation/creation on farmland previously channelized, drained, and cleared for more efficient agriculture and livestock management. Engagement on the Project is presented in the Updated EIS 2021 (AMNS 2021). The anticipated benefits of fish habitat rehabilitation/creation include both water quality (e.g., nutrient and thermal) and habitat (e.g., realignment and resizing to hydrologic regime and increased spawning/low water) enhancements.

The intent of this Plan is to describe and delineate the extent of possible Project effects on the aquatic environment and to further demonstrate that mitigation and avoidance measures have been considered to minimize the overall residual impacts on fish and fish habitat and, therefore, the HADD. The habitat potentially affected has been quantified in terms of its overall aerial extent. To allow direct comparison between various habitat types, quantification has also been completed using standardized metrics of fish species habitat suitability. These values may further assist in determining the overall HADD and have been appended (**Appendix** A).

The plan also outlines to the extent possible the offsetting provisions being considered and developed to allow the Project to meet the requirements of the *Fisheries Act*. The final HADD determination and compensation design will be completed during the authorization process. This draft Plan provides Fisheries and Oceans Canada (DFO) with information on the habitat within/near the Project, the possible effects of the Project, the mitigations being employed to minimize effects, and an outline of the compensation options. It begins the process of addressing the unavoidable effects on fish habitat (as defined in the *Fisheries Act*) and outlines the compensation options that show offsets are reasonable and can be achieved in a quantity to offset the potential impacts. A final Offset Plan will be developed and submitted as part of the Project's request for *Fisheries Act* Authorization at the permitting stage; however, plan development and discussions are ongoing through the assessment process. The draft Offsetting Plan has the following objectives:

1. Describe the fish species, habitat and extent of possible habitat loss and alteration due to the proposed Project;

2. Identify any avoidance and mitigation measures used to reduce the extent of possible habitat loss and alterations due to the Project; and

3. Describe the proposed offsets for the direct and indirect loss of fish productive capacity.

The organization of this Plan is based on DFO guidance concerning the Fisheries Protection Policy, fish habitat offsetting, and the content of applications for *Fisheries Act* Authorization (DFO, 2013, 2019). The potential losses, alterations, and offsetting concepts described will serve as the basis for ongoing consultation with Indigenous Groups and stakeholders and to ultimately support an application for authorization of HADD of fish habitat as required by the *Fisheries Act*.

Figure 1: Project Location and Study Area

wood.

1.1 Project Contact Information

Proponent:

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2.0 Regulatory Context

DFO's Fisheries Act (RSC, 1985, c.F-14) states under Section 35(1) that *No person shall carry on any work, undertaking or activity that results in harmful alteration, disruption or destruction of fish habitat*. Also, Section 34.4(1) states *No person shall carry on any work, undertaking or activity, other than fishing, that results in the death of fish*. Under subsection 35(1) a person may carry on such works, undertakings or activities without contravening this prohibition, provided that they are carried on under the authority of one of the exceptions listed in subsection 35(2), and in accordance with the requirements of the appropriate exception. In most cases, this exception would be Ministerial authorizations granted to proponents in accordance with the Authorizations Concerning Fish and Fish Habitat Protection Regulations.

The Policy for Applying Measures to Offset Adverse Effects on Fish and Fish Habitat Under the *Fisheries Act* (DFO 2019) states the following:

> *Works, undertakings or activities resulting in the death of fish or the harmful alteration, disruption or destruction of fish habitat are prohibited under the Fisheries Act unless otherwise authorized. Before approving works, undertakings or activities that will result in the death of fish and/or the harmful alteration, disruption or destruction of fish habitat, Fisheries and Oceans Canada (the Department), must consider if there are alternatives that avoid adverse effects on fish and fish habitat. If the adverse effects on fish and fish habitat are unavoidable, the Department must consider if there are measures to mitigate that would reduce or minimize those adverse effects. Finally, if there are any residual effects, then the Department must consider measures to offset or counterbalance the death of fish and the harmful alteration, disruption or destruction of fish habitat.*
>
> *The Department will apply a risk-based approach when evaluating the impacts of works, undertakings or activities on fish habitat. Following from the definition of fish habitat noted above, the Department interprets "harmful alteration, disruption or destruction" as any temporary or permanent change to fish habitat that directly or indirectly impairs the habitat's capacity to support one or more life processes of fish.*

The Project is currently undergoing federal and provincial environmental assessment under the Canadian Environmental Assessment Act, 2012 and Nova Scotia Environment Act, respectively. The Updated 2021 Environmental Impact Statement (EIS) describes the residual effects on fish and fish habitat when full project mitigations have been considered (AMNS 2021). As part of the planning and permitting process, the Updated EIS and this preliminary offset plan will be reviewed by DFO to confirm the likely residual effects of the Project on fish and fish habitat and the need for a Federal Fisheries Authorization. Subsequently, a *Fisheries Act* Application for Authorization including a detailed final offsetting plan will be developed.

2.1 Document Overview

This document is organized into the following sections:

- Brief Description of the Proposed Work, Undertaking and Activities (Section 3.0);
- Existing Fish and Fish Habitat (Section 4.0);
- HADD Habitat Quantification (Section 5.0); and
- Conceptual Habitat Offset Plans (Section 6.0)

3.0 Proposed Work, Undertaking and Activities

Atlantic Mining NS Inc. (AMNS) is proposing the construction, operation, and reclamation of an open pit gold mine in Marinette, Nova Scotia. As proposed, the Beaver Dam Mine Project would transport at a rate of 2MT a year over a five-year period. The property is located approximately 22 km from the community of Sheet Harbour, N.S and 30 km from the community of Mooseland. Ore from the project would be crushed and transported approximately 31 kilometres by an upgraded Haul Road to the Moose River (Touquoy) mine for processing and disposal in the existing exhausted pit. The Project is expected to have four phases consisting of one year of construction, five years of operations, two years of active closure and 10+ years of post closure monitoring. Components of the project include an open pit, mine site haul roads, waste rock material storage piles, potential acid generating (PAG) stockpile, ore stockpiles, topsoil and organic stockpiles, crusher, explosive storage area, administration buildings and facilities and water management structures.

The Project will also include all temporary activities associated with construction including stockpiles, laydown areas, access roads, water management, temporary flow isolation, environmental control measures (e.g. silt fencing), temporary facilities, and creek crossings, where required.

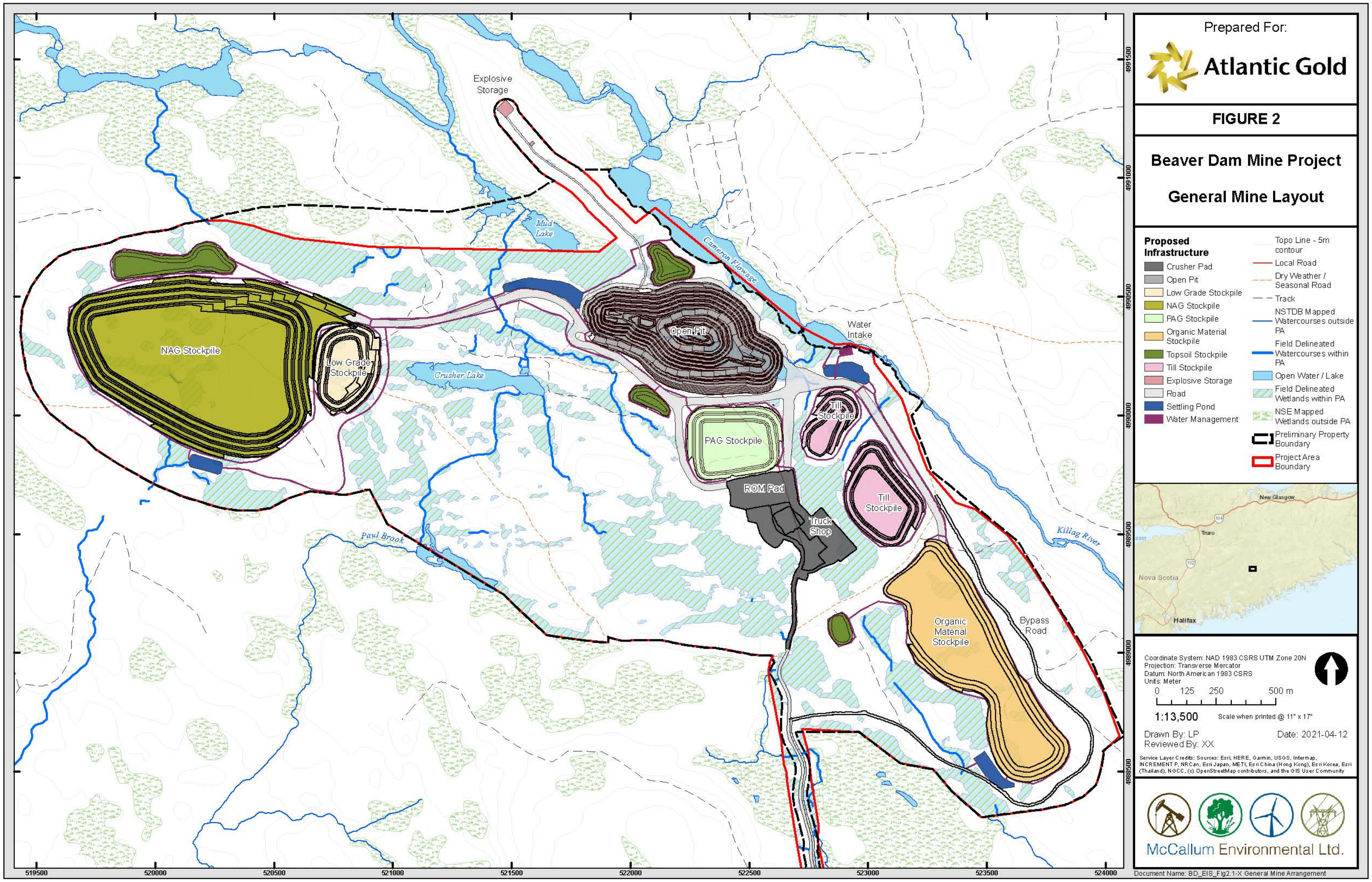


Figure 2: Project Site Plan

wood.

4.0 Existing Fish and Fish Habitat

The site lies within the West River Sheet Harbour 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 (MEL 2020). 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 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).

Elevations within the West River Sheet Harbour catchment vary from approximately 135 to 165 masl in the headwater areas and gradually decrease to sea level at the mouth. The headwaters of the drainage basin are located along the topographic divide separating the Musquodoboit River Valley to the northwest. 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 West River Sheet Harbour is not regulated for hydroelectric power production and many of the roads are seasonal; however, it has been affected by acidification. The West River Sheet Harbour (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 River. Fish surveys within the overall 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. The WRSH watershed is home to one of the largest and longest 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 ranges of the main WRSH and Killag River were approximately 4.3-5.5 and 4.7-5.5, respectively (Halfyard, 2013). 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 (MEL 2020). Their purpose is to increase the pH of the water into a range that is more suitable for juvenile salmon (approximate pH levels of 5.5). As a result of the Project, treated river pH has increased to 5.5-7.5 (Halfyard, 2013). The 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). Due to the sensitivity associated with Atlantic Salmon, a section on the species is provided for context in **Section** 4.2.1.

4.1 The Beaver Dam Mine Site

The proposed Beaver Dam Mine Site is located at the Beaver Dam Mines Road, in Marinette, approximately 22 km northwest of Sheet Harbour, Nova Scotia (**Figure** 2), on private land owned by the Northern Timber Nova Scotia Corporation.

The 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 softwood stand types 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 (MEL 2020).

The first step of the delineation of possible effects is to identify whether fish habitat is present within an area that may be potentially impacted, both directly and indirectly, by a project. If fish habitat is present, fish species utilizing that habitat, including their different life stages, are identified and the habitat to be potentially impacted is described and quantified. Fish habitat is defined in the *Fisheries Act* as '*spawning grounds and nursery, rearing, food supply and migration areas on which fish depend, directly or indirectly, in order to carry out their life processes*'. Thus, fish habitat is comprised of the physical, chemical and biological attributes of the environment. A standardized classification system that provides accurate information on fish habitat is essential when conducting habitat assessments (DFO 2012). The total extent of each habitat type potentially affected is provided in this document in square-metres (m^2) and habitat units (one habitat unit = 100 m^2); however, it has also been standardized using physical attributes of the habitat and species habitat suitabilities associated with these attributes so that direct comparisons between habitat types can be completed (**Appendix** A). This standardization process can also be used to determine the overall quality of habitat and to determine appropriate habitat design features/attributes for any offsetting.

The existing fish habitats within the Local and Regional Study Areas have been described and quantified using fish and fish habitat data collected using a variety of methods. Sampling was completed by MEL from 2015 to 2017 and 2020 (MEL 2020; MEL 2020b). This data has been used to determine fish habitat and species presence and to determine the extent of possible effects and to complete quantification processes to assist in the HADD determination process. All watershed drainages defined as potential fish bearing waters, and therefore fish habitat, as per federal (see above) or provincial definitions were surveyed in terms of physical and chemical characteristics. To determine fish species presence and suitability of the watershed drainages as fish habitat, surveys were completed using electrofishing (index and quantitative), fyke nets, eel pots, minnow traps, and environmental DNA (eDNA). The results provide the data required to delineate fish species presence, distribution, estimates of fish abundance within the Project footprint. Baseline reports have been appended and provided with the updated EIS (AMNS 2021).

4.2 Fish Species and Abundance

A series of surveys including electrofishing, fyke netting, eel pots, and minnow traps were deployed within the Project Study Area to determine the fish species present. While the complete dataset for all species captured by all methods are provided in the baseline report (MEL 2020; MEL 2020a), species abundance estimates developed using electrofishing Catch-per-Unit Effort (CPUE) indices, standardized to 300 seconds of effort (Scruton and Gibson 1995) are provided below for context on the relative species composition within the Project Area. The species identified within the Project Area have been used in the Habitat Suitability and Habitat Utilization Index calculations that are appended to this report and may be used during the final HADD determination and offset development with DFO..

Within the Project Study Area, a total of 1,877 fish within 11 different species have been captured, in order of total catch, Banded Killifish (*Fundulus diaphanous*), Golden shiner (*Notemigonus crysoleucas*), Lake Chub (*Couesius plumbeus*), Brook Trout (*Salvelinus fontinalis*), White Sucker (*Catostomus commersoni*), American Eel (*Anguilla rostrata*), Yellow Perch (*Perca flavescens*), Nine-spine Stickleback (*Pungitius pungitius*), Brown Bullhead (*Ameiurus nebulosus*), Northern Redbelly Dace (*Chrosomus eos*), Creek Chub (*Semotilus atromaculatus*) and Atlantic Salmon (*Salmo salar*). Within the Project Area where waterbodies will be directly impacted, eight species have been captured using electrofishing; Banded Killifish, Brook Trout, Brown Bullhead, Nine-spine Stickleback, American Eel, Creek Chub, Lake Chub, and White Sucker. **Table** 1 provides the catch data from electrofishing within the Study Area and **Figure** 3 provides the overall distribution of species captured. While sampling occurred in the Killag River in areas near the Project site, juvenile Atlantic Salmon were only captured at an electrofishing station downstream of the existing lime doser. It should be noted that recent environmental DNA sampling by the Nova Scotia Salmon Associated (NSSA) determined that Atlantic Salmon are present in the upper reaches (upriver of the Project site) in the Upper Killag River (Montgomery *et al*. 2020). Greater detail on the Atlantic Salmon populations of the area is provided below.

Table 1: Summary of Electrofishing Catch-per-Unit Effort (CPUE) and Mean Abundance estimates within the Project Footprint

Species	Quantitative Electrofishing		Qualitative Electrofishing	
	Total Catch (fish)	Mean Abundance Estimate (#/unit)	Total Catch (fish)	CPUE (fish/300 seconds)
Lake Chub	322	3.26	1	0.03
Brook Trout	167	8.12	12	0.32
White Sucker	47	0.60	-	-
Nine-spine Stickleback	16	0.69	14	0.37
Banded Killifish	14	0.66	11	0.29
American Eel	15	0.16	-	-
Northern Redbelly Dace	-	-	9	0.24
Creek Chub	3	0.14	-	-
Brown Bullhead	-	-	1	0.03
Yellow Perch	1	0.01	-	-
Atlantic Salmon[1]	4	0.03	-	-
Total	**589**		**48**	

1. [1] Killag River only
2. Total qualitative electrofishing effort was 11359 seconds throughout 2015-2020 field programs
3. Quantitative electrofishing population estimates are based of proportion of total catch for each species
4. Population estimates that could not be calculated due to capture pattern (low catch rates) were recorded as the total catch

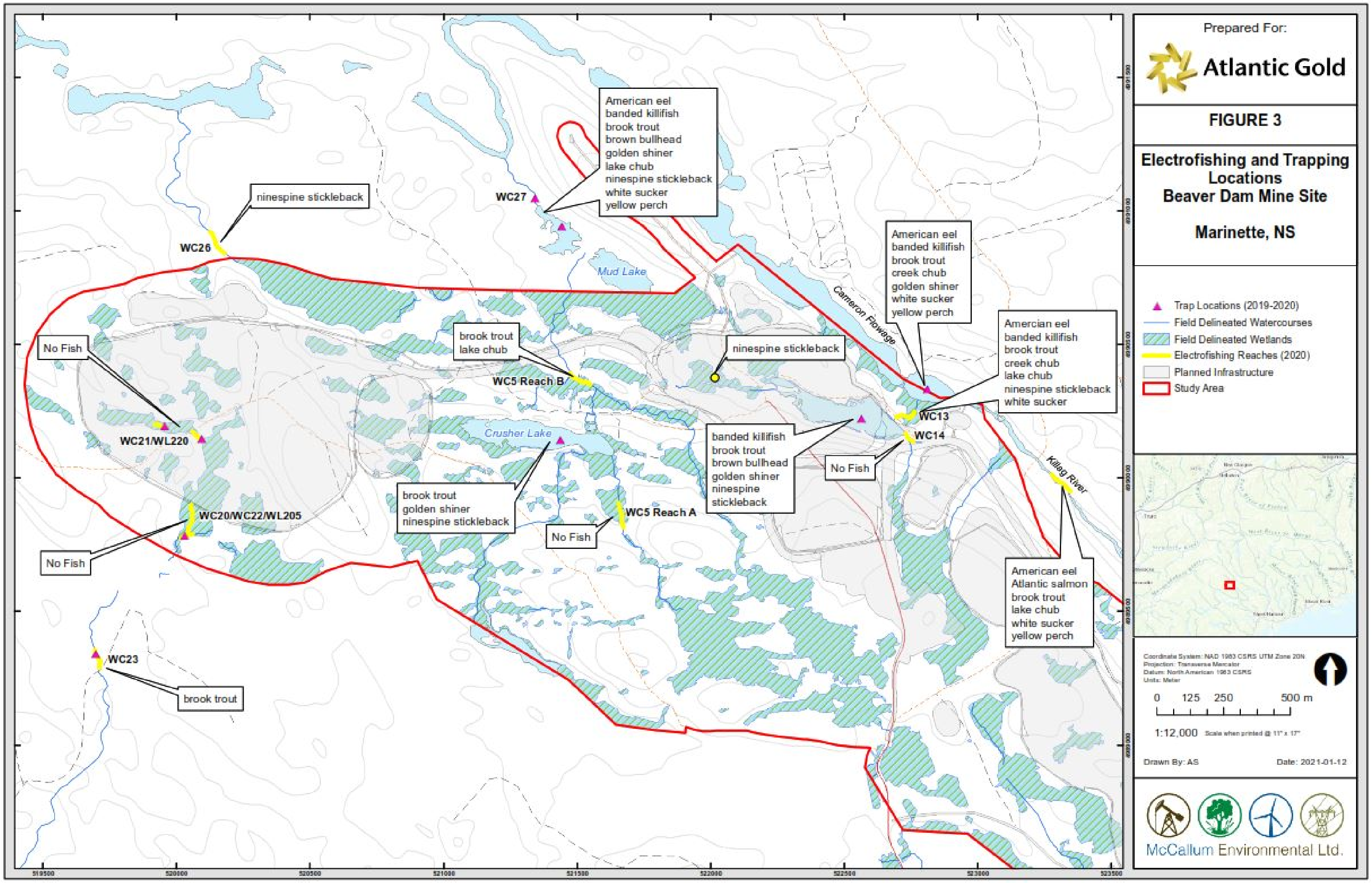


Figure 3: General distribution of fish species distribution based on fish sampling efforts

4.2.1 Atlantic Salmon

North American Atlantic salmon breed and spend the early part of their life cycle in freshwater systems throughout Atlantic Canada, eastern Québec, and the northeastern seaboard of the United States (**Figure** 4). This species requires rivers or streams that are generally clear, cool, and well-oxygenated for reproduction and the first few years of rearing but undertakes lengthy feeding migrations in the North Atlantic Ocean as older juveniles and adults (COSEWIC 2010). The genetic structure and life history traits of Atlantic salmon tend to vary among river populations and this variation among salmon rivers tends to increase with geographic distance. That is, salmon populations are more closely related the nearer their home rivers are located to each other. As a result, DFO manages groups of salmon rivers as metapopulations, called Designatable Units (DUs), based on geography and unique genetic and life history traits (COSEWIC 2010). Based on these features, Atlantic salmon populations are managed under 16 distinct DUs (**Figure** 5). Among these DUs, COSEWIC has identified five as Endangered (Outer Bay of Fundy, Inner Bay of Fundy, Southern Uplands, Eastern Cape Breton, and Anticosti Island metapopulations). The West River is located within the Southern Uplands DU.

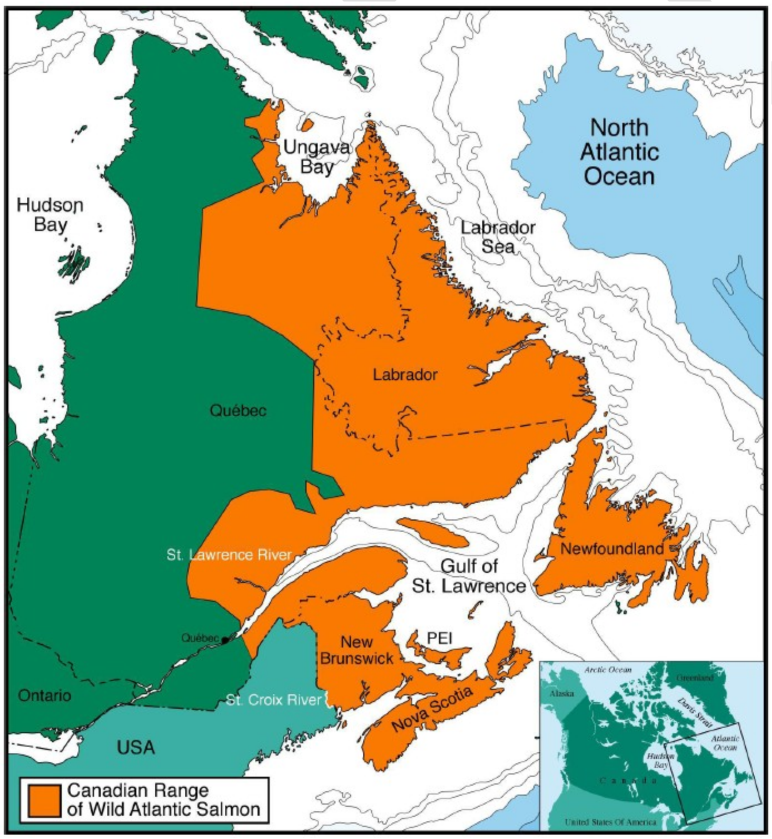


Figure 4: Inland Range of Atlantic Salmon in Canada (Source: DFO 2017b)

Nova Scotia Southern Upland Region

The Southern Upland region is located along the southern shore of Nova Scotia and is characterized by being relatively flat, covered either by dense, and in many areas shrub-like coniferous, deciduous and mixed forests or peat and wetlands. Muskegs are also common representing open peatland with stunted tree growth (NIVA 2001). The Atlantic Salmon population within DFO's Southern Upland DU are genetically distinct (CSAS 2013) and breeds in rivers from northeastern mainland Nova Scotia, along the Atlantic coast and into the Bay of Fundy as far as Cape Split (COSEWIC 2010). The exact numbers of rivers where salmon historically were found within the Southern Uplands is unknown, but they likely inhabited most accessible habitat. Of the estimated 585 watersheds draining the Southern Uplands, 72 of the larger systems are thought to historically have had Atlantic Salmon populations (CSAS 2013). During the past century, spawning occurred in 63 rivers (COSEWIC 2010), but of 54 rivers sampled in 2008-2009, only 22 contained juveniles (CSAS 2013).

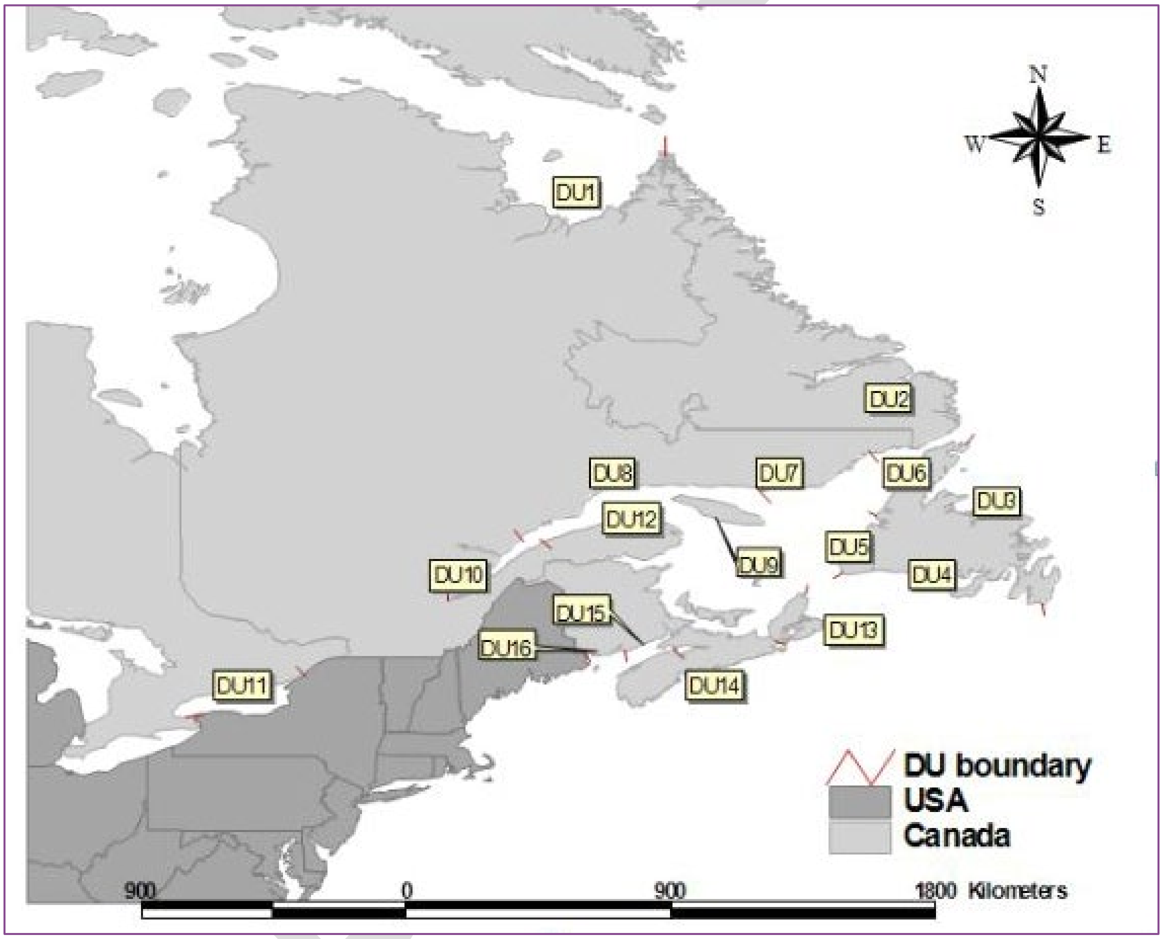


Figure 5: Designatable Units (DU) for Atlantic salmon in eastern Canada (source COSEWIC 2010)

The Southern Upland populations of small (one-sea-winter) and large (multi-sea-winter) fish have both declined over the last three generations by approximately 59% and 74%, respectively, for a net decline of all mature individuals of about 61% (COSEWIC 2010). Many factors may have, and continue to, contribute to population declines including acidification, logging, and habitat fragmentation (COSEWIC 2010; CSAS 2013; DFO 1997; MAPS 2013; Bowlby et al. 2013). The most widespread and pervasive is acidification.

Acidification of freshwater habitats brought about by acidic precipitation is a major, ongoing threat (COSEWIC 2010). Many rivers along the southern shore of Nova Scotia have been acidified due to anthropogenic long-range transport and deposition of sulphur ($H2SO4$) which was predicted in 1986 to have caused a 50% decline in salmon productive capacity since the 1950s (Watt 1986). This anthropomorphic deposition exacerbates a naturally acidic region where natural sources such as wetlands dominated by Sphagnum mosses and forests produce low pH surface waters (NIVA 2001). Even with reduced deposition, the natural alkalinity is low in the Southern Upland region due to poor cation-generating capacity of the soils and bedrock denudation continues to be overwhelmed by acid deposition causing very slow natural neutralization (DFO 1998; Ritter and Rutherford 2000). While sulphate levels have shown significant declines between 1981-1995 (DFO 1997), it did not lead to immediate improvements in river pH due to the low natural buffering capacity (MAPS 2013). Of 60 salmon rivers previously assessed for mean annual pH;

- 14 were identified as extirpated (mean annual river pH less than 4.7)
- 20 were identified as severely impacted (mean annual river pH between 4.7-5.0)
- 16 were identified as lightly impacted (mean annual river pH between 5.1-5.4)
- 13 were identified as not impacted (mean annual river pH greater than 5.5) (DFO 1997).

Only rivers with pH greater than 5.4 have non-impacted salmon populations within the Southern Uplands region of Nova Scotia (NIVA 2001). Mean annual river pH values less than 5.4 are thought to adversely affect salmon spawning success and survival rates (MAPS 2013) and a mean annual river pH less than 5.1 can destabilize salmon productivity (Bowlby et al. 2013).

With the surrounding Atlantic Salmon DUs also showing severely depleted populations, and genetic dissimilarity to those in the Southern Upland DU, there is no likelihood of rescue using restocking from outside the Southern Uplands DU (COSEWIC 2010). Given the low numbers of Atlantic Salmon within the Southern Upland DU, remediation of extirpated and/or severely impacted populations using nearby donor populations is also unlikely. The use of lime products to reduce water acidity and hence increase salmon production and survival has been ongoing in several rivers in the Southern Upland region including West River, Sheet Harbour.

4.3 Habitat Characterization and Predicted Effects/Alterations

The Beaver Dam Mine Site is located in and around former mining activities. It is reasonable to assume that former activities have been ceased long enough that the existing fish and fish habitat represents the now inherent natural variability in the area that fish have adapted to, and now depend upon.

Provided below are brief descriptions of aquatic habitat within and near the Project infrastructure footprint and haul road that has the potential to be either directly or indirectly affected by the Project should no mitigations be applied. Surveys and data are reproduced/summarized from the Baseline Fish and Fish Habitat 2020 Technical Report prepared by MEL and provided in MEL (2020) and MEL (2020a). These habitats have been assessed based on Project final infrastructure footprint (direct habitat destruction) as well as watershed/flow alterations (indirect habitat alterations and/or disruptions) in final determination of the extent of possible effects/alterations.

The Project footprint and haul road have been provided separately.

4.3.1 Direct Project Effects

Each watercourse was characterized via surveys using standard methodologies to gather important diagnostic measurements such as stream reach length (m), reach wetted and bank full width (m), reach slope (%), stream substrate composition (% composition), water depths (m), water velocities (m/s), and riparian habitat (% cover). Fish habitat reach description methodology, results, and figures are provided in the Baseline Fish and Fish Habitat Technical Reports (MEL 2020; MEL 2020a).

Direct Project effects have been determined by overlaying the Project Footprint over the existing aquatic habitat to determine whether infrastructure will cause the direct loss of habitat. While mitigations have been incorporated in project planning and design (see **Section** 5.2), some Project features cannot be relocated or mitigation (e.g., the mine pit and haul road). Direct habitat losses have been described within each watercourse.

4.3.2 Indirect Project Effects

The proposed Beaver Dam Project has been developed with mitigations such as minimizing direct fish and fish habitat impacts by relocating project infrastructure as much as feasibly possible. While several watercourses are not within the direct footprint, they are located nearby the project and may be subject to indirect habitat alterations due to reduced surface and/or groundwater input and hence available fish habitat. Potential for down-gradient, indirect fish and fish habitat impacts could occur throughout the Project Area because of up-gradient hydrological alterations through site water management of mine contact water and associated adjustments in local catchment areas at the Beaver Dam Mine Site.

The determination of the habitat indirectly affected by the proposed Project Mine Site is provided below. It begins with the watercourses closest to the Mine Site Footprint where changes in water balance within their drainages have been predicted and modelled: WC-5, WC-23, WC-26, Tent Brook, and WC-27. It also includes the Killag River which is the receiving watercourse for two of the drainages from the proposed Project Mine Site (WC-26 and WC-27) and is also predicted to have reduced baseflow (i.e. groundwater) input to its Cameron Flowage portion. Cope Brook is also included as it is the receiving watercourse for WC-23.

4.3.2.1 Flow Alterations

The data used to determine indirect effects within the watercourse were measures of instantaneous (daily) flows and measures of aquatic habitat. The predicted flow alterations were determined at a total of 15 stream site locations (**Figure** 6) and used to determine the extent as well as the frequency of any temporary or permanent change to fish habitat that would directly or indirectly impair the habitat's capacity to support one or more life processes. This determination followed the guidance of the DFO framework related to ecological flow requirements (DFO 2013) and included both **hydrologic** and **hydraulic** methods. Details of the process is provided in **Appendix** A. The following outlines the general process for delineating habitat potentially affected by flow alterations and therefore a habitat alteration.

Detailed, long-term, direct flow data from the project area is not available given the small size of the watercourses. Therefore, streamflow conditions for each affected watercourse were modelled. Streamflow within a watercourse is equal to surface runoff plus baseflow. Surface runoff and baseflow were generated using a conceptual hydrologic model in GoldSim which runs on a daily time step. Rainfall and snowmelt were added to a soil storage element as inputs, and evapotranspiration was subtracted from the soil storage element as an output on dry days. A "surplus" from the soil storage element was generated after the soil's available water capacity had been exceeded. The "surplus" was partitioned into surface runoff and baseflow recharge into a groundwater aquifer according to a baseflow index (BFI). The BFI was determined from the groundwater model results. Baseflow discharges from the groundwater aquifer at a rate based on the baseflow recession constant, also determined from the groundwater model.

Lakes were also modelled as storage elements in GoldSim, which were assumed to be full in initial conditions. Inputs to the lake include surface runoff, baseflow, and precipitation falling directly on the lake. Output is lake evaporation. Lake discharge is calculated as the overflow from the lake storage element.

End of Mine (EOM) and Post-Closure (PC) Conditions

The hydrologic model was used to model streamflow and lake discharge from non-site features in EOM/PC conditions. EOM and PC were used as these represent "worse-case" scenarios in terms of effect on streamflow. End-of-Mine would be at a time when mine pits and waste rock would be at a maximum and therefore having maximum influence on baseflow as well as surface flow conditions. Post-Closure conditions represent a time period after full mine pit flooding and no remaining active water management/pumping and/or discharges. Variations in baseflow due to the influence of mine development on groundwater flow patterns were determined in the groundwater model. These impacts were incorporated in the GoldSim model as percent changes from baseline conditions.

Site runoff from stockpiles was equal to the sum of surface runoff and seepage. These values were estimated as percentages of the total rainfall/snowmelt based on data collected at Touquoy. Surface runoff from impervious surfaces (the crusher pad) was set equal to rainfall/snowmelt. Groundwater from site area was accounted for in the percent change values described above, or as an input to the mine pit. Water collected in the mine pit will be pumped to the North Settling Pond. The Killag River will receive site runoff in EOM and PC conditions (post-treatment and discharge from various settling ponds). The North and Western Settling Pond/Mine Pit and East Settling Pond will discharge to the Killag River. The South Settling Pond will discharge to the Tent Lake system (**Figure** 7).

Estimates of daily flows for an average flow year were determined based on the median annual precipitation within the dataset (2003). The estimate for a dry flow year were based on lowest annual precipitation within the dataset (1992).

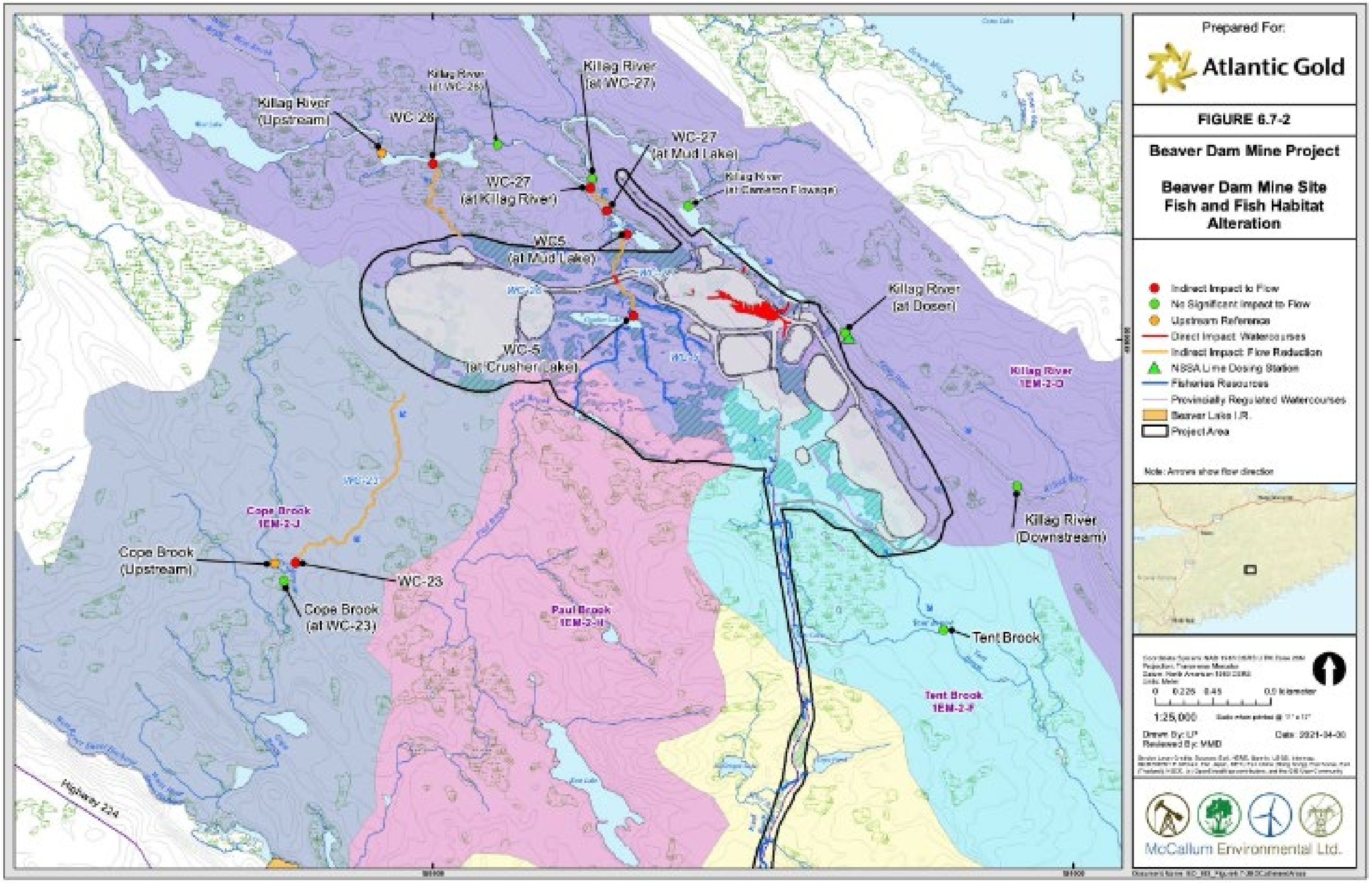


Figure 6: Location of transects used to determine indirect project effects on fish habitat

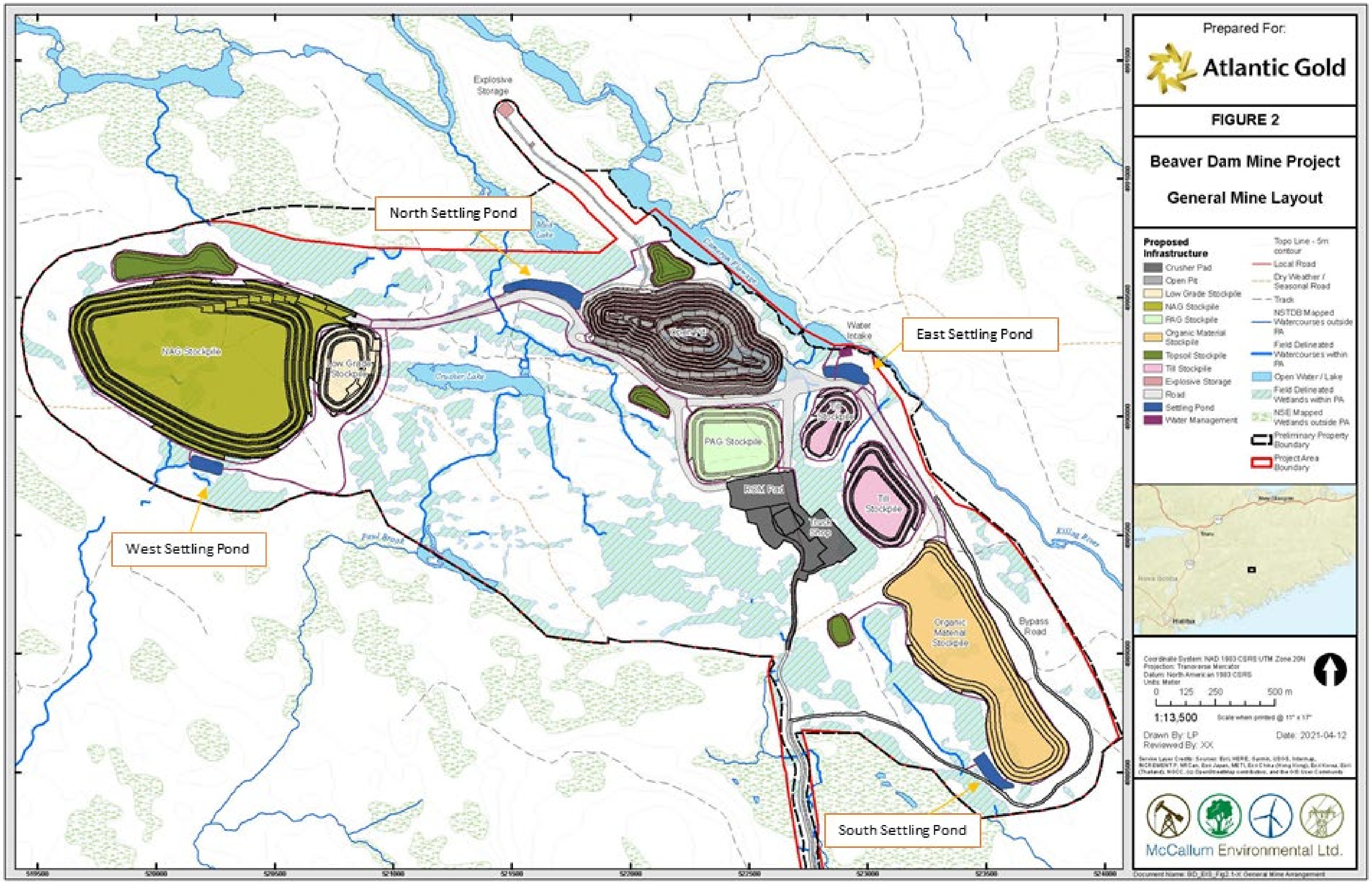


Figure 7: General layout configuration of settling ponds, Beaver Dam Mine Site

The method included a review of the instantaneous (daily) flows within each watercourse against the DFO framework related to ecological flow requirements (DFO 2013). That is, a review of instantaneous (daily) flow data to determine if:

- Cumulative flow alterations >10% in amplitude of the instantaneous flow in the river relative to a "natural flow regime" are predicted (a cumulative flow alteration of <10% is considered to have a low probability of detectable impacts to ecosystems); and/or

- Cumulative flow alterations that result in instantaneous flows <30% of the MAD are predicted (these may have a heightened risk of impacts).

If either condition was identified, a more rigorous level of assessment was completed to determine potential impacts on ecosystem functions which support fisheries. Streams that did not exceed these criteria were not included in further hydraulic analysis.

A comparison between existing and predicted flow alterations relative to an increase beyond 10% MAD is straight forward. Because estimated flow reductions are based on relatively permanent changes to watercourse conditions caused by changes in water balance, any watercourse that naturally contains a period of time with flows <30% MAD will continue to have instantaneous flows <30% MAD (by definition). The potential cumulative decrease in flow beyond 30% MAD, however, needs to be considered in terms of the relative change in duration (frequency) that may occur below 30% MAD.

An increase in the duration of instantaneous flow that is <30% MAD may be important in habitat reaches or regions where water temperatures, dissolved oxygen, or a combination of water quality parameter, could reach sub-lethal or lethal limits for a portion of the year. Simultaneous monitoring of such habitat parameters (e.g., thermal) and flow monitoring/modelling for small streams to correlate thermal limits and decreased flows would be challenging and may not identify the habitat limiting factor. Therefore, a moderate increase in the number of days where flows would be reduced to <30% was used as a trigger that conditions may occur, or be exacerbated, that might affect fish populations and habitat productivity/sustainability due to cumulative reductions in water and/or habitat quality.

A review of the instantaneous flow data indicates that additional days with flows <30% MAD occur either directly before or after a day, or series of days, already containing flows <30% MAD, that is they extend an existing period of lower flows. For example, **Figure** 8 shows the MAD as well as the predicted flow reductions in WC-27. While all extensions are at most two days, this could cumulatively affect fish within the affected habitat. Similar to the DFO framework approach where a cumulative flow alteration <10% would have a low probability of detectable impacts to ecosystems, a <10% increase in the frequency of instantaneous flow days occurring below 30% MAD for an average flow year (or <5% for a dry year) will likely have a low probability of detectable impacts to ecosystems. However, increases above this would have greater potential to indirectly impair the habitat's capacity to support one or more life processes.

Each stream with possible flow reductions were reviewed against the two flow criteria to determine if reductions had a probability of detectable impacts. If either trigger was exceeded, the habitat was described and quantified and recognized as being altered from natural conditions and/or variability. It is noted that habitat alterations due to the predicted flow reductions are not likely to result in a complete loss of aquatic habitat availability or suitability. The amount of harmful alteration of the flow reductions (HADD) and corresponding offset measures and quantities will be determined and documented further in the final draft of the offset plan.

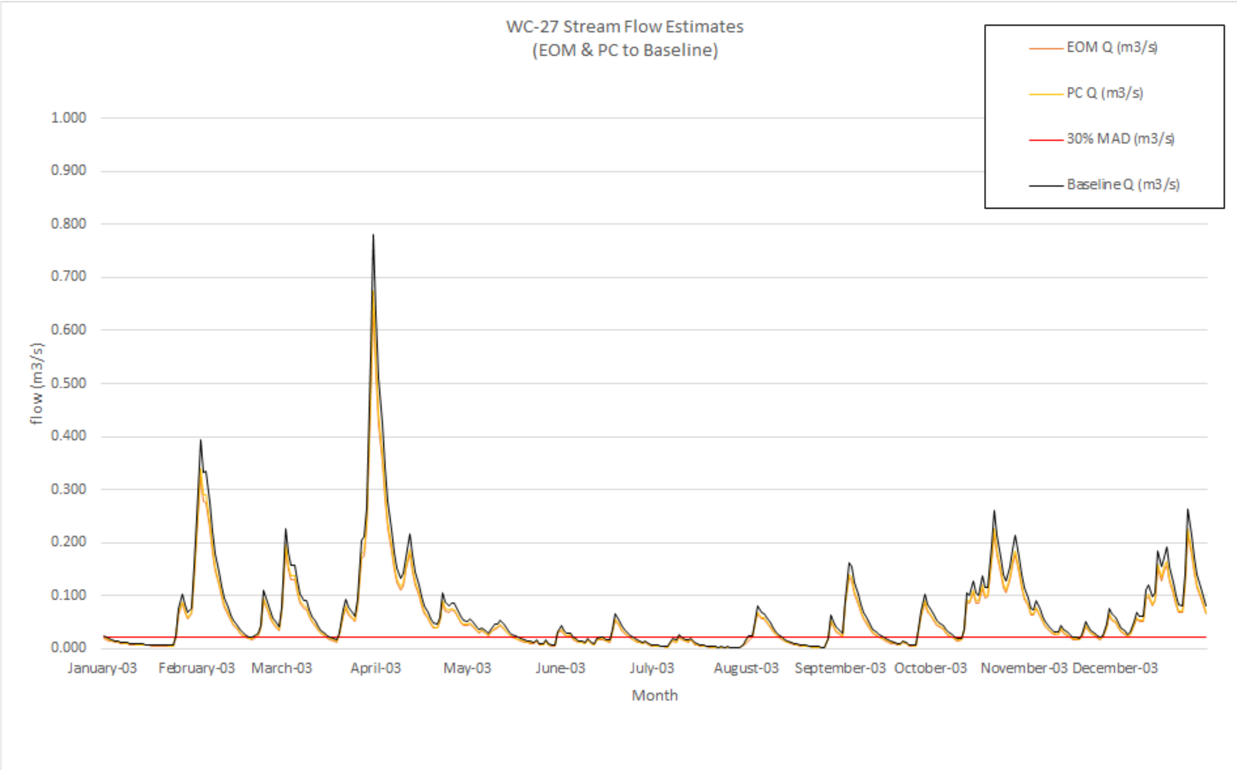


Figure 8: Instantaneous (daily) flow alterations (WC-27), average year (2003). Q=discharge, EOM=End-of-mine, PC=Post-Closure

It is also acknowledged that the use of models in predicting future habitat changes will also require a rigorous monitoring program associated with a *Fisheries Act* authorization within habitats considered indirectly affected to provide greater certainty in actual alterations and their impacts. Consideration might also be given to stream reductions that occur only during the life of the mine (up to EOM) but are then restored upon PC; these might require less offsetting or increased monitoring to determine the quantity of offset required.

Analysis was also completed on all watercourses that exceeded either the 10% MAD flow reduction or a 10% increase in number of days where flows were <30% MAD (or both) using measured habitat transects within each watercourse. Transects as well as stream measurements were used to generate stream cross section models to assist in describing the physical changes/losses due to flow reductions within each watercourse. Details are provided in **Appendix** A.

4.3.3 Project Footprint

There is a total of eight watercourses within the Project Footprint area that could be affected either directly or indirectly by construction, operation, and/or final closure. Each watercourse was surveyed, and fish habitat parameters measured to characterize the existing habitat reaches. The boundary of Project features as well as modelling of changes in drainage and/or baseflows were used to predict effects. Fluvial habitats within the Beaver Dam Mine footprint are shown in **Figure** 9. A summary of the habitat within each watercourse as well as the predicted habitat alterations are provided in **Tables** 2 and 3 for direct and indirect, respectively.

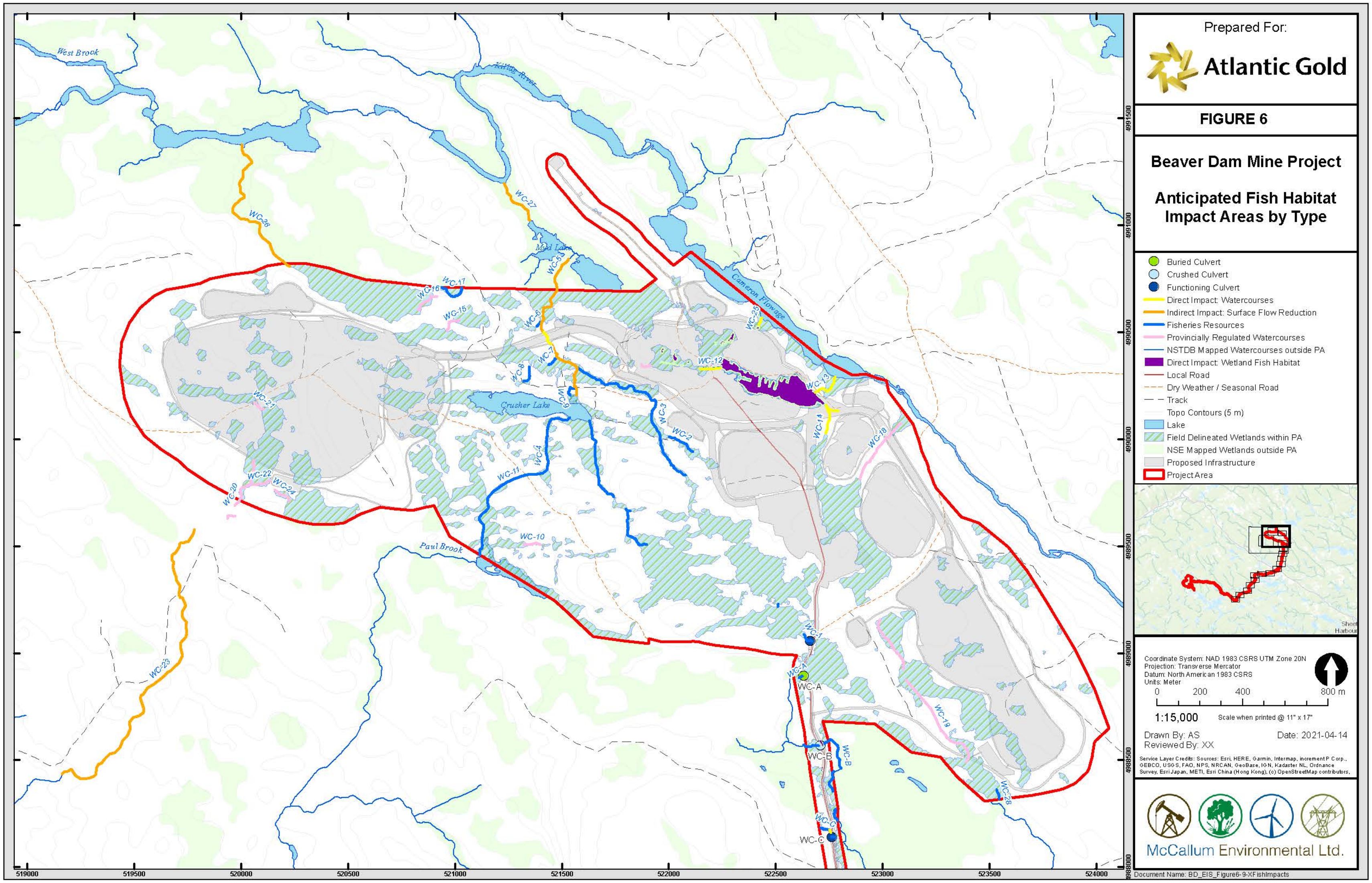


Figure 9: Potential Fisheries Resources Affected by the Project

Table 2: Aquatic habitat directly lost within the proposed Project Footprint

Watercourse / Waterbody	Infrastructure	Length (m)	Average Width (m)	Mean Depth (m)	Dominant Substrate	Area (m^2)	Habitat Units
WC-5	Internal Haul Road	70	2.2			154.00	1.54
WC-12	Pit	93	1.0			93.00	0.93
WL56	Pit	-	-	0.27-0.60	Muck/Detritus	1,454.27	14.54
WC-13	Loss of upstream flow	151	0.8 to 2.7			279.45	2.79
WL59	Pit, Internal Haul Road	-	-	0.19-1.88	Muck/Detritus	37,162.70	371.62
WC-14	Internal Haul Road, loss of upstream flow	196	0.4 to 0.8			108.80	1.09
WC-25	Loss of upstream flow	39	0.45			17.55	0.18
WL61	Pit Perimeter Road	-	-	0.30-1.00	Gravel	173.67	1.74
Total						**39,433.44**	**394.33**

Table 3: Aquatic habitat altered and therefore potentially indirectly affected by the proposed Project

Stream ID	Represented Habitat Length (m)	MAD			30% MAD		Modelled Flow Alteration at EOM				
		m^3/s	Existing Habitat Area (m^2)	Days <30% MAD	m^3/s	Existing Habitat Area (m^2)	(% MAD)	(m^3/s)	Habitat Loss at 30% MAD (m^2)	Days <30% MAD	Increase Days <30% (%)
WC-23	1053	0.054	**4487.64**	115	0.016	**3541.36**	-17.4	0.045	**161.53**	132	+14.8
WC-26	805	0.023	**1927.05**	115	0.007	**1554.50**	-25.0	0.018	**105.94**	144	+25.2
WC-5	832	0.025	**2075.04**	113	0.007	**1700.19**	-4.7	0.023	**17.40**	129	+12.2
WC-27	228	0.070	**1146.74**	112	0.021	**932.83**	-18.5	0.058	**37.54**	136	+21.4
Killag River Flows:											
Killag River Upstream of Project		0.412		115	0.124		0.0	0.412		115	+0.0
Killag River Downstream of WC-26 confluence		0.460		115	0.138		-1.2	0.454		115	+0.0
Killag River Downstream of WC-27 confluence		0.554		116	0.166		-3.2	0.536		119	+2.6
Killag River at Cameron Flowage		1.064		115	0.319		-1.7	1.046		116	+0.9
Killag River at NSSA Lime Dosing Station		1.118		115	0.335		+1.9	1.140		110	-13.0
Killag River Downstream of Project		1.169		115	0.351		+1.9	1.191		100	-13.0
Cope Brook:											
Cope Brook Upstream of WC-23		0.075		115	0.022		0.0	n/a		115	0.0
Cope Brook Downstream of WC-23 confluence		0.143		115	0.043		-6.6	0.133		121	+5.2
Cope Brook (downstream to next confluence)		0.190		115	0.057		-5.0	0.181		120	+4.3
Total Habitat Loss (m^2)			**9,636.47**			**7,728.88**			**322.41**[1]		
Notes:	Values show Positive flow alteration in Cameron Flowage due to Project drainage such that habitat losses are mitigated [1] EOM has greater habitat loss than PC scenario										

4.3.3.1 Watercourse WC-12

WC-12 is a first order stream originating in upland habitat east of Wetland WL56. The watercourse disperses through WL56, eventually re-channelizing within the wetland's eastern lobe. The watercourse exits the wetland via culvert under an existing forestry road and continues east to Wetland WL59. It has been described as an ephemeral groundwater seep. Evidence of groundwater seepage into WC-12 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 (**Figure** 10).

Photo 7: WC12 electrofishing reach (too dry).

Figure 10: Representative habitat photo WC-12 (MEL 2020)

No fish surveys were conducted during the 2019-2020 field program due to dry conditions. During 2015 baseline surveys, however, three juvenile Brook Trout were captured in WC-12 via electrofishing. It is presumed, therefore, that WC-12 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 WC-12, the watercourse has been assessed as suitable for Brook Trout spawning. However, the use of habitat by fish in WC-12 is extremely restricted, and is likely only accessible during a small, very wet time period of any year.

The 93.00 m^2 of fluvial habitat within WC-12 is predicted to be lost with the development of the pit.

Wetland WL56

WL56 is a wetland complex located just west of wetland WL59 within the northern area of the Project Area. 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 through flow water regime, receiving drainage from WC-12 which commences just 53 m to the west. 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 wetland WL59.

Fish habitat within the permanently flooded area of wetland 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 was 0.60 m, with an average depth of 0.47 m. 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.

The 1,454.27 m^2 of lacustrine habitat within WL56 is predicted to be lost with the development of the pit.

4.3.3.1 **Watercourse WC-25**

WC-25 exists as the outflow from Wetland WL61. It is a short, first order stream that travels 33 m before emptying into Cameron Flowage. It consists of a short riffle section followed by a low gradient flat. The short riffle exists immediately downstream of the pond where the channel is barely visible, only slightly entrenched from the surrounding wetland habitat. Water depths do not exceed 0.01 m and 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 (**Figure** 11).

Photo 48: WC25 Reach 1.

Photo 49: WC25 Reach 1.

Figure 11: Representative habitat photo WC-25 (MEL 2020)

WC-25 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. Dissolved oxygen levels in WC-25 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).

The 17.55 m^2 of fluvial habitat within WC-25 is predicted to be lost with the development of the pit perimeter haul road and pit.

Wetland WL61

In the northwestern lobe of wetland 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 except for 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. WC-25 exists as the pond's sole outflow – a short, first order stream that travels 33 m before emptying into Cameron Flowage.

The 173.67 m^2 of lacustrine habitat within WL61 is predicted to be lost with the development of the pit perimeter haul road.

4.3.3.2 Watercourse WC-13

WC-13 is a second order stream which serves as the outlet channel of Wetland WL59. From WL59, the watercourse flows northeast for approximately 280 m before emptying into Cameron Flowage.

Watercourse WC-13 generally contains shallow, higher velocity riffle areas dominated by smaller rocky substrate that are considered to provide suitable substrate for Brook Trout, Creek Chub, Lake Chub, and White Sucker based on spawning and rearing habitat preferences of these species (Reaches 1, 3 and 5). Vegetated, low velocity flats and pools also 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) (**Figure** 12).

Photo 34: WC13 Reach 2.

Photo 35: WC13 Reach 3.

Photo 36: WC13 Reach 4.

Photo 37: WC13 Reach 5.

Figure 12: Representative habitat photo WC-13 (MEL 2020)

Water quality measurements recorded in WC-13 during the 2019-2020 field program showed an increase in temperatures over the summer months, with peak temperatures recorded during the detailed fish habitat assessment on July 13, 2020 (MEL 2020; MEL 2020a). By early July, temperatures exceeded 20°C, and measurements recorded throughout the watercourse on July 13th, 2020 were relatively consistent, ranging from 23.4°C in Reach 1 to 25.9°C in Reach 4. The increase in summer temperatures also corresponded to a decrease in dissolved oxygen 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 quantity of fish captured during successive electrofishing surveys decreased; more specifically, Brook Trout captures dramatically reduced from 57 and 54 individuals in June and July, to only 3 individuals in August.

The 279.45 m^2 of fluvial habitat within WC-13 is predicted to be lost due to loss of all upstream flow with the development of the pit perimeter haul road and pit.

Wetland WL59

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 wetland 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 WC-12 and WC-14. WC-13 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 wetland 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 wetland 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. Wetland 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 wetland WL59 is approximately 50% vegetated with heavy 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 wetland WL59 into WC-13. 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 WC-13, 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.

The 37,162.70 m^2 of lacustrine habitat within WL61 is predicted to be lost with the development of the pit.

4.3.3.3 **Watercourse WC-14**

WC-14 is an intermittent, first order stream located south of Cameron Flowage and serves as one of two tributaries to Wetland WL59. The watercourse received a detailed fish habitat assessment on July 13, 2020, during which the watercourse was delineated into three homogenous reaches. The upper reach (Reach 1A) is one of two upper branches within the watercourse. It 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 0.09 m, channel width of 0.50 m, and rubble as the dominant substrate, which is intermixed with lesser amounts of muck. Overhanging riparian vegetation (predominantly tree branches) is the major source of cover within the reach (**Figure** 13).

Photo 38: WC14 Reach 1A.

Photo 39: WC14 Reach 1B.

Photo 40: WC14 Reach 2.

Photo 41: WC20 Reach 1.

Figure 13: Representative habitat photo WC-14 (MEL 2020)

Reach 1B is the second upper branch within the watercourse and 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 0.03 m, 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 0.03 m. 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℃ cooler 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.

Electrofishing in WC-14 resulted in no fish capture, likely due to dry channel conditions throughout most of the summer. 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, provided 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.

The 108.80 m^2 of fluvial habitat within WC-14 is predicted to be lost due to loss of all upstream flow with the development of the pit perimeter haul road and pit.

4.3.3.4 **Watercourse WC-5**

As outlined in the Baseline Fish and Fish Habitat 2020 Technical Report (MEL 2020; MEL 2020a), WC-5 is the most prominent stream within the Beaver Dam Mine Study Area and provides habitat for a variety of life stages of species confirmed and presumed to be present through the delineated fish habitat reaches (**Figure** 14). 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. In general, Reaches 1 through 7 are considered to provide a variety of suitable habitats for Lake Chub, Northern Redbelly Dace, Brook Trout, and American Eel. American Eel was the only species presumed to be present in these reaches (confirmed in Mud Lake within the WC-5 watershed) based on their capacity to navigate over and through barriers. 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.

Photo 5: WC5A electrofishing reach.

Photo 6: WC5B electrofishing reach.

Figure 14: Representative habitat photos WC-5 (MEL 2020)

Water quality measurements recorded throughout the 2019 to 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°C in Reach 7 to 24.4°C in Reach 3. Dissolved oxygen 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 WC-5 throughout the summer of 2020 were below the Canadian Council of Ministers of the Environment (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 greater than 5.

A small portion (154.00 m^2) of the fluvial habitat within WC-5 is predicted to be lost due to construction of a culvert across an internal haul road.

The remaining habitat within WC-5 is predicted to be subject to reduced instantaneous (daily) water flows of approximately 4.7% which would have a low probability of detectable effects. However, the estimated reduction is also predicted to increase the frequency of flows <30% MAD by as much as 12.2% which has the potential to indirectly exacerbate habitat quality such as water temperatures and/or dissolved oxygen levels during mid-summer flows. The available aquatic habitat at 30% MAD is estimated at 1700.19 m^2. Reduced flows are predicted to reduce available habitat by approximately 17.40 m^2 below that typically available at 30% MAD for an overall net reduction of 1.0%.

4.3.3.5 **Watercourse WC-23**

Located in the lower western lobe of the Project Area downstream of the WRSA, WC-23 is a first order stream within the Cope Brook tertiary watershed that commences in a boulder field at the southwestern extent of a 250 m expanse of upland forest (**Figure** 9). Approximately 1 km of the uppermost extent of the watercourse has been surveyed for fish habitat (**Figure** 15).

Photo 46: WC23 Reach 2.

Photo 47: WC23 Reach 3.

Figure 15: Representative habitat photo WC-23 (MEL 2020)

The surveyed portion of WC-23 has been delineated into three homogenous fish habitat reaches. After accumulating surface water through the boulder field, WC-23 flows southwest for 150 m, 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 perimeters range from 4-4.1 m and 2.3-3.5 m, respectively. Average water depth throughout this reach is 0.18 m, 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.

Within the second reach, WC-23 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 crisscrossing 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 0.12 m. Muck remains the dominant substrate, with lesser amounts of boulder present than in the upstream reach. The watercourse flows south for another 150 m, before crossing a forestry road through a corrugated steel culvert.

The lower reach begins below the culvert. This reach is 754 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 perimeters 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 except for short step-pool habitat, and average water depth is 0.20 m. Cover is mainly provided by overhanging vegetation and large woody debris.

At the time of assessment, there were four 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 at the headwaters, 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.

No portion of the fluvial habitat within WC-23 is predicted to be lost due to the Project, however, the watercourse is predicted to be subject to reduced instantaneous (daily) water flows of approximately 17.4% which would have a probability of causing detectable effects. The available aquatic habitat at 30% MAD is estimated at 3,541.36 m^2. The reduction in instantaneous flow is predicted to reduce available habitat by approximately 161.53 m^2 below that typically available at 30% MAD for an overall net reduction of 4.6%.

Watercourse WC-23 is a tributary of Cope Brook and therefore, the potential affect of flow reductions in WC-23 on Cope Brook were also investigated using similar instantaneous flow criteria. The location of greatest possible flow reduction in Cope Brook was just downstream of its confluence with WC-23. No portion of the fluvial habitat within Cope Brook is predicted to be lost due to the Project and the greatest predicted reduction in instantaneous (daily) water flows is approximately 6.6% (**Table** 3) which would have a low probability of causing any detectable effects.

4.3.3.6 **Watercourse WC-26**

WC-26 is a first order stream that originates as flow accumulation within wetland WL207, located along the northwestern edge of the Project Area (**Figure** 9). 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 (**Figure** 16).

Photo 50: WC26 Reach 1.

Photo 51: WC26 Reach 2.

Figure 16: Representative habitat photo WC-26 (MEL 2020)

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 0.34 m. 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, dissolved oxygen 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 to 4.7 m, widening as it approaches the Killag River. Abundant cover is available in the form 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.

Fish sampling efforts conducted during the 2019-2020 field program was concentrated within the uppermost reach of the watercourse. Only one individual nine spine 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 WC-26 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 nine spine 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. Dissolved oxygen 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).

No portion of the fluvial habitat within WC-26 is predicted to be lost due to the Project, however, the watercourse is predicted to be subject to reduced instantaneous (daily) water flows of approximately 25.0% which would have a probability of causing detectable effects. The available aquatic habitat at 30% MAD is estimated at 1,554.50 m^2. The reduction in instantaneous flow is predicted to reduce available habitat by approximately 105.94 m^2 below that typically available at 30% MAD for an overall net reduction of 6.8%.

Watercourse WC-26 is a tributary of the Killag River and therefore, the potential affect of flow reductions in WC-26 on the Killag River were also investigated using similar instantaneous flow criteria. The location of greatest possible flow reduction in the Killag River was just downstream of its confluence with WC-26. No portion of the fluvial habitat within Killag River is predicted to be lost due to flow reductions in WC-26 and the greatest predicted reduction in instantaneous (daily) water flows is approximately 1.2% with no change in frequency below 30% MAD (**Table** 3) which would have a low probability of causing any detectable effects.

4.3.3.7 Watercourse WC-27

The outlet of Mud Lake, watercourse WC-27 directs water northwest to the Killag River. Like Mud Lake, the riparian area of WC-27 is composed of wetland habitat in the form of a low shrub fen. In the spring, the riparian wetland floods which extends the wetted perimeter of the outlet. In the summer, channelized flow narrows into multiple braids which meander through wetland vegetation. WC-27 has been delineated into a single homogeneous reach of low-gradient flat which extends for 228 m before emptying into the Killag River (**Figure** 17). The main channel ranges from 3.4 to 9 m wide, velocity is sluggish to visibly stagnant, and the average water depth is 0.58 m. 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).

Most 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 WC-27 support spawning by these species 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-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 dissolved oxygen 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.

Photo 52: WC27 Reach 1.

Figure 17: Representative habitat photo WC-27 (MEL 2020)

No portion of the fluvial habitat within WC-27 is predicted to be directly lost due to the Project, however, the watercourse is predicted to be subject to reduced instantaneous (daily) water flows of approximately 18.5% which would have a probability of causing detectable effects. The entire aquatic habitat at 30% MAD is estimated at 932.83 m^2. Although the reduction in instantaneous flow is predicted to reduce available habitat by only approximately 37.54 m^2 below that typically available at 30% MAD (net reduction of 4.0%) we have included the full area below 30% MAD as potentially altered.

Like WC-26, Watercourse WC-27 is also a tributary of the Killag River and therefore, the potential cumulative effect of flow reductions in WC-26 and WC-27 on the Killag River was investigated using similar instantaneous flow criteria. The location of greatest possible flow reduction in the Killag River as a result of flow reductions in WC-26 and WC-27 was just downstream of its confluence with WC-27. No portion of the fluvial habitat within Killag River is predicted to be lost due to flow reductions in WC-26 and WC-27 and the greatest predicted reduction in instantaneous (daily) water flows is approximately 2.5% with three additional days of flows <30% MAD annually (**Table** 3) which would have a low probability of causing any detectable effects.

4.3.3.8 **Killag River**

While most aquatic habitat within the Project Area consists of streams and ponds that have been previously impacted by historic mining activities, the Killag River is located to the north and east of the proposed open pit area and is a tributary of the West River, Sheet Harbour. The West River supports a population of anadromous Atlantic Salmon (*Salmo salar*) that numbered between 3-600 fish in the 1970s (Ducharme and Jansen 1973) but was estimated to be as low as 40 in 1993 (O'Neil et al. 1995). The rivers along Nova Scotia's Southern Upland region have been experiencing declines in Atlantic Salmon population numbers and distribution for at least the last three generations (COSEWIC 2010).

The Killag River is one of two large tributaries of the West River Sheet Harbour. According to Ducharme (1972) and NIVA (2001), the Killag River is the most important portion for salmon production due to the presence of excellent spawning grounds. As stated above, a lime dosing station was installed on the Killag River in 2017 just downriver of the Beaver Dam Site to assist in increasing river water pH to a more suitable range for juvenile Atlantic Salmon. As a recommendation to the liming program, NIVA (2001) recommended a monitoring program to document increased salmon production. It was noted that using salmon as an indicator would be useful due to its sensitivity, especially represented by the smolt life stage.

Prior to field sampling, a desktop review was conducted to identify known fish species within major watercourses and waterbodies within the Study Area. 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, Nine-Spine Stickleback, Golden Shiner, and White Sucker (Halfyard, 2007; NSFA, 2016).

As shown above, the predicted flow reductions from tributaries does not contribute to alterations in flow within the Killag River that would likely be detectable. However, several other possible interactions between the proposed Project and the Killag River were considered and investigated including changes in habitat quantity due to pit influences, thermal effects of reduced groundwater inflow, the location of the North Pond discharge into Cameron Flowage, possible habitat dewatering and habitat accessibility due to water release delays, and possible water quality alterations.

Changes in Habitat Quantity – Altered Baseflows

Cameron Flowage is located to the east of the Project's open pit and is part of the Killag River. The location of the treated settling pond surface water discharge from the North Settling Pond into Cameron Flowage was informed based on groundwater modelling which indicates that a portion of existing baseflow will be directed toward the open pit rather than naturally to Cameron Flowage (**Appendix** C). Without mitigation, there would be a reduction to baseflows and an alteration to the habitat. To mitigate the effect of reduced flows, and hence avoid reduced habitat area within Cameron Flowage, all water collected within the pit will be collected, treated, and discharged back into the Killag River.

The original discharge location of the treated water was determined using the shortest flow distance between the North Settling Pond and Cameron Flowage; however, a slightly longer path will allow the discharge to be such that ninety-nine percent of the predicted baseflow reduction will occur downstream of its location (**Figure** 18). As shown above, this flow augmentation will mitigate flow impacts that a reduction in baseflow would have on the total flow in Cameron Flowage and further downriver within the Killag River (**Table** 3).

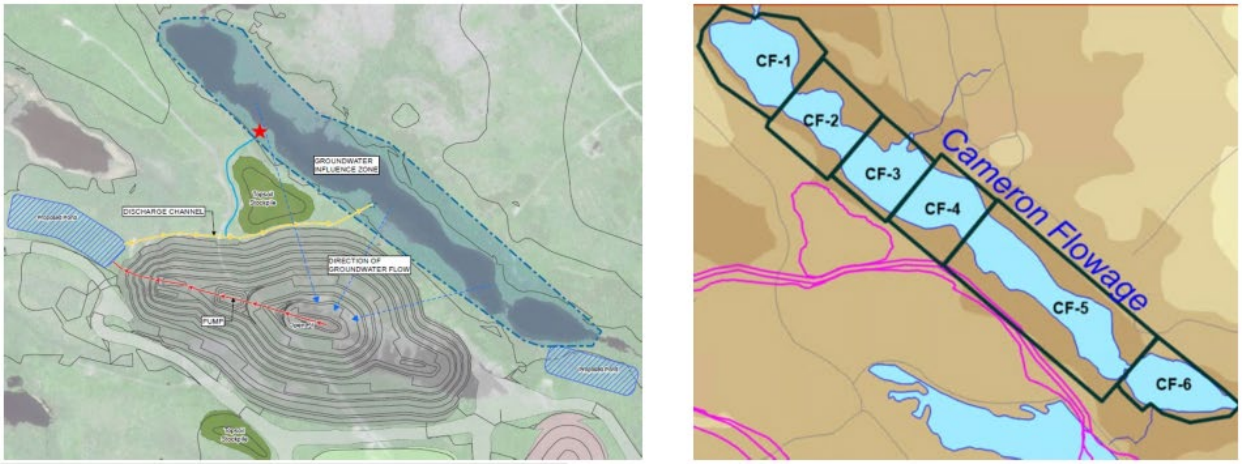


Figure 18: Final North Pond discharge location (red star) at Cameron Flowage based on groundwater modelling

Changes in Baseflow – Atlantic Salmon Thermal Habitat Quality

Organisms will try to maintain body temperature at or near optimal levels by engaging in behavioural thermoregulatory strategies such as sheltering or using thermal refugia (Wood 1991; Thorpe 1994) which has been observed in both juvenile (e.g., Breau et al. 2007: Cunjak et al. 2005; Gibson 1966; Cunjak et al. 1993) and adult Atlantic Salmon (Frechette et al. 2018). Juvenile Atlantic Salmon prefer water temperatures between 16-18ºC (Javaid and Anderson 1967), with an upper lethal temperature limit of 27.8$\pm$0.41ºC (<147 mm) (Garside 1973). Many rivers containing juvenile salmon can commonly exceed both preferred and upper limits. When ambient river temperatures reach 22 to 24ºC it can cause juvenile (1+ and 2+) Atlantic Salmon to abandon territorial behaviour and move to cool water sources where they will aggregate (Breau et al. 2007: Cunjak et al. 2005; Gibson 1966; Cunjak et al. 1993). Areas of cooler water can include tributaries as well as discrete, potentially limited patches of cooler groundwater seepage. The use of these groundwater seepages and tributaries can include large numbers of juveniles in aggregations that typically do not feed or show aggressive behaviours (Breau et al. 2007).

The surface water temperature data collected from upstream and downstream of the Cameron Flowage shows that summer water temperatures appear to consistently exceed the preferred thermal range of juvenile Atlantic Salmon as well as the upper range known to trigger movement to cooler refugia (>23ºC) (**Figure** 19). Fish capture data also supports that this wider reach of the Killag River may be thermally stressed for juvenile Atlantic Salmon (i.e., none captured in this area during the summer sampling months) but also emphasizes the possible importance of thermal refugia throughout the Killag and West River Sheet Harbour system. While the Cameron Flowage can be described as a semi-confined river channel section, given the general topography (i.e., low river valley relief, lack of river channel curvature, and limited inflow tributaries near the Open Pit area) large groundwater upwelling locations have not been identified and are not likely in this area. However, groundwater refugia may still be important within the Killag River and the larger West River Sheet Harbour.

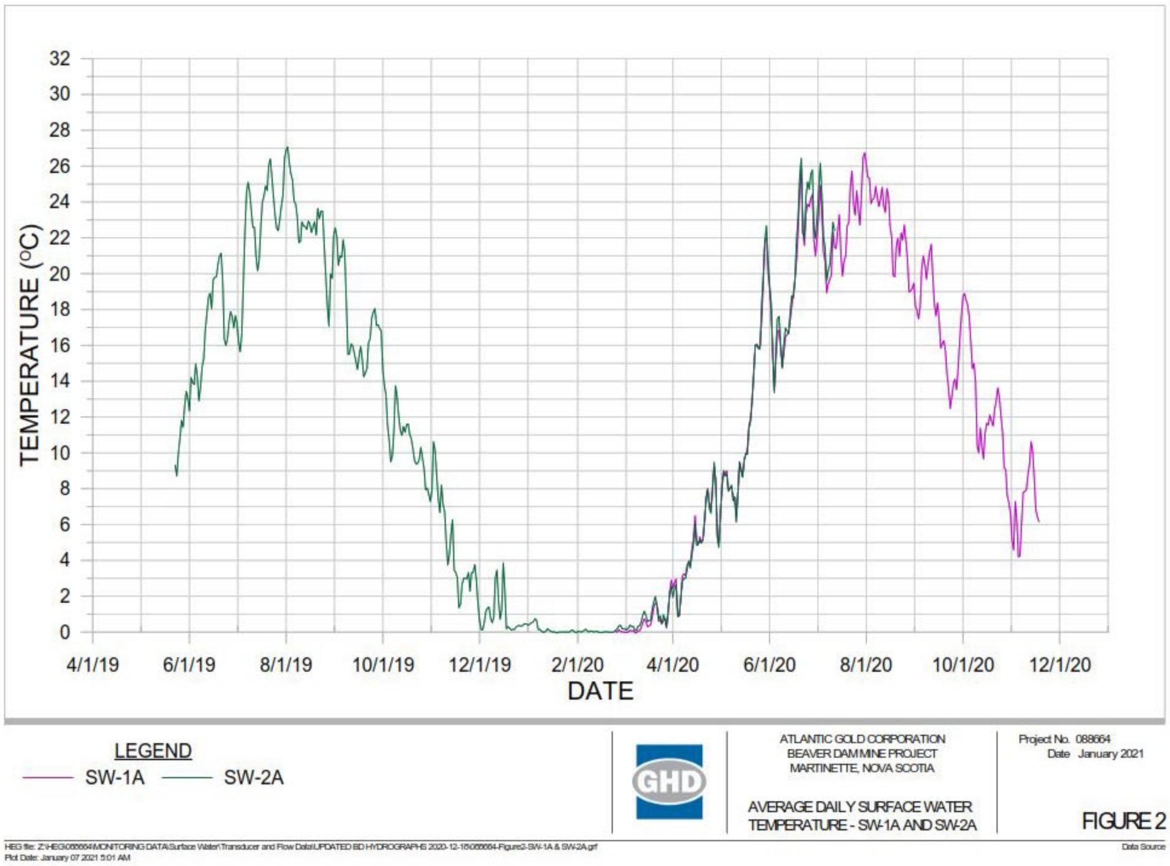


Figure 19: Mean daily surface water temperatures upstream and downstream of Cameron Flowage, Killag River (reproduced from GHD 2021 – Appendix C).

Under low-flow conditions during summer months, groundwater discharge (baseflow) to Cameron Flowage may sustain a significant portion of the total flow within Cameron Flowage; therefore, the potential reduction in baseflow as a result of the Beaver Dam Mine Site development may impact the average temperature within Cameron Flowage. While all water pumped from the proposed open pit will be rerouted via surface water ditches to maintain the same total flow within Cameron Flowage relative to baseline conditions (**Table** 3), water entering Cameron Flowage via surface water ditches may be at a higher temperature than if that water reached Cameron Flowage through subsurface baseflow. Therefore, measured groundwater and surface water temperatures were evaluated relative to the predicted reduction in baseflow to predict the potential average temperature change in Cameron Flowage under low-flow conditions that could result from development of the Beaver Dam Mine Site (GHD 2021b).

GHD estimated the potential temperature change in Cameron Flowage as a result of the development of the Beaver Dam Mine Site based on the measured flow rates and temperatures in Cameron Flowage, the measured groundwater temperatures and the predicted baseflow reduction at EOM and PC as presented in GHD (2021c). Cameron Flowage will likely be most sensitive to potential reductions in baseflow during low-flow conditions in summer months when baseflow makes up the largest proportion of total stream flow and surface water temperatures within Cameron Flowages are near their maximum. Therefore, GHD selected the two-week period with the lowest average flow rate recorded at surface water monitoring stations installed in the Killag River between May 2019 and December 2020 (SW-1A and SW-2A - see **Figure** 20), corresponding to August 16 through August 29, 2019, as being representative of low-flow conditions in Cameron Flowage. By applying heat and mass balance modelling, the predicted temperature increase during the identified low-flow conditions is 0.5°C under EOM conditions relative to baseline, and 0.26°C under PC conditions relative to baseline. These predicted increases correspond to an increase from mean baseline water temperature (20.21°C) to 20.71°C and 20.47°C for EOM and PC, respectively.

Monitoring will be completed to demonstrate that temperature changes within Cameron Flowage are within the predicted range. These monitoring commitments will be confirmed in the Aquatic Effects Monitoring Program (AEMP), which is included in the Updated 2021 EIS (AMNS 2021b).

The size of groundwater seepages does not have to be very large (e.g., 4 to 24 m^2) to dramatically increase salmonid survival during high water temperatures nor to have juveniles locate and aggregate at them (Breau et al. 2007). During non-high temperature conditions, juvenile Atlantic Salmon show territorial behaviours with densities of approximately 1.5 to 7 individuals per 100 m^2 (0.02 to 0.07/habitat unit) (Breau et al. 2007); however, in the Little Southwest Miramichi River during high water temperature events, a total of 709 to 1,000 juveniles have been observed using groundwater locations only totalling 78 m^2 for a density of 9.1 to 12.8 per m^2. Given these aggregation densities, a groundwater seepage of 5 m^2 could assist in the survival of juvenile Atlantic Salmon that would typically be distributed across **7 to 33** habitat units (estimating a mean juvenile density of 10.0 juveniles/m^2 at a groundwater sampling location and a typical juvenile density range of 1.5 to 7 per habitat unit). This would equate to one groundwater seepage location at 0.15 to 0.7 m^2 supporting the production of one habitat unit (100 m^2) of juvenile salmonid habitat.

The resolution of baseflow modeling within Cameron Flowage cannot determine if existing groundwater inflows to Cameron Flowage are diffuse or provide concentrated "upwelling" area(s). Field surveys to confirm the absence (or presence) of groundwater upwelling area(s) along the west shore of Cameron Flowage have been partially completed; however, icing conditions just prior to surveys limited the ability of the thermal drone to detect possible groundwater upwelling sites. Therefore, additional surveys are scheduled during the 2021 open water season and the uncertainty around existing groundwater seepages can be addressed prior to final offset design.

The thermal regime of a river or reach is tied to its landscape geomorphology, geology, and vegetation (O'Sullivan et al. 2019); however, studies on the spatial distribution of thermal refuges have found greater occurrences to be significantly associated with areas of higher channel curvature, close proximity of incoming tributaries, and channel confinement (ratio of valley width to channel width) (Dugdale et al. 2015; Larken and Sharp 1992; van Balen et al. 2008; Winter et al. 1998). While the Cameron Flowage can be described as a semi-confined river channel section, given the general topography (i.e., low river valley relief, lack of river channel curvature, and limited inflow tributaries near the Open Pit area) concentrated groundwater upwelling locations are not likely. While the overall change in water temperature is not predicted to increase more than 0.5°C over baseline, if groundwater upwelling(s) are confirmed, a portion of the west shoreline within baseflow model cells numbered CF-3 to CF-6 (see **Figure** 18) would be altered and therefore a portion of the estimated total area of those cells (68,957.41 m^2), may be included in the fish habitat affected.

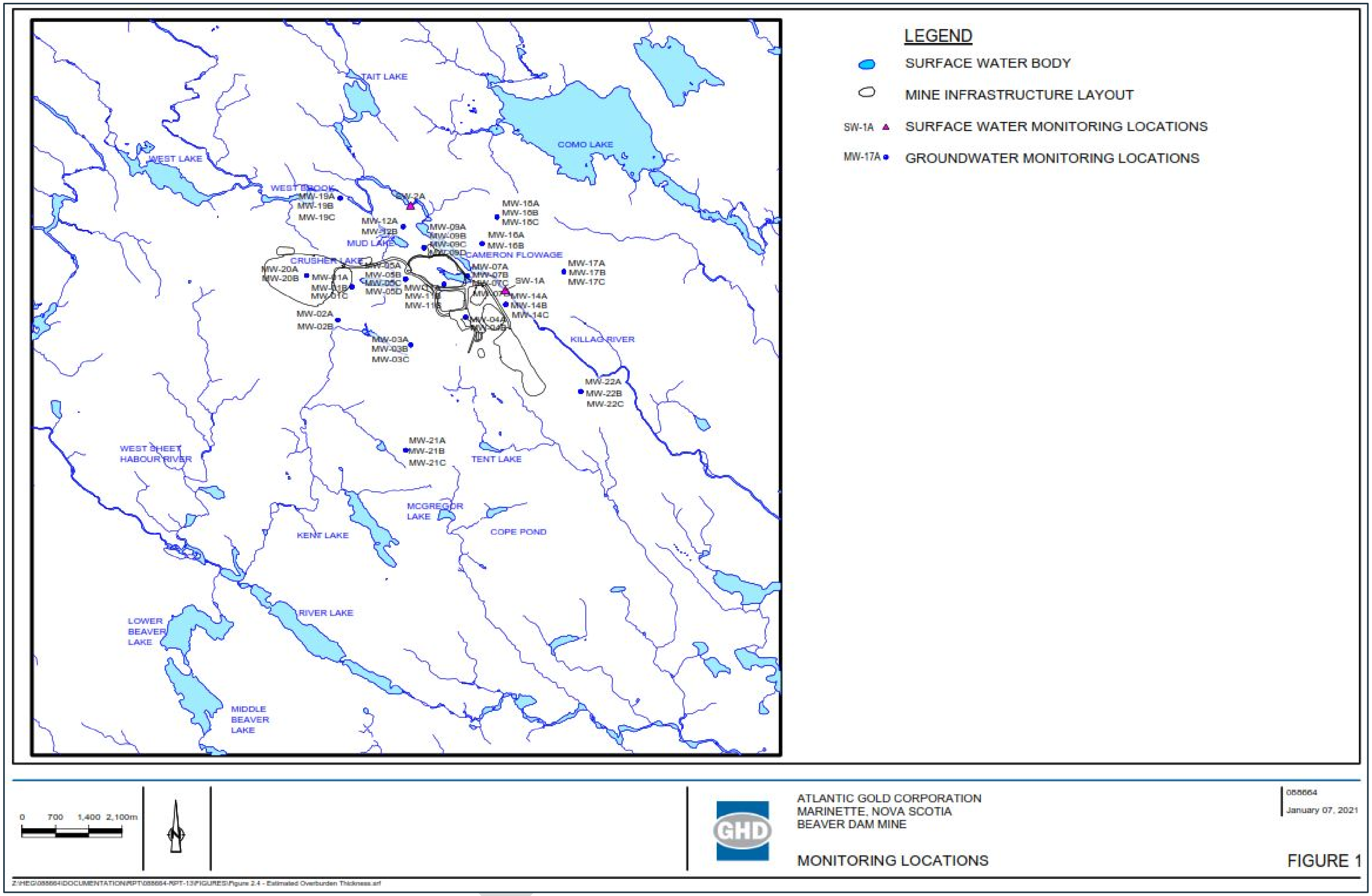


Figure 20: Surface water sample locations for thermal modelling (GHD 2021)

Habitat Dewatering Due to Water Release Delays

A reduction to the operational discharge flow regime from North Pond to Cameron Flowage outlined above, particularly cessation for any extended time period, is not anticipated under normal operating conditions because non-compliance conditions such as high TSS of release water will be addressed immediately (GHD 2021). For example, flocculent treatment will be available as soon as conditions require. However, under a highly unlikely emergency scenario whereby water within North Pond does not meet water quality criteria for release, a worse case scenario would be no augmented flow from the project into Cameron Flowage for an extended time period. This would effectively reduce flows in Cameron Flowage to only that available from natural sources. This reduced flow would extend downriver until water releases from North Pond resumed and/or natural groundwater and tributaries reduced its influence to within background variation. In this highly unlikely situation where non-compliance water is required to be contained within North Pond for an extended time, alternative water sources such as other Project settling ponds may be used to minimize the quantity and/or duration of any reduced flow. However, for this analysis to show a worse-case scenario and the upset habitat effect on Killag River, it was assumed that all water from the Project site is held from Cameron Flowage for a one-week period. Additionally, it was assumed that this occurred during the lowest-flow month in the year with the lowest mean annual flow in the long-term dataset, as represented by the year 1992.

Based on water balance flow modelling for the driest year (1992), the mean monthly surface flow in June at the outflow of Cameron Flowage is 0.106 m^3/s. Mean monthly baseflow from the water balance modelling indicates that baseflow accounts for approximately 43% of the total mean monthly flow in Cameron Flowage. If it is assumed that baseflow has equivalent contribution from the east and west shoreline of Cameron Flowage, then half of the total baseflow contribution during a low-flow scenario can be used as a conservative worse-case flow reduction during a complete cessation of discharge from the North Pond. Additionally, the lowest 7-day low flow period in 1992 was in September and would therefore represent the worse possible timing/flow for a cessation in flows. Therefore, the reduction in streamflow in Cameron Flowage due to a 50% removal of all baseflow during the lowest 7-day low flow period in September of 1992 was used to determine habitat conditions.

Two representative habitat transects located just downstream of Cameron Flowage near the bridge crossing and lime doser were used to estimate habitat (Transects T7 and T9) (**Figure** 21). The estimated 7-day low flow of 0.038 m^3/s from September 1992 was modelled to determine naturally available habitat (wetted width). The estimated reduction in flow at due to cessation of baseflow along the west shore of Cameron Flowage was estimated at 0.030 m^3/s. The estimated wetted width under this unlikely scenario was predicted to be reduced from the natural 7-day low flow width of 6.01 and 2.01 m at transect T7 and T9, respectively to 5.89 and 1.96 m, respectively. This is equivalent to an overall reduction of 2-2.5 %, for Transect T7 and T9, respectively (**Figures** 22 - 23).

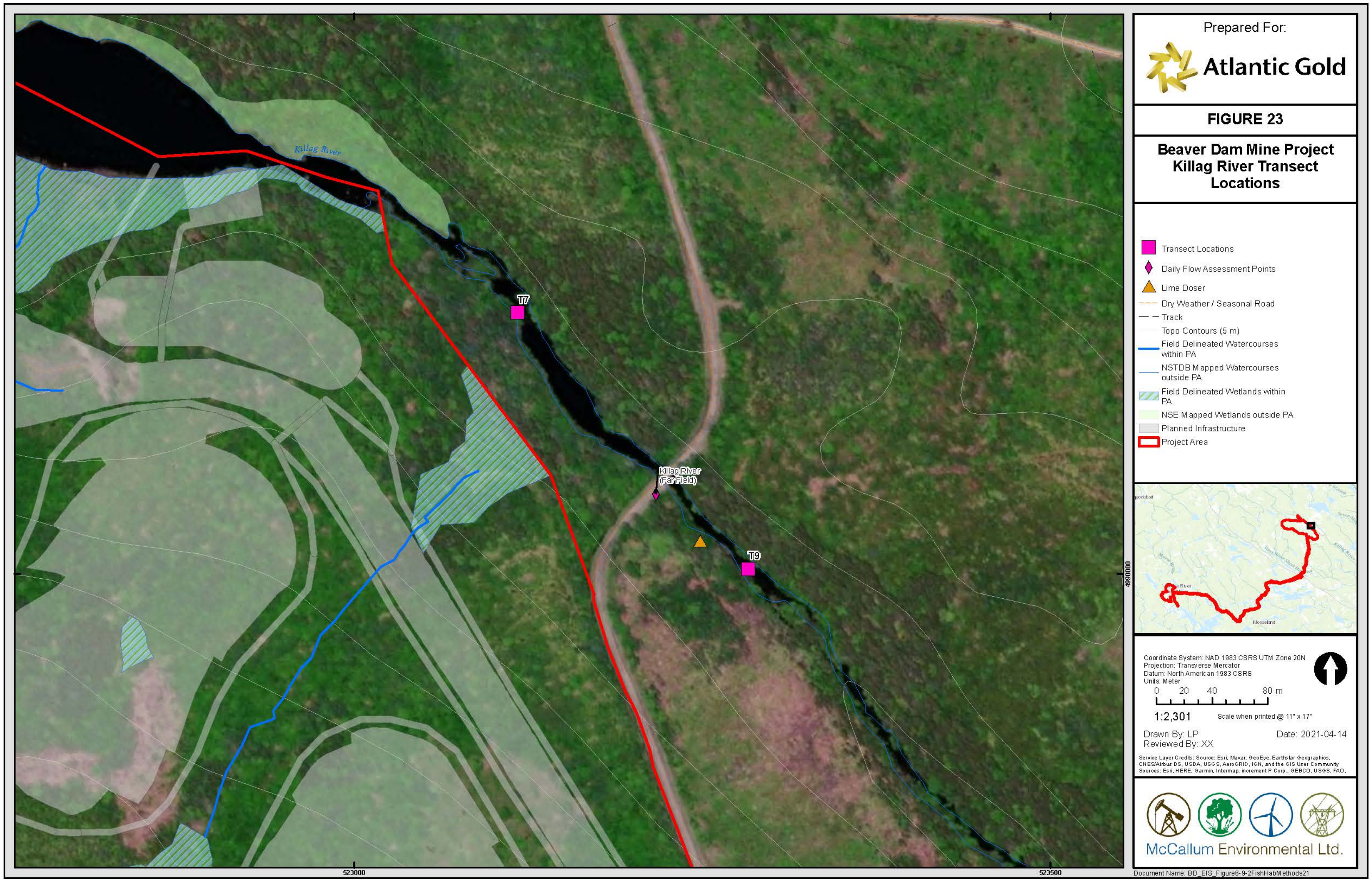


Figure 21: Killag River transects

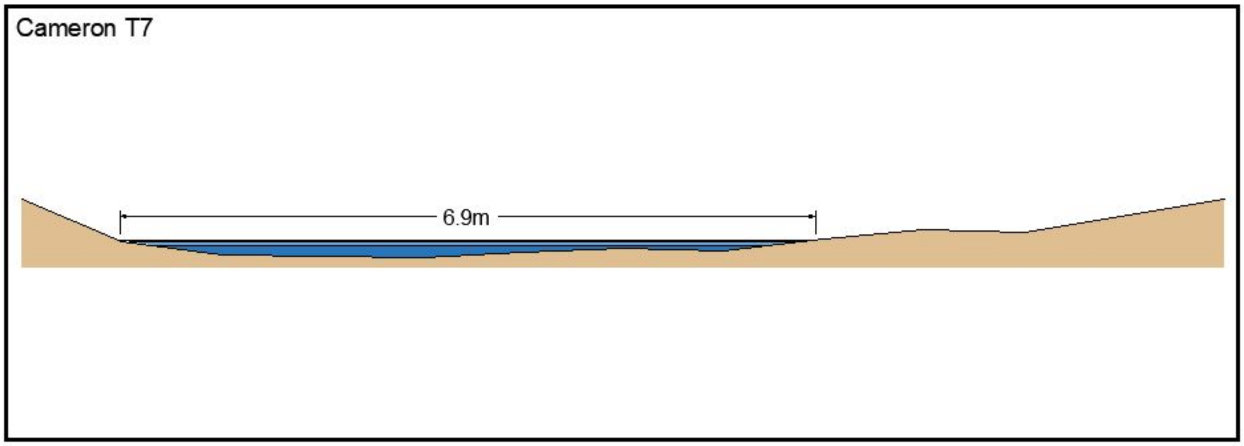


Figure 22: Wetted Perimeter model outputs, Transect T7, Killag River

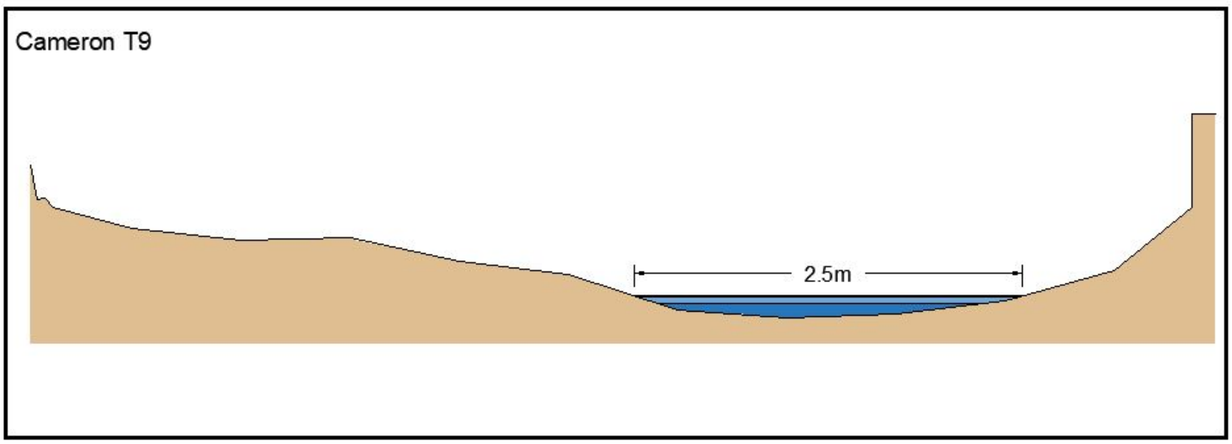


Figure 23: Wetted Perimeter model outputs, Transect T9, Killag River

Habitat Accessibility Due to Water Release Delays

A reduction in water flow due to the inability to augment surface water flows via North Pond discharges also has the potential to reduce habitat accessibility by causing water depths that hinder upriver migration of adult salmon and/or juveniles. The same modelling approach used to determine the quantity of habitat potentially dewatered due to delayed release of water from North Pond into Cameron Flowage can also be used to determine the estimated drop in mean and maximum water depths. The mean water depth at both transects used in the modelling is the overall water depth across the entire transect while the maximum water depth is the water depth at the deepest location along the transect (typically the thalweg).

Based on the same two representative habitat transects just downstream of Cameron Flowage (Transects 7 and 9), the mean monthly flow and the 7-day instantaneous (daily) low flow with no North Pond discharge (0.038 m^3/s) was modelled to determine reductions in mean water velocity, mean water depth, and maximum water depth. **Table** 4 provides estimates of the June mean monthly, typical September 7-day low flow and September 7-day low flow with no North Pond discharge.

Table 4: Summary of estimated habitat parameters at various flows during dry year (1992), Killag River

Transect	Mean Velocity (m/s)	Mean Water Depth (m)	Maximum Water Depth (m)
June Mean Monthly Flow (0.106 m^3/s)			
Transect T7	0.14	0.11	0.17
Transect T9	0.46	0.09	0.14
Natural September 7-Day Low Flow (0.038 m^3/s)			
Transect T7	0.10	0.06	0.11
Transect T9	0.32	0.06	0.09
7-Day Low Flow No North Pond Discharge (0.030 m^3/s)			
Transect T7	0.09	0.06	0.10
Transect T9	0.31	0.05	0.08

At a 7-Day Low flow of 0.038 m^3/s, the mean water velocity at both locations remains within suitable salmonid range. The maximum water depth would be reduced by an estimated 0.01 m at both Transects T7 and T9, respectively between typical 7-Day Low flows and the 7-Day Low flow with no North Pond input. Given the overall predicted reduction in maximum depths and given the range of water depths during a typical 7-Day Low and one with no North Pond Discharge, migration through the area is not considered any more restricted than under natural conditions. It is notable that water depths appear to remain suitable for juvenile salmonids, particularly for a short-term flow reduction.

Habitat Quality/Suitability – Water Quality

Water quality could be affected by alterations in water temperature, pH, or metals.

The water quality assessment completed for the Project demonstrated the need for treatment of mine water prior to discharge into the Killag River during End-of-Mine and Post-Closure conditions. As treatment will allow compliance with all regulatory limits prior to release during Construction, Operations and Closure phases of the Project, no significant residual impact to fish and fish habitat is expected. Greater detail is provided within the EA (AMNS 2021).

4.3.4 Haul Road Footprint

There is a total of 36 watercourses located at or near crossings and/or road expansions of the haul road. Each was surveyed to determine the quantity of habitat at each. **Table** 5 provides a summary of the characterization of each and the quantity within the haul road footprint and therefore a direct loss of fish habitat. In total, it is estimated that 2,430.3 m^2 of habitat is directly lost within the haul road footprint.

Table 5: Fluvial habitat within footprint of proposed Haul Road

Watercourse Location	Current Crossing (Condition)	Plan for Upgraded Haul Road	Direct Footprint Impact (m^2)	HADD
WC-1	Culvert (functioning)	Crusher Pad - Extension to Haul Road	None	Not expected. There is a minor direct impact to stream from culvert extension, but culvert replacement is perpendicular to watercourse and along a straight section of stream.
WC-A	Culvert (buried)	Proposed upgraded road alignment perpendicular to WC along a straight section of stream. Replace buried culvert. Standard mitigation will apply to limit impact to fish habitat and overall improve fish habitat through removal of buried culvert.	None	Not expected. There is a minor direct impact to stream from culvert extension, but culvert replacement is perpendicular to watercourse and along a straight section of stream. Overall mitigated by the replacement of the buried culvert and improvements to historic fish habitat fragmentation.
WC-B	Culvert (crushed)	Proposed upgraded road alignment perpendicular to WC along a straight section of stream. Replace crushed culvert. Standard mitigation will apply to limit impact to fish habitat and overall improve fish habitat through removal of crushed culvert.	None	Not expected. There is a minor direct impact to stream from culvert extension, but culvert replacement is perpendicular to watercourse and along a straight section of stream. Overall mitigated by the replacement of the crushed culvert and improvements to historic fish habitat fragmentation.
WC-C	Culvert (functioning)	Proposed upgraded road alignment perpendicular to WC on eastern side of road. Replace functioning culvert. On western side of road, alignment expected to have direct impact on WC through ditching/infilling. Standard mitigation will apply to limit impact to fish habitat.	7.4	Expected along western side of upgraded road alignment where extension impacts WC-C through ditching/infilling. Not expected for culvert replacement. There is a minor direct impact to stream from culvert extension, but culvert replacement is perpendicular to watercourse and along a straight section of stream.
WC-D	None	Proposed upgraded road alignment perpendicular to WC. Install new culvert at crossing location. Standard mitigation will apply to limit impact to fish habitat.	10.5	Potential based on installation of new culvert where none existed. However, culvert installation is perpendicular to watercourse and along a straight section of stream. Entire length of stream under proposed road alignment given as a conservative estimate of impact. Detailed calculations to be refined during permitting.
WC-E	Culvert (blocked)	Proposed upgraded road alignment perpendicular to WC, east of existing road. Remove blocked culvert on existing	None	Not expected. There is a minor direct impact to stream from culvert installation, but alignment of new watercourse crossing perpendicular to

Watercourse Location	Current Crossing (Condition)	Plan for Upgraded Haul Road	Direct Footprint Impact (m^2)	HADD
		road and install new culvert downstream at new crossing location. Standard mitigation will apply to limit impact to fish habitat and overall improve fish habitat through removal of blocked culvert.		watercourse and along a straight section of stream. Overall mitigated by replacement of blocked culvert and improvements to historic fish habitat fragmentation.
WC-F	Culvert (crushed)	Proposed upgraded road alignment perpendicular to WC, west of existing road. Remove crushed culvert on existing road and install new culvert downstream at new crossing location. Standard mitigation will apply to limit impact to fish habitat and overall improve fish habitat through removal of crushed culvert.	None	Not expected. There is a minor direct impact to stream from culvert installation, but alignment of new watercourse crossing perpendicular to watercourse and along a straight section of stream. Overall mitigated by replacement of blocked culvert and improvements to historic fish habitat fragmentation.
WC-G	Culvert (crushed)	Proposed upgraded road alignment perpendicular to WC. Replace crushed culvert. Standard mitigation will apply to limit impact to fish habitat and overall improve fish habitat through replacement of crushed culvert.	None	Not expected. There is a minor direct impact to stream from culvert extension, but culvert replacement is perpendicular to watercourse and along a straight section of stream. Overall mitigated by the replacement of the crushed culvert and improvements to historic fish habitat fragmentation.
WC-H	Bridge (functioning)	Proposed upgraded road alignment perpendicular to WC. Existing bridge to be expanded. Standard mitigation will apply to limit impact to fish habitat.	None	Not expected. Bridge expansion to use standard construction methods – no impacts to the watercourse expected.
WC-I	Culvert (buried)	Proposed upgraded road alignment perpendicular to WC. Replace buried culvert. Standard mitigation will apply to limit impact to fish habitat.	None	Not expected. There is a minor direct impact to stream from culvert extension, but culvert replacement is perpendicular to watercourse and along a straight section of stream.
WC-J	Culvert (buried)	Proposed upgraded road alignment perpendicular to WC on eastern side of road. Replace buried culvert. On western side of existing road, alignment overlaps approximately 17.3 m of parallel stream that flows into western ditch. Proposed road upgrade will funnel the WC directly across the road to the eastern side and away from the ditch network associated with	21.6	Expected along eastern side of upgraded road alignment where extension impacts WC-J through ditching/infilling. Not expected for culvert replacement. There is a minor direct impact to stream from culvert extension, but culvert replacement is perpendicular to watercourse and along a straight section of stream. Overall mitigated

Watercourse Location	Current Crossing (Condition)	Plan for Upgraded Haul Road	Direct Footprint Impact (m^2)	HADD
		the road. Standard mitigation will apply to limit impact to fish habitat.		by the replacement of the buried culvert and improvements to historic fish habitat fragmentation.
WC-K	Culvert (buried)	Proposed upgraded road alignment perpendicular to WC. Install new culvert. Replace buried culvert. Standard mitigation will apply to limit impact to fish habitat and overall improve fish habitat through installation of culvert.	None	Not expected. There is a minor direct impact to stream from culvert extension, but culvert replacement is perpendicular to watercourse and along a straight section of stream. Overall mitigated by the replacement of the buried culvert and improvements to historic fish habitat fragmentation.
WC-L	Culvert (functioning)	WC runs parallel to current road in western roadside ditch. Proposed road upgrade will require the functioning culvert to be replaced to funnel the WC directly across the road to the eastern side and away from ditch network associated with the road. Proposed road alignment overlaps approximately 53 m of parallel ditched stream. Standard mitigation will apply to limit impact to fish habitat.	15.9	Expected along western side of upgraded road alignment where extension impacts WC-L through ditching/infilling. Not expected for culvert replacement. There is a minor direct impact to stream from culvert extension, but culvert replacement is perpendicular to watercourse and along a straight section of stream.
WC-M	Culvert (functioning, North), None (South)	Proposed upgraded road alignment is perpendicular to WC at two locations (north and south). Northern crossing will require an extension to existing culvert which is functioning. Southern crossing will require installation of a new culvert. Standard mitigation will apply to limit impact to fish habitat.	10.9	Potential based on installation of new culvert where none existed (southern crossing). However, culvert replacement is perpendicular to watercourse and along a straight section of stream. Entire length of stream under proposed road alignment given as a conservative estimate of impact. Detailed calculations to be refined during permitting. Not expected for culvert replacement. There is a minor direct impact to stream from culvert extension, but culvert replacement is perpendicular to watercourse and along a straight section of stream.
WC-N-West River	Bridge (functioning)	Proposed upgraded road alignment perpendicular to WC. Requires upgraded bridge at current crossing location. Standard mitigation will apply to limit impact to fish habitat.	None	Not expected. Bridge expansion to use standard construction methods – no impacts to the watercourse expected.

Watercourse Location	Current Crossing (Condition)	Plan for Upgraded Haul Road	Direct Footprint Impact (m^2)	HADD
WC-O	None	Proposed new road designed perpendicular to WC. Requires culvert installation. Standard mitigation will apply to limit impact to fish habitat.	29.3	Potential based on installation of new culvert where none existed (southern crossing). However, culvert installation is perpendicular to watercourse and along a straight section of stream. Entire length of stream under proposed road alignment given as a conservative estimate of impact. Detailed calculations to be refined during permitting.
WC-P	None	Proposed new road designed perpendicular to WC. Requires culvert installation. Standard mitigation will apply to limit impact to fish habitat.	10.2	Potential based on installation of new culvert where none existed. However, culvert installation is perpendicular to watercourse and along a straight section of stream. Entire length of stream under proposed road alignment given as a conservative estimate of impact. Detailed calculations to be refined during permitting.
WC-T	Culvert (buried)	Proposed upgraded road alignment perpendicular to WC. Replace buried culvert. Standard mitigation will apply to limit impact to fish habitat and overall improve fish habitat through removal of buried culvert.	None	Not expected. There is a minor direct impact to stream from culvert extension, but culvert replacement is perpendicular to watercourse and along a straight section of stream. Overall mitigated by the replacement of the buried culvert and improvements to historic fish habitat fragmentation.
WC-U	Culvert (functioning)	Proposed upgraded road alignment perpendicular to WC. Replace functioning culvert. Standard mitigation will apply to limit impact to fish habitat.	None	Not expected. There is a minor direct impact to stream from culvert extension, but culvert replacement is perpendicular to watercourse and along a straight section of stream.
WC-V	Culvert (buried)	Proposed upgraded road alignment perpendicular to WC. Replace buried culvert. Standard mitigation will apply to limit impact to fish habitat and overall improve fish habitat through removal of buried culvert.	None	Not expected. There is a minor direct impact to stream from culvert extension, but culvert replacement is perpendicular to watercourse and along a straight section of stream. Overall mitigated by the replacement of the buried culvert and improvements to historic fish habitat fragmentation.
WC-W	Culvert (hung)	Proposed upgraded road alignment perpendicular to WC. Replace hung culvert. Standard mitigation will apply to limit impact to fish habitat and overall improve fish habitat through replacement of hung culvert.	None	Not expected. There is a minor direct impact to stream from culvert extension, but culvert replacement is perpendicular to watercourse and along a straight section of stream. Overall mitigated by the replacement

Watercourse Location	Current Crossing (Condition)	Plan for Upgraded Haul Road	Direct Footprint Impact (m^2)	HADD
				of the hung culvert and improvements to historic fish habitat fragmentation.
WC-X	None	Proposed upgraded road alignment is perpendicular to WC and will require a new culvert installation. Standard mitigation will apply to limit impact to fish habitat and overall improve fish habitat through providing fish access to upstream aquatic resources.	12.1	Potential based on installation of new culvert where none existed (southern crossing). However, culvert installation is perpendicular to watercourse and along a straight section of stream. Entire length of stream under proposed road alignment given as a conservative estimate of impact. Detailed calculations to be refined during permitting. Mitigation to historic fish habitat fragmentation expected with installation of culvert where there was none (aquatic features located upstream and downstream of road currently not connected).
WC-Y	Culvert (buried)	Proposed upgraded road alignment is perpendicular to WC. Replace buried culvert. Standard mitigation will apply to limit impact to fish habitat and overall improve fish habitat through replacement of buried culvert.	None	Not expected. There is a minor direct impact to stream from culvert extension, but culvert replacement is perpendicular to watercourse and along a straight section of stream. Overall mitigated by the replacement of the buried culvert and improvements to historic fish habitat fragmentation.
WC-AA	Culvert (hung)	Proposed upgraded road alignment perpendicular to WC. Replace hung culvert. Standard mitigation will apply to limit impact to fish habitat and overall improve fish habitat through removal of hung culvert.	None	Not expected. There is a minor direct impact to stream from culvert extension, but culvert replacement is perpendicular to watercourse and along a straight section of stream. Overall mitigated by the replacement of the hung culvert and improvements to historic fish habitat fragmentation.
WC-AC	None	Proposed upgraded road alignment overlaps with the top end of this watercourse (3.7 m). This area may be altered to support road upgrades. Standard mitigation will apply to limit impact to fish habitat.	8.3	Expected along northern side of upgraded road alignment where extension impacts WC-AC through ditching/infilling.
WC-AD- Morgan River	Bridge (functioning)	Proposed upgraded road alignment will require upgraded bridge at current crossing location. Standard mitigation will apply to limit impact to fish habitat.	None	Not expected. Bridge expansion to use standard construction methods – no impacts to the watercourse expected.

Watercourse Location	Current Crossing (Condition)	Plan for Upgraded Haul Road	Direct Footprint Impact (m^2)	HADD
WC-AE	Culvert (buried)	Proposed upgraded road alignment perpendicular to WC. Replace buried culvert. Standard mitigation will apply to limit impact to fish habitat and overall improve fish habitat through replacement of buried culvert.	None	Not expected. There is a minor direct impact to stream from culvert extension, but culvert replacement is perpendicular to watercourse and along a straight section of stream. Overall mitigated by the replacement of the buried culvert and improvements to historic fish habitat fragmentation.
WC-AF	None	Proposed upgraded road alignment overlaps with the bottom end of this watercourse (40.2 m), at which point the watercourse currently empties into the southern ditch along the existing road. Current ditch drains east towards culvert at WC-AE. Proponent will consider installation of a culvert to funnel the watercourse directly across the road north towards WC-AH, away from the ditch network associated with the road. Standard mitigation will apply to limit impact to fish habitat.	46.3	Expected along southern side of upgraded road alignment where extension impacts WC-AF through ditching/infilling. Potential installation culvert to funnel the watercourse directly across the road north may provide improvements to historic fish habitat fragmentation.
WC-AG	None	Proposed upgraded road alignment overlaps with the bottom end of this watercourse (18.4 m), at which point the watercourse currently empties into the southern ditch along the existing road. Current ditch drains east towards culvert at WC-AE. Proponent will consider installation of a culvert to funnel the watercourse directly across the road north towards WC-AH, away from the ditch network associated with the road. Standard mitigation will apply to limit impact to fish habitat.	12.0	Expected along southern side of upgraded road alignment where extension impacts WC-AF through ditching/infilling. Potential installation of culvert to funnel the watercourse directly across the road north may provide improvements to historic fish habitat fragmentation.
WL64	Culvert (buried) – see WC-A	Buried culvert associated with WC-A located at wetland crossing. Proposed upgraded road alignment overlaps surface water features (presumed fish habitat) both sides of road. Replacement of buried culvert likely to improve fish access into wetland.	48.7	Expected. Direct impact to wetland habitat (presumed fish habitat).

Watercourse Location	Current Crossing (Condition)	Plan for Upgraded Haul Road	Direct Footprint Impact (m^2)	HADD
WL66	Culvert (crushed) at northern crossing – see WC-B, None at southern crossing	Proposed upgraded road alignment overlaps wetland complex at two locations – a northern crossing (associated with WC-B) and a southern crossing. At northern crossing, proposed upgraded road alignment overlaps surface water features (presumed fish habitat) on both sides of road. Replacement of crushed culvert on WC-B likely to improve fish access into wetland. No culvert/bridge currently exists at southern crossing. Proposed upgraded road alignment overlaps surface water features (presumed fish habitat) on west side of road. Proponent will consider installation of a culvert to re-establish natural wetland hydrology which may provide fish access into previously inaccessible fish habitat.	487.0	Expected. Direct impact to wetland habitat (presumed fish habitat).
WL73	None	No culvert is present at current wetland crossing. Proposed upgraded road alignment overlaps surface water features (presumed fish habitat) currently exist on both sides of road, likely caused by road impoundment. Proponent will consider installation of a culvert to re-establish natural wetland hydrology which may provide fish access into previously inaccessible fish habitat.	185.2	Expected. Direct impact to wetland habitat (presumed fish habitat).
WL76	Culvert (crushed) – see WC-G	Crushed culvert associated with WC-G located at wetland crossing. Proposed upgraded road alignment overlaps surface water features (presumed fish habitat) both sides of road. Replacement of crushed culvert likely to improve fish access into wetland.	398.6	Expected. Direct impact to wetland habitat (presumed fish habitat).
WL146	None	No culvert is present at wetland crossing. Proposed upgraded road alignment overlaps surface water feature (presumed fish habitat) on both sides of road – extensive flooding on west side likely caused by road impoundment. Proponent will	106.4	Expected. Direct impact to wetland habitat (presumed fish habitat).

Watercourse Location	Current Crossing (Condition)	Plan for Upgraded Haul Road	Direct Footprint Impact (m^2)	HADD
		consider installation of a culvert to re-establish natural wetland hydrology which may provide fish access into previously inaccessible fish habitat from WC-Z.		
WL154	None	Headwater wetland confined to west side of road. Proposed upgraded road alignment overlaps surface water feature (presumed fish habitat). No culvert proposed.	176.9	Expected. Direct impact to wetland habitat (presumed fish habitat).
WL159	Culvert (hung) – see WC-AA	Hung culvert associated with WC-AA located at wetland crossing. Proposed upgraded road alignment overlaps surface water feature (confirmed fish habitat). Replacement of hung culvert likely to improve fish access upstream to WL160.	6.5	Expected. Direct impact to wetland habitat (presumed fish habitat).
WL160	Culvert (hung) – see WC-AA	Hung culvert associated with WC-AA located at wetland crossing. Proposed upgraded road alignment overlaps surface water feature (presumed fish habitat). Flooding observed in wetland likely caused by improper culvert sizing. Replacement of crushed culvert likely to improve fish access and re-establish natural wetland hydrology.	836.5	Expected. Direct impact to wetland habitat (presumed fish habitat).
Total			**2,430.3**	

5.0 Aquatic Habitat Affected by the Project

Fish habitat components, their function and attributes, and the fish populations that rely on them (e.g., aquatic ecosystems) are dynamic and complex. It can be more difficult, costly and uncertain to restore, enhance, or create, aquatic ecosystems than it is to avoid adverse effects in the first place. For this reason, the DFO emphasizes measures to avoid and mitigate as the preferred steps in the hierarchy of project planning, followed by measures to offset any HADD as a means of last resort.

The Policy's hierarchies are listed below along with a summary of how they have been considered with this Project. The three levels include:

- Measures to Avoid;
- Measures to Mitigate; and
- Measures to Offset.

The Updated 2021 EIS (AMNS 2021b) and subsequent Information Request, Round 2 responses (AMNS 2021a) have further details on the project, avoidance measures, mitigations, and effects assessment for Fish and Fish Habitat (AMNS 2021a, b). This information is not reproduced here but rather synthesized to bring forward key avoidance strategies, mitigations, and offsetting related to DFO's hierarchy of measures. The first two measures, avoidance and mitigation, are provided here prior to a summary of habitat that may be affected by the Project by varying degrees and hence may be included in DFO's HADD determination. Preliminary measures to offset impacted habitat are provided in **Section** 6.0.

5.1 Measures to Avoid

Measures to Avoid for the conservation and protection of fish habitat is the first and most important step in the hierarchy of measures and therefore have been the major focus of this project to date. There have been several measures put in place to avoid and minimize the effects on Fish and Fish Habitat.

5.1.1 Site Plan Alternatives

As part of project planning and site assessment efforts, multiple site layouts were considered for both project efficiencies and the avoidance of impacts to fish frequented waters. Although components such as the open pit are fixed due to the orebody, other project footprints such as stockpiles, the WRSA and road networks have some flexibility in their location. To this end, the Project team reviewed multiple locations and site plans for these features, before selecting the proposed arrangement.

5.1.1.1 Waste Rock Storage Area

The WRSA was relocated to its currently proposed location at the west of the property to avoid known fish frequented water. To date extensive fish sampling from 2015 to 2017 and 2020 have not captured fish within the WRSA footprint (MEL 2020; MEL 2020a). Additionally, environmental DNA samples collected both upstream and downstream of the barrier on WC-23 supports the sampling conclusion that no fish frequent the limited standing water within the WRSA boundary upstream of a natural barrier.

5.1.1.2 **Preferred Alternative Haul Road**

The Preferred Alternative Haul Road has been removed from the Beaver Dam Mine Project Description (AMNS 2021b). The movement of ore will be transported between the Beaver Dam Mine Site and the Tuoquoy Mine Site for processing using an existing road network. A portion of the network requires upgrading and some re-alignment to allow safe movement of large ore-carrying vehicles. Additionally, an ATV bypass road will be constructed parallel to the haul road to allow for safe non-mine, recreational vehicle use. As a result, direct impacts can be minimized and existing impacts due to damaged, non-functioning crossings can be mitigated (**Section** 5.2.2).

5.2 Measures to Mitigate

Measures to mitigate adverse effects on fish and fish habitat include both standard best practices that are implemented through all phases of the Project (e.g., construction, operation, decommissioning) and site-specific mitigation designs. Measures to Mitigate and minimize losses or reduced productivity of fish habitat have been established at several locations within the Project. Site-specific mitigation designs include a potential redesign of the North Settling Pond outflow to better simulate a natural groundwater upwelling, a possible groundwater pump at Cameron Flowage and fish relocation activities.

5.2.1 Standard Measures and Best Practices

To avoid or mitigate additional loss of waters frequented by fish or harm to fish habitat during implementation of the plan, a combination of site-specific mitigation measures as defined in permits, approvals or environmental assessment commitments and best management practices will be used. Measures and standards would include but not be limited to construction water management; erosion and sedimentation controls; and, timing windows to protect sensitive fish life cycle periods.

To mitigate and reduce overall loss of function of fish and fish habitat, the actions provided in **Table** 6 will be implemented by the Proponent within wetlands and watercourses where direct impacts and potential indirect impacts to fish and fish habitat are expected. Mitigation measures will be confirmed and adaptively managed through ongoing monitoring requirements, as described at the permitting stage. Considering the extensive planning, the ongoing engagement with the Mi’kmaq of Nova Scotia and stakeholders, and the use of proven mitigation measures/best management practices, the Proponent is confident that the Project can be constructed, operated, rehabilitated and closed, in an environmentally responsible and safe manner that minimizes and mitigates impacts to fish habitat.

Where possible the offset and compensation measures will be constructed in advance of major Project impacts. This approach will allow for the initial development and stabilization of the works to be achieved, and significant colonization of the new replacement habitats by adjacent fish communities while fisheries impacts occur. Any changes to the approximate time periods specified in the final plan would require notification and approval by DFO in advance of a revised schedule within an authorization.

Table 6: List of Mitigation Measures for Fish and Fish Habitat

Project Phase	Mitigation Measure
C, O, CL	Complete site meetings with relevant staff/contractors to educate and confirm policies related to working around fish bearing surface water systems including schedule of construction activities to minimize unauthorized disturbance and limit vegetation clearing
C	Provide signage on fish habitat streams
C	Complete micro siting of mine infrastructure to avoid or minimize fish habitat impact as necessary
C	Complete fish rescue within all fish bearing streams to be impacted by the Project, prior to commencement of mine development, with DFO approval if required
C	Implement construction methods that reduce potential interaction with fish habitat and limit vegetation clearing around watercourses
C	Complete culvert installations and upgrades in accordance with the NSE Watercourse Standard (2015) or as updated at time of construction. Limit vegetation clearing
C, O	Maintain 30 m riparian wetland and watercourse buffers, where practicable.
C, O	Use vegetated buffers and aquatic vegetation wherever practicable to provide shade to on-site ponds.
C, O	Install groundwater pumps to supplement baseflow in Cameron Flowage, if necessary
C, O, CL	Implement a groundwater interceptor trench on the west side of the PAG stockpile, if necessary
C	Minimize the removal of vegetation upgradient of watercourses and stabilize shorelines or banks disturbed by any activity associated with Project activities
C	Minimize the temporal extent of in-stream works as much as practicable
C, O	Follow DFO-advised *Measures to avoid causing harm to fish and fish habitat* pertaining to blasting (DFO 2019)
C, O	Implement Explosive Management Plan
C, O	Use an emulsion-type explosive that will minimize nitrogen release to surface water and groundwater
C, O	Use clean, non-ore-bearing, non-watercourse derived and non-toxic materials for erosion control methods
C, O	Incorporate drainage structures, where necessary, to dissipate hydraulic energy and maintain flow velocities sufficiently low to prevent erosion of native soil material
C, O	Limit clearing within confirmed fish habitat outside of approved alteration areas to within approved areas.
C, O	Acquire and follow watercourse alteration permits
C, O	Adhere to applicable timing windows, as directed by DFO, for construction where infilling has been approved in wetlands and watercourses where fish habitat is present
C, O	Ensure fueling areas are a minimum of 30 m from waterbodies
C, O	Use and maintain properly sized screens on any water intakes or outlet pipes to prevent entrainment or impingement of fish (DFO, 2020)
C, O	Ensure that machinery arrives on site in a clean condition and is maintained and free of fluid leaks
C, O	Develop and implement Mine Water Management Plan
C, O, CL	Collect and treat all contact water, as required
C, O, CL	Implement Erosion and Sediment Management Plan
C, O, CL	Maintain pre-construction hydrological flows into and out of down-stream surface water habitats, to the extent practicable, to limit indirect impacts to fish habitat
C, O, CL	Complete offsetting for HADD including for permanent loss of fish habitat through fish habitat restoration activities, subject to DFO approval, as required under the *Fisheries Act*
C, O, CL	Develop and implement the Aquatic Effects Monitoring Program to identify and further mitigate any additional adverse impacts to fish and fish habitat

Notes: C = Construction; O = Operations; PC = Post Closure; DFO = Fisheries and Oceans Canada; HADD = Harmful Alteration, Disruption or Destruction; NSE = Nova Scotia Environment; EEM = Environmental Effects Monitoring; MDMER = Metal and Diamond Mining Effluent Regulation.

5.2.2 Haul Road Habitat Connectivity

The proposed haul road location and fish habitat within the footprint are shown in **Figure** 23 with further detailed mapping in **Appendix** B. As shown, many existing road crossings are damaged and were considered non-functioning in terms of providing habitat connectivity between downstream and upstream fish habitat. In total, 17 of the 23 existing culverts along the haul road have been identified as crushed, buried, or hung. Three other existing crossings have functioning bridges and ten locations have been identified where new culverts are required. All crossings will be inspected and upgraded to meet the requirements of the haul road and any new or re-installations will be completed as per the Guidelines for the design of fish passage for culverts in Nova Scotia (DFO 2015). The replacement of damaged crossing structures with new under the existing guidelines will provide fish passage at all locations and hence mitigate historic habitat fragmentation. **Table** 7 provides a summary of existing crossings where replacement of damaged structures with properly designed and installed crossing infrastructure will re-establish habitat connectivity. The footprint of any new culvert locations and roadway widening remain as potential direct fish habitat losses and have been quantified.

Table 7: Haul road locations where crossing replacements will mitigate historic fish habitat fragmentation

Watercourse Location	Current Crossing (Condition)
WC-A	Culvert (buried). Proposed upgraded road alignment perpendicular to WC along a straight section of stream. Replace buried culvert. Standard mitigation will apply to limit impact to fish habitat and overall improve fish habitat through removal of buried culvert. HADD not expected. There is a minor direct impact to stream from culvert extension, but culvert replacement is perpendicular to watercourse and along a straight section of stream. Overall mitigated by the replacement of the buried culvert and improvements to historic fish habitat fragmentation.
WC-B	Culvert (crushed). Proposed upgraded road alignment perpendicular to WC along a straight section of stream. Replace crushed culvert. Standard mitigation will apply to limit impact to fish habitat and overall improve fish habitat through removal of crushed culvert. HADD not expected. There is a minor direct impact to stream from culvert extension, but culvert replacement is perpendicular to watercourse and along a straight section of stream. Overall mitigated by the replacement of the crushed culvert and improvements to historic fish habitat fragmentation.
WC-E	Culvert (blocked). Proposed upgraded road alignment perpendicular to WC, east of existing road. Remove blocked culvert on existing road and install new culvert downstream at new crossing location. Standard mitigation will apply to limit impact to fish habitat and overall improve fish habitat through removal of blocked culvert. No HADD expected. There is a minor direct impact to stream from culvert installation, but alignment of new watercourse crossing perpendicular to watercourse and along a straight section of stream. Overall mitigated by replacement of blocked culvert and improvements to historic fish habitat fragmentation.
WC-F	Culvert (crushed). Proposed upgraded road alignment perpendicular to WC, west of existing road. Remove crushed culvert on existing road and install new culvert downstream at new crossing location. Standard mitigation will apply to limit impact to fish habitat and overall improve fish habitat through removal of crushed culvert. No HADD expected. There is a minor direct impact to stream from culvert installation, but alignment of new watercourse crossing perpendicular to watercourse and along a straight section of stream. Overall mitigated by replacement of blocked culvert and improvements to historic fish habitat fragmentation.
WC-G	Culvert (crushed). Proposed upgraded road alignment perpendicular to WC. Replace crushed culvert. Standard mitigation will apply to limit impact to fish habitat and overall improve fish habitat through replacement of crushed culvert. No HADD expected. There is a minor direct impact to stream from culvert extension, but culvert replacement is perpendicular to watercourse and along a straight section of stream. Overall mitigated by the replacement of the crushed culvert and improvements to historic fish habitat fragmentation.

Watercourse Location	Current Crossing (Condition)
WC-H	Bridge (functioning). Proposed upgraded road alignment perpendicular to WC. Existing bridge to be expanded. Standard mitigation will apply to limit impact to fish habitat. Not expected. Bridge expansion to use standard construction methods – no impacts to the watercourse expected.
WC-I	Culvert (buried). Proposed upgraded road alignment perpendicular to WC. Replace buried culvert. Standard mitigation will apply to limit impact to fish habitat. No HADD expected. There is a minor direct impact to stream from culvert extension, but culvert replacement is perpendicular to watercourse and along a straight section of stream.
WC-K	Culvert (buried). Proposed upgraded road alignment perpendicular to WC. Install new culvert. Replace buried culvert. Standard mitigation will apply to limit impact to fish habitat and overall improve fish habitat through installation of culvert. No HADD expected. There is a minor direct impact to stream from culvert extension, but culvert replacement is perpendicular to watercourse and along a straight section of stream. Overall mitigated by the replacement of the buried culvert and improvements to historic fish habitat fragmentation.
WC-N-West River	Bridge (functioning). Proposed upgraded road alignment perpendicular to WC. Requires upgraded bridge at current crossing location. Standard mitigation will apply to limit impact to fish habitat. No HADD expected. Bridge expansion to use standard construction methods – no impacts to the watercourse expected.
WC-T	Culvert (buried). Proposed upgraded road alignment perpendicular to WC. Replace buried culvert. Standard mitigation will apply to limit impact to fish habitat and overall improve fish habitat through removal of buried culvert. No HADD expected. There is a minor direct impact to stream from culvert extension, but culvert replacement is perpendicular to watercourse and along a straight section of stream. Overall mitigated by the replacement of the buried culvert and improvements to historic fish habitat fragmentation.
WC-U	Culvert (functioning). Proposed upgraded road alignment perpendicular to WC. Replace functioning culvert. Standard mitigation will apply to limit impact to fish habitat. HADD not expected. There is a minor direct impact to stream from culvert extension, but culvert replacement is perpendicular to watercourse and along a straight section of stream.
WC-V	Culvert (buried). Proposed upgraded road alignment perpendicular to WC. Replace buried culvert. Standard mitigation will apply to limit impact to fish habitat and overall improve fish habitat through removal of buried culvert. HADD not expected. There is a minor direct impact to stream from culvert extension, but culvert replacement is perpendicular to watercourse and along a straight section of stream. Overall mitigated by the replacement of the buried culvert and improvements to historic fish habitat fragmentation.
WC-W	Culvert (hung). Proposed upgraded road alignment perpendicular to WC. Replace hung culvert. Standard mitigation will apply to limit impact to fish habitat and overall improve fish habitat through replacement of hung culvert. No HADD expected. There is a minor direct impact to stream from culvert extension, but culvert replacement is perpendicular to watercourse and along a straight section of stream. Overall mitigated by the replacement of the hung culvert and improvements to historic fish habitat fragmentation.
WC-Y	Culvert (buried). Proposed upgraded road alignment is perpendicular to WC. Replace buried culvert. Standard mitigation will apply to limit impact to fish habitat and overall improve fish habitat through replacement of buried culvert. HADD not expected. There is a minor direct impact to stream from culvert extension, but culvert replacement is perpendicular to watercourse and along a straight section of stream. Overall mitigated by the replacement of the buried culvert and improvements to historic fish habitat fragmentation.
WC-AA	Culvert (hung). Proposed upgraded road alignment perpendicular to WC. Replace hung culvert. Standard mitigation will apply to limit impact to fish habitat and overall improve fish habitat through removal of hung culvert. No HADD expected. There is a minor direct impact to stream from culvert extension, but culvert replacement is perpendicular to watercourse and along a straight section of stream. Overall mitigated by the replacement of the hung culvert and improvements to historic fish habitat fragmentation.
WC-AD-Morgan River	Bridge (functioning). Proposed upgraded road alignment will require upgraded bridge at current crossing location. Standard mitigation will apply to limit impact to fish habitat. HADD not expected. Bridge expansion to use standard construction methods – no impacts to the watercourse expected.
WC-AE	Culvert (buried). Proposed upgraded road alignment perpendicular to WC. Replace buried culvert. Standard mitigation will apply to limit impact to fish habitat and overall improve fish habitat through replacement of buried culvert. No HADD expected. There is a minor direct impact to stream from culvert extension, but culvert replacement is perpendicular to watercourse and along a straight section of stream. Overall mitigated by the replacement of the buried culvert and improvements to historic fish habitat fragmentation.

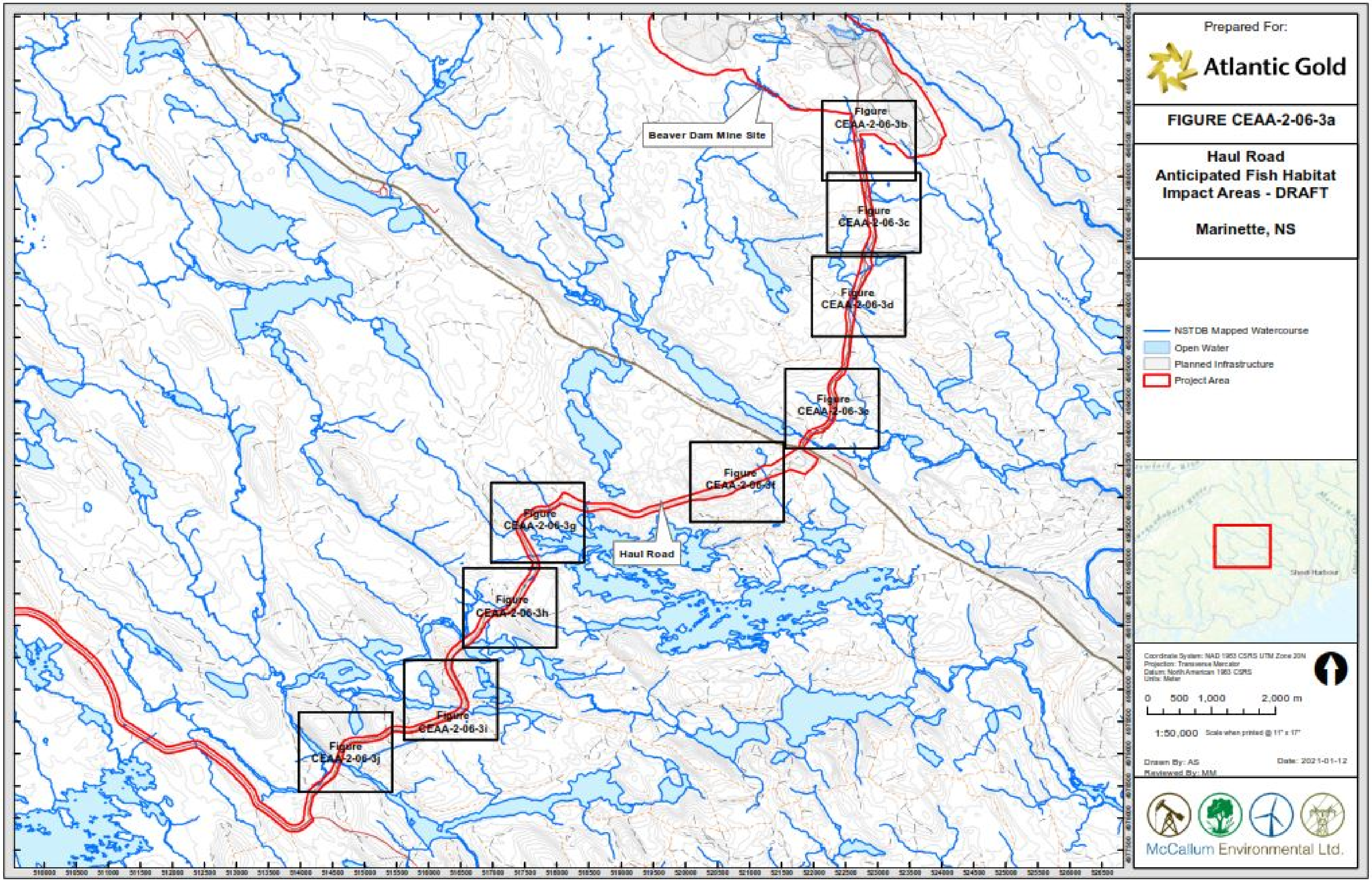


Figure 24: Haul Road Crossing locations (overview map), Beaver Dam Project (individual map sheets provided in Appendix B)

5.2.3 Potential Cameron Flowage Groundwater Mitigations

As noted previously, project scheduling will provide time to confirm existing groundwater upwelling potential within the Cameron Flowage near the Open Pit area. Therefore, the uncertainty around losses of existing groundwater seepages can be addressed prior to any final HADD determination of offset design. Should groundwater upwelling locations be identified during ongoing monitoring and used within Cameron Flowage, further mitigation will be considered including the design and installation of groundwater pump(s) during Project Operations or modification of the North Settling Pond discharge to traverse underground and be more similar to baseflow conditions.

Based on observations of juvenile Atlantic Salmon behaviour and habitat use at groundwater seepages, older juveniles used slightly deeper habitat even if the cooler water associated with the seepage was at a shallower water depth. Based on Breau et al. (2007), artificial sites should be relatively deep and variable water depths up to 0.5 m; water velocity and substrate were not considered key parameters.

Details on possible locations would require additional site-specific details such as groundwater depth, temperature, access, groundwater recharge rate, power requirements, and geology, would be required prior to final determination as a feasible mitigation option during Project operations.

5.2.4 Fish Relocation

Watercourses requiring fish relocation include those sections of fish habitat within the Open Pit area (e.g., WC-12, WC-13, WC-14, WC-25, WL56, WL59). The following outlines the general tasks required to complete the capture and relocation of fish.

5.2.4.1 Permitting

Upon issuance of an authorization under Section 35 of the *Fisheries Act*, general permits required for fish relocation include an experimental license from DFO to handle fish, and a relocation permit to move fish from one waterbody to another (particularly if transfers are required outside the fish's resident watershed). A detailed fish rescue plan will be provided to DFO at the permitting phase of the Project, prior to completion of this task. Within the Project area, all fish can be relocated to other portions of their resident watershed (Killag River). Given the numbers of fish captured in baseline habitat characterization, numbers of fish are anticipated to be low; and such it is expected that the adjacent waterbodies can accommodate the numbers of transferred fish.

5.2.4.2 Tributary Isolation and Relocation

Guidance for the approach to fish rescue was obtained from Fisheries and Oceans Canada Fish Rescue Guidelines (DFO 2015). The general approach outlined therein will involve a combination of passive trapping, seine netting, fish collection via electrofishing where possible, and dip-netting isolated pools during de-watering. The approach to the fish rescues typically involves adaptive management based on fish collection results and site conditions.

The fish rescue will be completed by a team of aquatic ecologists, experienced in the collection, handling and transfer of fish. For linear features and open water features which are safely wadable and easily isolated, the following approach to fish rescue will be taken. The license holder will identify the area to be isolated by installing barrier nets (or similar) on the upstream and downstream ends of the reach. The specific fish rescue methodology will vary based on factors such as depth, substrate, wade ability, water temperature and turbidity of the water. The following techniques will be used either alone or in combination, until an appropriate depletion target is reached.

- Passive trapping (minnow traps, eel pots, fyke nets);
- Seining;
- Electrofishing; and
- Dip-netting.

The rescue will be completed to minimize handling of fish, particularly if completed during warmer months, to reduce stress to fish. Measures such as oxygen supplementation and water cooling can be used as needed. A sub-sample of individuals per species will be sampled (physical measurements recorded), with the remaining to be identified and enumerated only. To reduce handling and stress to fishes, measurements of length, weight and age class, will not be recorded, unless requested by DFO (in consideration of Atlantic salmon, if caught). Fish will be released into the natural environment as soon as possible, and the rescue team will closely monitor fish for signs of stress. For each individual reach requiring fish rescue, a release point will be clearly identified, as close to the rescue site as possible in directly contiguous waters.

For open water features where safe wading is not possible, consideration will be given to the use of a barge or boat-based electrofisher or rely on passive trapping. Within the open water portion of WL59, abundant standing dead trees and snags present challenges for both access and fishing efforts, particularly electrofishing. In this habitat, the fish rescue will occur through successive isolation of sections wherever possible, using repeated days of extensive trapping efforts and seine netting. This work will be conducted immediately prior to, and during dewatering efforts.

Fish will be released primarily into Killag River, as it is the nearest contiguous watercourse. Based on the catch results, the team will consider releasing some fish into Crusher Lake and/or Mud Lake, to reduce competition for resources in a single release location. During each rescue reach, personal will remain on site during de-watering to dip-net any fish remaining in the reach, wherever safely practicable. This will allow an estimate of mortalities, to be provided to DFO in a summary report outlining results of the fish rescue.

5.2.5 Mitigation Monitoring

Monitoring of standard mitigations described above are to be outlined in the Mine Water Management Plan (MWMP). Effects monitoring and adaptive management measures will be outlined within the Aquatic Effects Monitoring Plan (AEMP). To ensure that the measures and standards described are implemented as proposed, AMNS onsite monitors (or designates) will monitor construction and implementation of this plan. Monitoring will clearly be defined in the final offset plan, and DFO Authorizations, and be reported to DFO in an “as constructed” report provided following the works being completed. The “as constructed” monitoring report will document the construction of the offset and works as per the approved plans, and a summary of the mitigation measures and any contingency measures implemented to prevent further impacts to fish habitat. A detailed photographic record will be taken during implementation of the plan using consistent vantage points prior to, during and post construction.

5.3 Summary Habitat Effects / Alterations

Standard mitigations as well as project-specific avoidances and redesigns have minimized the potential aquatic habitat effects / alterations. It is understood that the final HADD determination will be provided by DFO; however, this description of habitat effects and extent of possible alterations is provided to show that all interactions with the aquatic environment has been considered and that offset concepts described in **Section** 6.0 can be designed to meet HADD quantity expectations, including any offset ratios. It should be noted that most of the impacted habitat is degraded due to past disturbances by others. The description and quantity of the habitat was not adjusted/corrected for existing degradation or species utilization and therefore represent very high quantities of habitat potentially affected / altered by the Project. Further quantification as to the relative loss of habitat in terms of productivity and species utilization will be confirmed during ongoing HADD determination with DFO.

The quantification of fish habitat for the purposes of determining HADD to fish habitat waterbodies requires a process that removes as much subjectivity as possible so that final determinations are defensible in approach and rationale. Revised federal habitat classification and quantification systems were developed by DFO Newfoundland and Labrador Region to assist in assessing proposed developments for potential to cause HADD of both riverine and lacustrine fish habitats. An overview of the processes is provided below based on information contained within DFO (2012), and DFO (2005). While developed in a different region of Atlantic Canada, it is adjacent and appropriate for the similar dominant maritime fish complex found within the Project footprint. Further examples of habitat quantification for habitat affected by the Project using these methods is provided in **Appendix** A.

5.3.1 Mine Site – Direct Impact

Direct projects effects include all watercourses and waterbodies that would be lost as a result of direct interaction with Project infrastructure. These habitats include watercourses within the pit footprint, stream sections lost under the haul road, and waterbodies that will be drained because they near the ore body (pit). Details of each watercourse is provided in **Sections** 4.3.3 and 4.3.4. A total of 39,433.44 m^2 of fish habitat of varying quality will be lost within the project footprint; 652.80 m^2 of fluvial and 38,790.64 m^2 of lacustrine habitat (**Table** 8).

Table 8: Summary of aquatic habitat directly lost within the proposed Project Footprint

Watercourse / Waterbody	Infrastructure	Area (m^2)	Habitat Units
WC-5	Internal Haul Road	154.00	1.54
WC-12	Pit	93.00	0.93
WL56	Pit	1,454.27	14.54
WC-13	Loss of upstream flow	279.45	2.79
WL59	Pit, Internal Haul Road	37,162.70	371.62
WC-14	Internal Haul Road, loss of upstream flow	108.80	1.09
WC-25	Loss of upstream flow	17.55	0.18
WL61	Pit Perimeter Road	173.67	1.74
Total		**39,433.44**	**394.33**

5.3.2 Haul Road – Direct Impact

Updating the existing road used to transport ore between the Beaver Dam Mine Site will require widening and new culverts in select locations. A portion of the wider footprint is needed to accommodate a parallel ATV trail to maintain recreational access. All watercourses and wetlands along the Haul Road identified as potential fish habitat were considered fish habitat for the purposes of the direct impact estimates (wetlands with contiguous and/or open water areas). Direct habitat loss caused by the haul road have been calculated using average width and length measurements (i.e., width of watercourse x length of impacted watercourse = area of directly impacted waterbody), including the allowance for the ATV bypass road, which has been added to the Project Description in the Updated 2021 EIS (AMNS 2021B).

It should be noted that replacement of existing damaged crossing structures will reconnect downstream and upstream fish habitat; therefore, these replacements are considered mitigation towards the replaced crossing footprint (**Section** 5.2.2). The remaining fish habitat directly under the upgraded haul road (e.g., new crossing structures and road footprint widening) has been quantified and included in direct habitat losses. In total, 2,430.3 m^2 of fish habitat of varying quality will be lost within the haul road footprint; 184.50 m^2 of fluvial and 2,245.80 m^2 of lacustrine habitat (**Table** 9).

Table 9: Fluvial habitat directly impacted by proposed from construction of infrastructure along the Haul Road

Watercourse Location	Current Crossing (Condition)	Direct Footprint Impact (m^2)	Habitat Units
WC-C	WL67 under footprint. Proposed upgraded road alignment perpendicular to WC on eastern side of road. Replace functioning culvert. On western side of road, alignment expected to have direct impact on WC through ditching/infilling. Standard mitigation will apply to limit impact to fish habitat	7.4	0.07
WC-D	New culvert to be installed. Proposed upgraded road alignment perpendicular to WC. Install new culvert at crossing location. Standard mitigation will apply to limit impact to fish habitat.	10.5	0.11
WC-J	Proposed upgraded road alignment perpendicular to WC on eastern side of road. Replace buried culvert. On western side of existing road, alignment overlaps approximately 17.3 m of parallel stream that flows into western ditch. Proposed road upgrade will funnel the WC directly across the road to the eastern side and away from the ditch network associated with the road. Standard mitigation will apply to limit impact to fish habitat.	21.6	0.22
WC-L	WC runs parallel to current road in western roadside ditch. Proposed road upgrade will require the functioning culvert to be replaced to funnel the WC directly across the road to the eastern side and away from ditch network associated with the road. Proposed road alignment overlaps approximately 53 m of parallel ditched stream. Standard mitigation will apply to limit impact to fish habitat.	15.9	0.16
WC-M	Proposed upgraded road alignment is perpendicular to WC at two locations (north and south). Northern crossing will require an extension to existing culvert which is functioning. Southern crossing will require installation of a new culvert. Standard mitigation will apply to limit impact to fish habitat.	10.9	0.11
WC-O	New culvert installation. Proposed new road designed perpendicular to WC. Requires culvert installation. Standard mitigation will apply to limit impact to fish habitat.	29.3	0.29

Watercourse Location	Current Crossing (Condition)	Direct Footprint Impact (m^2)	Habitat Units
WC-P	New culvert installation. Proposed new road designed perpendicular to WC. Requires culvert installation. Standard mitigation will apply to limit impact to fish habitat.	10.2	0.10
WC-X	New culvert installation. Proposed upgraded road alignment is perpendicular to WC and will require a new culvert installation. Standard mitigation will apply to limit impact to fish habitat and overall improve fish habitat through providing fish access to upstream aquatic resources.	12.1	0.12
WC-AC	New culvert installation. Proposed upgraded road alignment overlaps with the top end of this watercourse (3.7 m). This area may be altered to support road upgrades. Standard mitigation will apply to limit impact to fish habitat.	8.3	0.08
WC-AF	New culvert installation. Proposed upgraded road alignment overlaps with the bottom end of this watercourse (40.2 m), at which point the watercourse currently empties into the southern ditch along the existing road. Current ditch drains east towards culvert at WC-AE. Proponent will consider installation of a culvert to funnel the watercourse directly across the road north towards WC-AH, away from the ditch network associated with the road. Standard mitigation will apply to limit impact to fish habitat.	46.3	0.46
WC-AG	New culvert installation. Proposed upgraded road alignment overlaps with the bottom end of this watercourse (18.4 m), at which point the watercourse currently empties into the southern ditch along the existing road. Current ditch drains east towards culvert at WC-AE. Proponent will consider installation of a culvert to funnel the watercourse directly across the road north towards WC-AH, away from the ditch network associated with the road. Standard mitigation will apply to limit impact to fish habitat.	12.0	0.12
WL64	Buried culvert associated with WC-A located at wetland crossing. Proposed upgraded road alignment overlaps surface water features (presumed fish habitat) both sides of road. Replacement of buried culvert likely to improve fish access into wetland.	48.7	0.49
WL66	Proposed upgraded road alignment overlaps wetland complex at two locations – a northern crossing (associated with WC-B) and a southern crossing. At northern crossing, proposed upgraded road alignment overlaps surface water features (presumed fish habitat) on both sides of road. Replacement of crushed culvert on WC-B likely to improve fish access into wetland. No culvert/bridge currently exists at southern crossing. Proposed upgraded road alignment overlaps surface water features (presumed fish habitat) on west side of road. Proponent will consider installation of a culvert to re-establish natural wetland hydrology which may provide fish access into previously inaccessible fish habitat.	487.0	4.87
WL73	No culvert is present at current wetland crossing. Proposed upgraded road alignment overlaps surface water features (presumed fish habitat) currently exist on both sides of road, likely caused by road impoundment. Proponent will consider installation of a culvert to re-establish natural wetland hydrology which may provide fish access into previously inaccessible fish habitat.	185.2	1.85
WL76	Crushed culvert associated with WC-G located at wetland crossing. Proposed upgraded road alignment overlaps surface water features (presumed fish habitat) both sides of road. Replacement of crushed culvert likely to improve fish access into wetland.	398.6	3.99
WL146	No culvert is present at wetland crossing. Proposed upgraded road alignment overlaps surface water feature (presumed fish habitat) on both sides of road – extensive flooding on west side likely caused by road impoundment. Proponent will consider installation of a culvert to re-establish natural wetland hydrology which may provide fish access into previously inaccessible fish habitat from WC-Z.	106.4	1.06
WL154	Headwater wetland confined to west side of road. Proposed upgraded road alignment overlaps surface water feature (presumed fish habitat). No culvert proposed.	176.9	1.77
WL159	Hung culvert associated with WC-AA located at wetland crossing. Proposed upgraded road alignment overlaps surface water feature (confirmed fish habitat). Replacement of hung culvert likely to improve fish access upstream to WL160.	6.5	0.07

Watercourse Location	Current Crossing (Condition)	Direct Footprint Impact (m^2)	Habitat Units
WL160	Hung culvert associated with WC-AA located at wetland crossing. Proposed upgraded road alignment overlaps surface water feature (confirmed fish habitat). Flooding observed in wetland likely caused by improper culvert sizing. Replacement of crushed culvert likely to improve fish access and re-establish natural wetland hydrology.	836.5	8.37
Total		**2,430.3**	**24.30**
Note: WC – watercourse (fluvial), WL – waterbody (lacustrine)			

5.3.3 Mine Site - Indirect Alterations

Table 10 provides a summary of instantaneous flow analysis from each watercourse for an average and dry flow year, respectively. Site locations for instantaneous flow estimates are shown in **Figure** 6. Watercourses determined to be altered by hydrological changes of sufficient quantity and/or duration to cause greater potential to indirectly impair the habitat's capacity to support one or more life processes are those highlighted (bolded) in the table, as described in **Section** 4.3.2.1. Each habitat is predicted to show reduced streamflow; however, the remaining habitat will not be completely lost, and it is anticipated that some level of productivity will remain.

As shown, watercourses WC-5, WC-23, WC-26, and WC-27 all have exceedances of at least one criterion and were carried forward to be described and quantified. In total, the four watercourses contain an estimated 7,728.88 m2 of fluvial habitat at 30% MAD of varying quality and species utilization that may be altered as a result of flow reductions.

The predicted flow reductions in Cope Brook downstream of its confluence with WC-23 are <10% overall flow reduction and only an additional five and four days with flows <30% for average and dry years, respectively. Therefore, any alteration is considered to have a low probability of causing a detectable effect.

While flow reductions within WC-26 and WC-27 were predicted to be moderate, the change in flows within the Killag River immediately downstream of each confluence is predicted to be relatively low at less than 3.5 % showing the overall low contribution and effect of each tributary to the flow within the Killag River.

Table 10: Summary analysis of instantaneous flows against criteria (bold values are exceedances)

Watercourse	Modelled DFO Criteria			Modelled % Flow Alteration (%MAD)[1]	>10% Flow Alteration Criteria Exceeded?	Increase Days <30% (%)
	100% MAD (m^3/s)	**90% MAD (m^3/s)**	**30% MAD (m^3/s)**			
Average Flow Year (2003)						
WC-5	0.025	0.022	0.007	-4.7	Yes	**+12.2**
WC-23	0.054	0.049	0.016	**-17.4**	Yes	**+14.8**
WC-26	0.023	0.021	0.007	**-25.0**	Yes	**+25.2**
WC-27	0.070	0.063	0.021	**-18.5**	Yes	**+21.4**
Killag River						
Killag River Upstream of Project	0.412	0.371	0.124	0.0	No	+0.0
Killag River Downstream of WC-26 confluence	0.460	0.414	0.138	-1.2	No	+0.0
Killag River Downstream of WC-27 confluence	0.554	0.499	0.166	-3.2	No	+2.6
Killag River at Cameron Flowage	1.064	0.958	0.319	-1.7	No	+0.9
Killag River at NSSA Lime Dosing Station	1.118	1.001	0.335	+1.0	No	-7.0
Killag River Downstream of Project	1.169	1.052	0.351	+1.0	No	-9.6
Cope Brook						
Cope Brook Upstream of WC-23	0.075	0.068	0.335	0.0	No	0.0
Cope Brook Downstream of WC-23 confluence	0.143	0.129	0.351	-6.7	No	+5.2
Dry Flow Year (1992)						
WC-5	0.016	0.015	0.005	-6.1	Yes	**+11.6**
WC-23	0.037	0.033	0.011	**-18.9**	Yes	**+10.5**
WC-26	0.016	0.014	0.005	**-25.0**	Yes	**+14.7**
WC-27	0.047	0.042	0.014	**-17.0**	Yes	**+15.3**
Killag River						
Killag River Upstream of Project	0.279	0.251	0.084	0.0	No	+0.0
Killag River Downstream of WC-26 confluence	0.311	0.280	0.093	-1.3	No	+0.7
Killag River Downstream of WC-27 confluence	0.374	0.337	0.112	-3.2	No	+2.8
Killag River at Cameron Flowage	0.720	0.648	0.216	-1.8	No	+0.7
Killag River at NSSA Lime Dosing Station	0.756	0.680	0.227	+1.6	No	-6.3
Killag River Downstream of Project	0.802	0.722	0.241	+1.4	No	-6.3
Cope Brook						
Cope Brook Upstream of WC-23	0.051	0.046	0.015	0.0	No	+0.0
Cope Brook Downstream of WC-23 confluence	0.097	0.087	0.029	-7.2	No	+2.8

[1] Flow alteration noted is the largest reduction between End-of-Mine and Post-closure. All flows based on instantaneous (daily) flows

DFO = Fisheries and Oceans Canada; m3/s = cubic meters per second; MAD = mean annual discharge; > = greater than; < = less than; % = percent; WC = watercourse.

The total number of days when flow within the Killag River just downstream of each confluence was <30% MAD also reviewed under baseline (non-project) and EOM/PC conditions. The Killag River would incur no additional and one additional day below the 30% MAD at the confluence of WC-26 (average and dry years, respectively) and only three or four additional days a year below the confluence of WC-27 (average and dry years, respectively). Additionally, at the upriver end of Cameron Flowage, approximately 2.0 km downriver from the confluence of WC-27, there is only one additional day below 30% MAD (in both average and dry years). The Killag River had a predicted increase in flow and decrease in number of days <30% MAD within and downstream of Cameron Flowage likely because baseflow losses to the nearby pit will be augmented by the collection, treatment, and release of all pit water back to the Killag River which would include flows from around the full mine pit from other watercourses. Therefore, flow reductions within the northern portion of the Killag River as a result of flow reductions in WC-26 and WC-27 is considered to have low probability of causing any detectable effects.

While the Cameron Flowage can be described as a semi-confined river channel section, given the general topography (i.e., low river valley relief, lack of river channel curvature, and limited inflow tributaries near the Open Pit area) concentrated groundwater upwelling locations are not likely. While the Cameron Flowage can be described as a semi-confined river channel section, given the general topography (i.e., low river valley relief, lack of river channel curvature, and limited inflow tributaries near the Open Pit area) concentrated groundwater upwelling locations are not likely. While the overall change in water temperature is not predicted to increase more than $0.5^{\circ}C$ over baseline, if groundwater upwelling(s) are confirmed, a portion of the west shoreline within baseflow model cells numbered CF-3 to CF-6 (see **Figure** 18) would be altered and therefore a portion of the estimated total area of those cells (68,957.41 m^2), may be included in the fish habitat affected.

Field surveys to confirm the absence (or presence) of groundwater upwelling area(s) along the west shore of Cameron Flowage have been partially completed; however, icing conditions just prior to surveys limited the ability of the thermal drone to detect possible groundwater upwelling sites. Therefore, additional surveys are scheduled during the 2021 open water season and the uncertainty around existing groundwater seepages can be addressed prior to final offset design.

6.0 Preliminary Habitat Offsets

The Project as proposed would likely result in the permanent direct loss of fish habitat and its associated productive capacity, through a portion of watercourses within the Project Mine site as well as the Haul Road. It also would result in indirect alterations downstream of the Project infrastructure footprint due to partial flow reductions and possible reductions in existing baseflow that may form concentrated upwelling(s). While complete habitat loss as a result of predicted flow reductions (both surface water and groundwater) is not predicted, the extent and magnitude of possible effects on fish habitat production will be determined with DFO as the HADD is finalized.

Regardless of the final HADD quantity, proven rehabilitation and habitat creation techniques in similar geographic settings for similar fish species provide the greatest likelihood of offsetting lost productive capacity for the long term, are least likely to fail structurally, and require the least amount of maintenance. Low-risk options that are biologically relevant were prioritized during the development of this preliminary Offsetting Plan. In addition to using proven offsetting methods, habitat improvements and rehabilitation around Atlantic Salmon, a fish species of local and provincial importance, was also incorporated wherever possible in each offset option.

The technical feasibility of the proposed offsetting options was assessed in consideration of the site conditions present, including topography, geomorphology, hydrology, site accessibility, and the type of physical works proposed; however, additional field information upon confirmation of the approach with DFO will help complete final design and construction methods.

Greater fish habitat offsetting ratios may also be required if the offsetting plan includes options that utilize techniques with long lag-times before they become fully functional. Likewise, lesser ratios may be required where habitat is only marginally altered. Equivalency of the proposed offsets is also considered relative to the productivity, importance, and quality of net fish habitat losses identified in the HADD determination.

The information below is a list of preliminary information and strategies to offset fish habitat (HADD) after measures to avoid and mitigate have been accounted. Preferred offsetting options will be further refined based on discussions with DFO and relevant stakeholders during the detailed offset planning process. It is also possible that alternative approaches not listed could be integrated into any Final Authorization Application (via an Offsetting Plan) if required or that exact locations of offsetting measures may change. The offsetting alternatives provided below have been developed consistent with DFO's Policy for Applying Measures to Offset Adverse Effects on Fish and Fish Habitat Under the *Fisheries Act* (hereafter this Policy).

6.1.1 Offset Options

Preliminary offset planning has begun which will enable DFO and others to assess the alternatives for feasibility and acceptability. Provided below are several options that have been considered feasible at the preliminary stage and, based on habitat needs of resident species and experience on similar offset designs, have a high degree of successfully being implemented.

Several options have been identified for preliminary assessment. Each was assessed using a ranked scale (**Table** 11) across numerous categories that describe various aspects of option feasibility (**Table** 12).

Potential options were evaluated by consideration of multiple criteria including:

- Adherence to DFO's principles and policy for offsetting;
- Location within the Beaver Dam watersheds (e.g., Killag River) and close to the Beaver Dam Mine Site;
- Self-sustaining;
- Technically feasible and economically viable; and
- Provide similar "in-kind", or higher quality, habitat as an offset.

The identified potential offsetting concepts (**Table** 13) were developed without detailed consultation with Indigenous Groups, agencies, or public groups and are therefore considered preliminary; however, the options identified conform to the criteria and provide offset habitat located within the same ecological unit / watershed and provide habitat types and suitabilities similar to, or greater than, the habitat being lost.

Table 11: Ranking Scale Legend for Candidate Fish Habitat Offset Options

Rank Scale	Rank Meaning	Rank Definition
1	Very Low	Very Low feasibility and/or certainty of the proposed offset alternative relative to the specific category
2	Low	Low feasibility and/or certainty of the proposed offset alternative relative to the specific category
3	Moderate	Moderate feasibility and/or certainty of the proposed offset alternative relative to the specific category
4	Moderate to Good	Moderate to Good feasibility and/or certainty of the proposed offset alternative relative to the specific category
5	Good	Good feasibility and/or certainty of the proposed offset alternative relative to the specific category
6	Very Good	Very Good feasibility and/or certainty of the proposed offset alternative relative to the specific category

Table 12: Definition of Categories for Candidate Compensation Options

Categories	Definition
Overall rank	Rank is order of highest cumulative ranking scores (an overall rank of 1 being the highest or more likely feasible alternatives).
Alternative	Description of alternative, representing the type of alternative (i.e., channel realignment, new pond basin, existing habitat enhancement).
Simplicity of concept and pre-design info needs	Simplicity ranking, with 1 being the least simple and 6 being the simplest. Lower rankings will require more extensive field programming, modelling, engineering design, and/or time to obtain necessary pre-design information.
Monitoring simplicity and success certainty	Monitoring success simplicity ranking, with 1 being the least simple and 6 being the simplest. Effort required to establish certainty of project success through monitoring.
Operational relevance	Relevance to facilitation of project site development. High relevance (e.g., 6) means the alternative also facilitates site infrastructure development.
Compatibility with existing land use	Brief description of existing land use and proposed offsetting alternative feasibility / compatibility with this land use type. Proposed offset alternative relevance to the existing land use, habitat type or fishery. High compatibility (e.g., 6) means the alternative is highly compatible with existing land use.
Habitat area gain - portion of constructed or restored habitat credited to offset balance	The proportion of the total area required to be compensated that the specific alternative can provide. New habitats receive highest values (100%= very high) while habitat enhancement may only receive partial credit.
Habitat area gain – percent of total offset amount required	The percent of the total area required to be compensated that the specific alternative can provide. This percent can be broken up into two groups: watercourse % and waterbody %. Higher values are awarded to larger alternatives.
Construction implementation and required controls	Level of controls and implementation required during the specific alternative construction to prevent additional environmental damage. Higher values are awarded where fewer controls are needed
Construction certainty	Feasibility of constructing the specific offset alternative, including access to the offset location and terrain type. High certainty (e.g., 6) means the constructability is highly certain.
Land tenure certainty	Certainty that Proponent will have tenure of the lands proposed to be included in the specific offsetting alternative. High certainty (e.g., 6) means the lands are under control of Proponent.
Relative cost per type of offset measure	Cost of the specific offset alternative relative to other proposed alternatives within the matrix. High relative cost (e.g., 1) means the cost is higher then other alternatives.
Stakeholder interest (aligns with interests of several groups, increases Diversity of fish community[1]	How well the specific offset alternative aligns with the interests of different stakeholder groups and provincial management objectives. Higher values are awarded to alternatives with high stakeholder alignment.
Cumulative score (highest is most preferred)	Cumulative score of the specific offset alternative using the rank scale (Table 10).

[1] Stakeholder interest is preliminary based on regulatory guidance and anticipated community interest. This ranking will need to be confirmed during consultation efforts.

Table 13: Candidate Compensation Concept / Options Matrix

Overall Rank	Alternative	Simplicity of Concept and Pre-design Information Needs	Monitoring Simplicity and Success Certainty	Operational Relevance	Compatibility with Existing Land Use and Ecological Relevance	Habitat Area Gain		Construction Implementation and required controls	Construction Certainty	Land Tenure Certainty	Relative Cost per Type of Compensation / Offset Measure	*Stakeholder Interest (Aligns with Interests of Several Groups, Increases Diversity of Fish Community)	Cumulative Score (Highest is Most Preferred)
						Portion of Constructed or Restored Habitat Credited to Compensation / Offset Balance	Percent of Total Compensation Amount Required						
1	Alternative 2A Excavate new pond Basins and channelized stream rehabilitation – offsite (four possible locations including identified West & East Blocks) Off-channel Pond constructed in Musquodoboit river outside of AGC lands	Good (5) Pond development is simple concept. Basic Fisheries and engineering values needed from reference lakes to replicate habitat. Most information is available or readily obtainable. Engineering studies required to predict ground conditions and hydraulic suitability.	Good (5) Monitoring is simple and relies on comparison to baseline reference values. Relatively short duration 3-10 years. Similar habitat should have similar fish values.	Low (2) Not required to facilitate project site development.	Ecological Relevance Good (5) Options to improve deficiencies in existing habitat; however, additional baseline data may be required.	Very Good (6) 100 percentage of the new basin should be credited to the compensation.	Good (5) Large areas may be available to provide 100% of required area but requires further study.	Good (5) New basins can be constructed in isolation and filled prior to connection. Excavations and habitat placements within new pond footprint will require sediment and erosion control planning to protect existing waterbodies during construction. Stream rehabilitation uses standard methods	Certain (6) Offsite access to site via site roads is good. New pond construction is relatively predictable. Alignment may be in soft wetland terrain and may require winter construction and or a new construction access road.	Good (6) Third party agreement is in place for West Block and very positive interest in East Block option. Other three locations are in various stages of agreement / discussions	Moderate (3) Waterbody construction cost is Moderate. Stream rehabilitation is cost-effective	Moderate (3) Works are somewhat removed from site and area of impact. Works are in area of interest and should have support of regulators, providing onsite options are not viable.	51
	Alternative 6 Excavate new pools and stream rehabilitation – onsite (within watercourses predicted to have reduced flows – WC-5, WC-23, WC-26, WC-27)	Very Good (6) Pool development and stream rehabilitation are simple concepts. Most information is available or readily obtainable. Stream surveys may be needed to determine exact rehabilitations that might best suit each watercourse.	Good (5) Monitoring is simple and relies on comparison to baseline reference values. Relatively short duration 3-10 years. Similar habitat should have similar fish CPUE. CPUE can also be compared against pre-construction baseline from same watercourse.	Moderate (3) Within property boundary. Coordination with Project construction timing may be required.	Ecological Relevance Good (5) Options to improve deficiencies in existing habitat; exact structure placement (e.g., pools, riffles) will require additional baseline data.	Good (4) Increased habitat availability and suitability for resident fish species in areas that may have reduced flows would be highly beneficial and valuable. High percentage of the enhancements should be credited to the compensation.	Low (2) Limited areas may be available to provide 100% of required area but requires further study. Not likely to offset entire HADD.	Good (5) Construction could require flow control and pumping during placement. Further engineering and regulatory discussion required. Instream work will require sediment and erosion control planning to protect existing habitat during construction. Stream rehabilitation uses standard methods	Certain (5) Onsite access is good. New pool and riffle construction are predictable. Access may require planning if machinery is required for pool excavations.	Good (6) Option would be on AMNS property boundary or nearby surrounding. Landowner likely agreeable to works but may require agreements if beyond property boundary.	Good (5) Watercourse enhancement construction is cost-effective. Due to size of streams, activities would not require excessive construction equipment.	Moderate (3) Works are within the property boundary and would benefit species / populations being affected by the Project and should have support of regulators.	49
2	Note: This alternative is considered mitigation and not an offset at this time Alternative 1 Groundwater Seepage Pump near Killag River	Moderate (3) Groundwater pumping used in various other applications; however, suitable location(s) would require further surveys	Very Good (6) Monitoring is simple and relies on visual (remote camera) and thermal monitoring in affected habitat. Methods are routine and standard	Good (5) Presence of existing groundwater seepage is yet to be confirmed. If present, mitigation could be important in juvenile salmon survival during warm water	Land Use Good (4) Mostly wetland and existing aquatic corridor. Ecological Relevance Very Good (6) High relevance as groundwater seepage will assist in alleviating juvenile stress and mortality during warm water	Moderate (4) Based on previous juvenile salmon densities at groundwater seeps, a 5m² seep can support juvenile salmon equivalent to 7-33 habitat units	Good (5) The groundwater seep can be used ot mitigate impact of groundwater upwelling loss but requires confirmation of ratio of mitigation with DFO. Estimated Habitat Equivalent Units can be up to 33 habutat units per pump	Moderate to Good (4) Not associated with project construction unless site power is used to power the pumping system. The unit(s) can be indepenent of site infrastructure and power	Good (5) Limited construction uncertainty. Exact location would need additional data related to geology, groundwater recharge rate, access, etc.	Low (2) Land tenure of pump locations would require confirmation	Moderate (3) Engineering an geotechnical data required and cost would depend on access and equipment needs	Good (5) Other stakeholders require further consultation, but concept would be focused on a known species of concern in Southern Uplands	46

Overall Rank	Alternative	Simplicity of Concept and Pre-design Information Needs	Monitoring Simplicity and Success Certainty	Operational Relevance	Compatibility with Existing Land Use and Ecological Relevance	Habitat Area Gain		Construction Implementation and required controls	Construction Certainty	Land Tenure Certainty	Relative Cost per Type of Compensation / Offset Measure	*Stakeholder Interest (Aligns with Interests of Several Groups, Increases Diversity of Fish Community)	Cumulative Score (Highest is Most Preferred)
						Portion of Constructed or Restored Habitat Credited to Compensation / Offset Balance	Percent of Total Compensation Amount Required						
2	Alternative 2B Salmon spawning & rearing enhancement, Musquodoboit River	Good (4) Design is typical but construction may be challenging. Further surveys in the main stem are pending	Good (5) Monitoring is simple and relies on comparison to baseline reference values. Relatively short duration 3-10 years. Similar habitat should have similar fish values	Low (2) Not required to facilitate project site development.	Ecological Relevance Very Good (6) Options to improve deficiencies in existing habitat; however, additional baseline data will be required. High existing juvenile rearing may limit further enhancement.	Good (5) A portion of HADD but direct enhancement of salmon habitat	Moderate (4) Overall portion of HADD is moderate but species focus in on key species of concern (Atlantic Salmon)	Moderate (3) Construction could require flow control and pumping during placement. Further engineering and regulatory discussion required	Moderate (4) Features are typical but may be challenging to install	Good (5) Third party agreement is in place for property along the north shore but may also need discussion / permitting from province	Moderate (3) Enhancement features highly beneficial for salmon but construction cost could be high – depends on installation	Good (5) Works are furthest removed from site but in area of impact. Works are in "area of concern" and should have interest of federal gov. public and FN.	46
3	Alternative 3 Complementary Measures	Good (5) Measures improve existing fisheries knowledge in areas of interest to Indigenous communities. Success is measured by the collection of data and greater understanding.	Moderate to Good (4) Monitoring is simple and relies on collection and analysis of data. Duration varies depending on study. Often relies on multiple groups collaborating.	Moderate (3) Not required to facilitate project site development but topic of study may interact with the site development.	Land Use Assumed Good (5) Studies generally examine existing aquatic habitat / fisheries. Good (5) Ecological Relevance High as the measure informs management decisions and can be relevant to ongoing project activities and other projects / initiatives.	Moderate (3) Value varies - habitat credit is given up to maximum of 10% of the Offset requirements.	Low (2) Maximum of 10% of the Plan.	Good (5) Generally, has limited construction and relies on study design and sampling logistics.	Good (5) Generally, has limited construction and relies on study design and sampling logistics.	Moderate (3) Landowner likely agreeable to works but may require agreements.	Moderate (3). Generally, cost effective to conduct studies, but values may be prorated to overall plan cost.	Very Good (6) Works are generally requested / proposed by Indigenous Communities and/or public and have interest of federal gov. public and FN.	44
4	Alternative 5 Restoration of degraded habitats in other watersheds outside the Project Area. May include removal of fish barriers. Possible collaboration with Indigenous Groups or other NS conservation groups	Moderate (3) Measures improve existing habitat and require detailed existing habitat values to compare to predicted values. Option has not been prepared to concept level as data required would be on a location-by-location basis.	Moderate (3) Post construction comparison must demonstrate that channel improvements have transferred to increased productivity. May require higher effort over 5-10 years to clearly demonstrate success. Unless physical completion is success metric.	Low (2) Not required to facilitate project site development and further removed from site.	Land Use Very Good (6) Existing channel / aquatic habitat. Good (5) Ecological Relevance Is high with restoration of former habitat that can be focused on target recreational species, but option has lower certainty of ecological success.	Moderate (3) The channel is existing and only partial credit for improvement will be given and/or will be based on relative productivity increases.	Moderate (3) Creek Length / habitat area to meet Project requirements is uncertain due to partial credit.	Moderate (3) Will require complex sediment and erosion control and water management planning to protect existing waterbodies during construction.	Good (5) Access unknow without further study. Habitat rehabilitation methods relatively standard.	Moderate to Good (4) Landowner likely agreeable to works but requires agreements.	Moderate (3) Cost per unit of creek / channel is unknown but expected to be high; however, lower uncertainty related to possible previous contamination.	Good (5) Works are furthest removed from site but would be in an area identified as requiring rehabilitation and would have interest of federal gov. public and FN.	40

Overall Rank	Alternative	Simplicity of Concept and Pre-design Information Needs	Monitoring Simplicity and Success Certainty	Operational Relevance	Compatibility with Existing Land Use and Ecological Relevance	Habitat Area Gain: Portion of Constructed or Restored Habitat Credited to Compensation / Offset Balance	Habitat Area Gain: Percent of Total Compensation Amount Required	Construction Implementation and required controls	Construction Certainty	Land Tenure Certainty	Relative Cost per Type of Compensation / Offset Measure	*Stakeholder Interest (Aligns with Interests of Several Groups, Increases Diversity of Fish Community)	Cumulative Score (Highest is Most Preferred)
5	Alternative 4 Restoration of degraded habitats in former mining areas. Includes barrier removal considerations. Possible collaboration with NS Lands	Moderate (3) Measures improve existing habitat and require detailed existing habitat values to compare to predicted values. Option has been prepared to concept level by Remedial action group (NS Lands). Requires planning and agreements with multiple groups.	Moderate (3) Post construction comparison must demonstrate that channel improvements have transferred to increased productivity. May require higher effort over 5-10 years to clearly demonstrate success. Unless physical completion is success metric.	Low (2) Not required to facilitate project site development and further removed from site.	Land Use Very Good (6) Existing channel / aquatic habitat. Very Good (6) Ecological Relevance Is high with restoration of former habitat, but option has lower certainty of ecological success.	Moderate (3) The channel is existing and only partial credit for improvement will be given and/or will be based on relative productivity increases.	Moderate (3) Creek Length/ habitat area to meet Project requirements is uncertain due to partial credit. Uncertainty related to water quality effects of former mining operations also requires consideration.	Moderate (3) Will require complex sediment and erosion control and water management planning to protect existing waterbodies during construction. May require complex schedule dependant on others (e.g., containment cells).	Good (5) Access unknow without further study. Habitat rehabilitation methods relatively standard.	Moderate to Good (4) Landowner likely agreeable to works but requires agreements.	Poor (2) Cost per unit of creek / channel is unknown but expected to be high due to contamination controls.	Good (5) Works are furthest removed from site but in area of impact. Works are in "area of concern" and have interest of federal gov. public and FN.	39

6.2 Alternative 1 – Groundwater Upwelling Stations (Mitigation)

While the presence of existing groundwater upwelling locations within Cameron Flowage is unlikely, and yet to be confirmed, the importance of such habitat features have been identified within the Maritime's range of Atlantic Salmon and can be critical during periods of low flows and high water temperatures (see **Section** 4.3.3.8). The possible installation of autonomous (i.e., wind or solar) groundwater pumping stations that can mimic the biological characteristics of natural groundwater upwelling may be beneficial to the existing Atlantic Salmon population within Killag River, the larger West River Sheet Harbour system, and further abroad. Additionally, the discharge from the North Settling Pond into Cameron Flowage can be modified to mimic a groundwater upwelling by discharging into the nearby baseflow area and allowing flows to percolate through existing groundwater routes or directed to a constructed underwater location to mimic an upwelling location. Burying a portion of the lower discharge channel will also allow greater water cooling.

The biological habitat design of a groundwater upwelling system would provide suitable habitat features for Atlantic Salmon juveniles to have greater chances of survival during warm water conditions. The concept has been previously described as a mitigation measure in **Section** 5.2.3. It has been carried into this section because if it is confirmed that a concentrated groundwater habitat is not present in Cameron Flowage, this option could be considered an option for offsetting lost habitat productivity. If installations in other portions of West River Sheet Harbour are considered, these would also be included as offsetting measure.

Additional engineering design would be required for both options, particularly if modifications to the North Settling Pond discharge is considered. Possible alterations to flow conditions, capacity, and maintenance may alter the overall design and feasibility.

6.3 Alternative 2 - Offsite Habitat Rehabilitation/Enhancement

The species and habitat within the Project footprint have been altered due to past mining activities. An ecosystem approach to offsetting has been applied to the planning; however, due to the location of the proposed mine site within the West River Sheet Harbour system and the social, recreational, and cultural significance of Atlantic Salmon in the area, consideration has been given to habitat features that, while would be beneficial to most species, would maximize utilization by salmonids. As shown by the surface water temperatures from the main stem of the Killag River near Cameron Flowage (**Section** 4.3.3.8 **Figure** 19), water temperatures can become high enough to trigger movement of juvenile Atlantic Salmon out of the area in search of cooler conditions (or toward local groundwater seepage). As a result, additional fish habitat enhancement features near the Project site within Killag River have not been considered at this time beyond possible groundwater options outlined above.

Open water habitat rehabilitation and/or creation is a well-known, successful method used in numerous offset plans to provide suitable young-of-year, juvenile, and adult habitat for most of the species identified within the Project footprint as well as Atlantic Salmon. Typical habitat features include those that rehabilitate overall habitat suitability, such as those that improve water quality, and those that increase a habitat type suitability for a life stage, such as increased spawning and rearing habitat.

Atlantic salmon of the Southern Upland of Nova Scotia have been designated as Endangered since November 2010 by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2010). As stated in the COSEWIC report, "*This species requires rivers or streams that are generally clear, cool and* *well-oxygenated for reproduction and the first few years of rearing but undertakes lengthy feeding migrations in the North Atlantic Ocean as older juveniles and adults. This population breeds in rivers from northeastern mainland Nova Scotia, along the Atlantic coast and into the Bay of Fundy as far as Cape Split. Small (one-sea-winter) and large (multi-sea-winter) fish have both declined over the last three generations by approximately 59% and 74%, respectively, for a net decline of all mature individuals of about 61%. Moreover, these declines represent continuations of greater declines extending far into the past. During the past century, spawning occurred in 63 rivers, but a recent (2008) survey detected juveniles in only 20 of 51 rivers examined. There is no likelihood of rescue, as neighbouring regions harbour severely depleted, genetically dissimilar populations. The population has historically suffered from dams that have impeded spawning migrations and flooded spawning and rearing habitats, and other human influences, such as pollution and logging, that have reduced or degraded freshwater habitats. Acidification of freshwater habitats brought about by acidic precipitation is a major, ongoing threat, as is poor marine survival related to substantial but incompletely understood changes in marine ecosystems. There are a few salmon farms in this area that could lead to negative effects of interbreeding or ecological interactions with escaped domestic salmon*."

Based on genetic evidence, regional geography and differences in life history characteristics Southern Upland Atlantic salmon is considered to be biologically unique (Gibson et al. 2011) and its extirpation would constitute an irreplaceable loss of Atlantic salmon biodiversity (DFO 2013). The genetic heterogeneity of the populations makes it more imperative that enhancement of the existing populations relies heavily on the remaining salmon and not on fish transfers from other nearby units.

6.3.1 Musquodoboit River

The Musquodoboit River Valley is located approximately 14 km west of the Beaver Dam Mine Site and generally comprises floodplain/intervale land adjacent to the Musquodoboit River and has been subject to intense farming practices. Land to the east and west of the lower lying floodplain areas rise in elevation and is dominated by undeveloped forested land that has been subject to infrequent tree harvesting activities. Many headwater streams originate from these higher lands and drain through the lower lying agricultural areas via a combination of undisturbed streams and ditching networks into the Musquodoboit River. It has been identified as a river system (e.g., Kent Brook) where efforts to increase the abundance of Atlantic Salmon may be a worthwhile investment (Montgomery *et al*. 2020).

A review of MEL's existing database of potential locations was completed within the Musquodoboit River watershed to determine if suitable fish habitat rehabilitation/enhancements could be possible. In total, four locations have been identified with potential for habitat rehabilitation (**Figure** 25). Provided below is a summary of one key area as well as an overview of the offsets types available. Review of available literature provided limited fish species presence information; however, MEL indicates that similar forage species composition to that of West River would be anticipated (e.g., lake chub, creek chub, banded killifish, white sucker). Species of recreational value include Atlantic Salmon and searun Brook Trout.

The Musquodoboit River is located in central Nova Scotia and is generally northwest of the Beaver Dam Mine Site. The river is 97 km long with a drainage basin approximately 1,409 km^2. In 2011, the watershed was assessed as part of Nova Scotia's Watershed Assessment Program (NSE 2011). The assessment included many watershed impact indices including Portion of human land use, Acid Rain rating, Portion of streams bound by human land use, and Stream/Road crossings. The overall index for Musquodoboit River was determined to be "3" and is considered High which indicates an overall increased impact to the system.

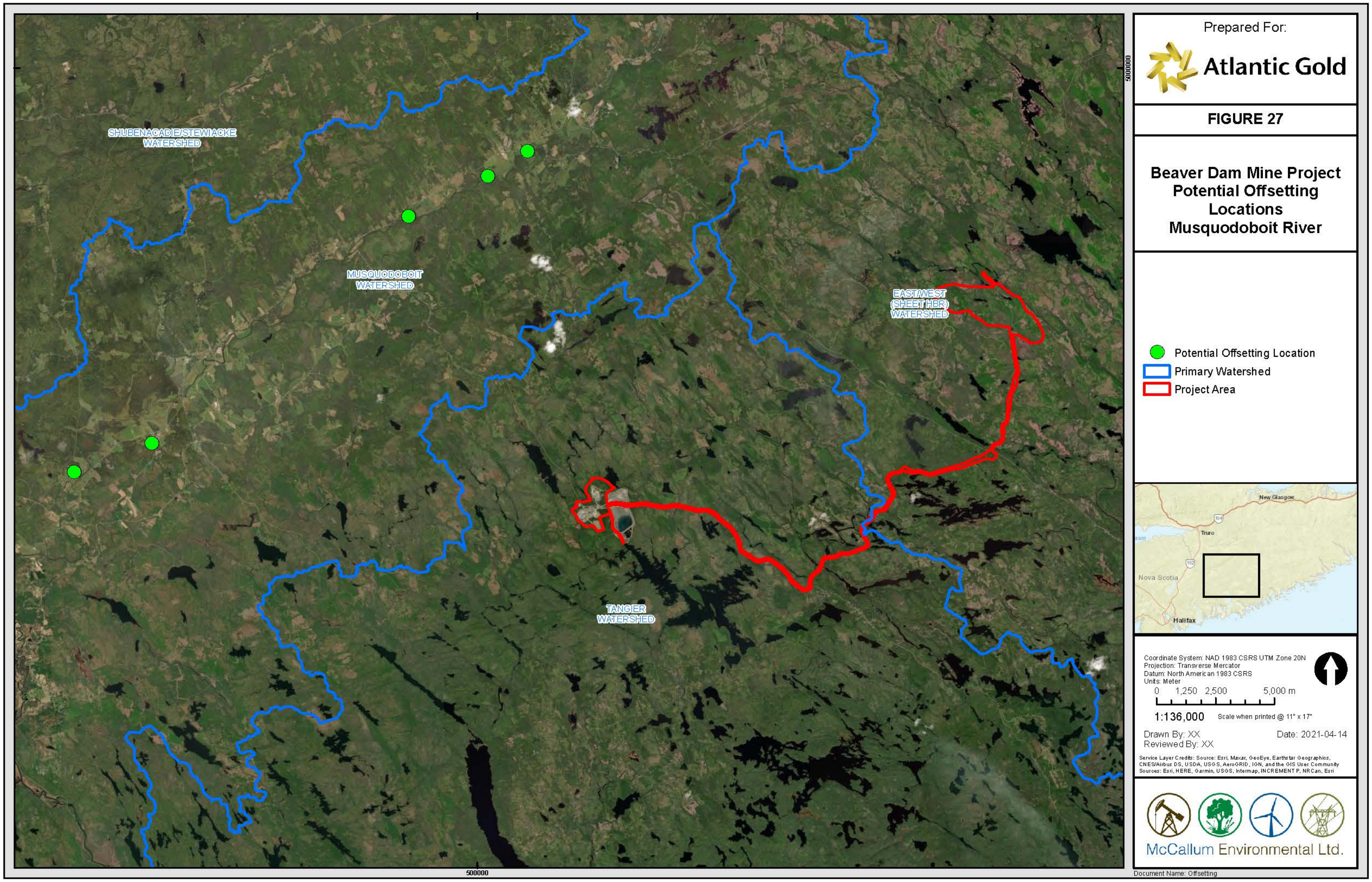


Figure 25: Proposed habitat offset locations, Musquodoboit River

The existing information within the assessment program report does not provide the individual index rankings to allow further analysis of indices with the greater influence on watershed conditions; however, additional data has been extracted from the provincial website (https://novascotia.ca/nse/water.strategy/).

6.3.1.1 Water Quality

A total of three waterbodies have been sampled by the provincial government for water quality parameters within the Musquodoboit River with varying time series. A key limiting factor to successful habitat rehabilitation would be low pH within the watershed. If pH conditions are too low, survival of eggs and young salmonids may be too low to adequately utilize any increased habitat suitability and/or availability.

One waterbody sampled within the watershed is Dry Lake located near the community of Centre Musquodoboit. Unfortunately, only one sample year of data is available on the provincial Surface Water Quality Monitoring Network Lake Mapping Tool (NSE 2020). The water quality collected in 1981 (April) included a pH surface water measurement of 6.10. A small waterbody to the southwest of Dry Lake called Watson Lake was sampled in 1992 and recorded a pH measurement of 6.20. Cooks Lake, located to the northwest of the community of Elderbank was sampled on July 1984 (surface water pH of 5.97 and 5m water depth pH of 5.98, and an 8m water depth pH of 6.47). Dollar Lake, within the Dollar Lake Provincial Park, has been sampled several times between 1950 and 2007. Surface water samples collected in 1950, 1975, 1983, 1984, and 2007 showed pH values of 6.10, 6.80, 5.20, 4.91, and 7.00, respectively. The trend appears to show a depressed pH in the 1980s with subsequent recovery to some extent throughout the watershed. This water quality data also appears to agree with the Acidification Index which indicates a lower risk of acidification (**Figure** 26).

While the dataset is limited and analysis is not comprehensive, it can be reasonably assumed that if habitat rehabilitation were to occur within the Musquodoboit River system, critically low pH values would not impede its use by salmonids and other fish species at this time. Site-specific water quality measurements at proposed offset locations are provided below.

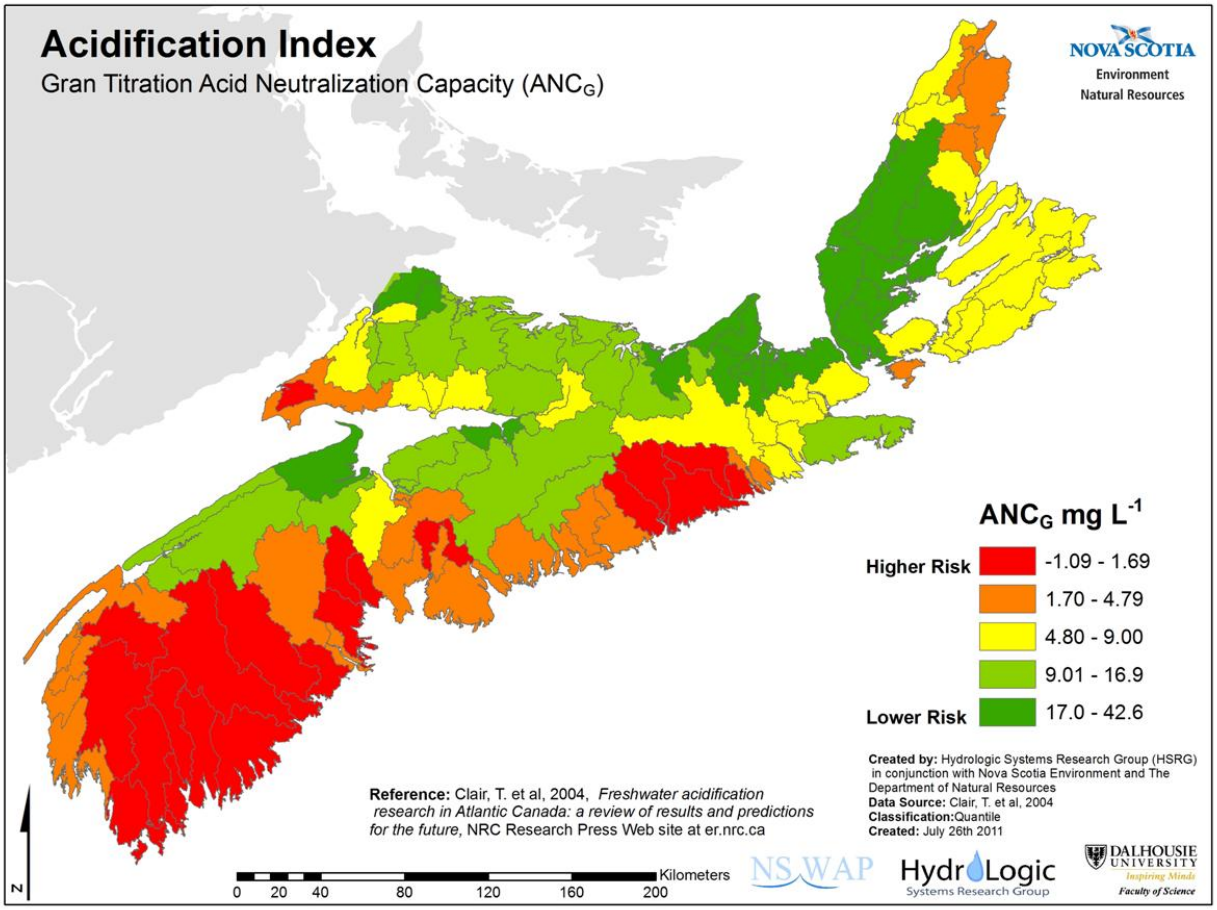
6.3.1.2 Human Land Use Activities

Within the Musquodoboit River watershed, several human activities have the potential to affect the aquatic resources; the largest being agriculture and forestry. Given the agriculture activities within the Musquodoboit River system, the proportion of human land use by this sector is considered moderate but among some of the higher indices within the province (**Figure** 29) (NSE 2011). Likewise, forestry activities are also considered to be high (**Figure** 30).

6.3.1.3 Aquatic Habitat

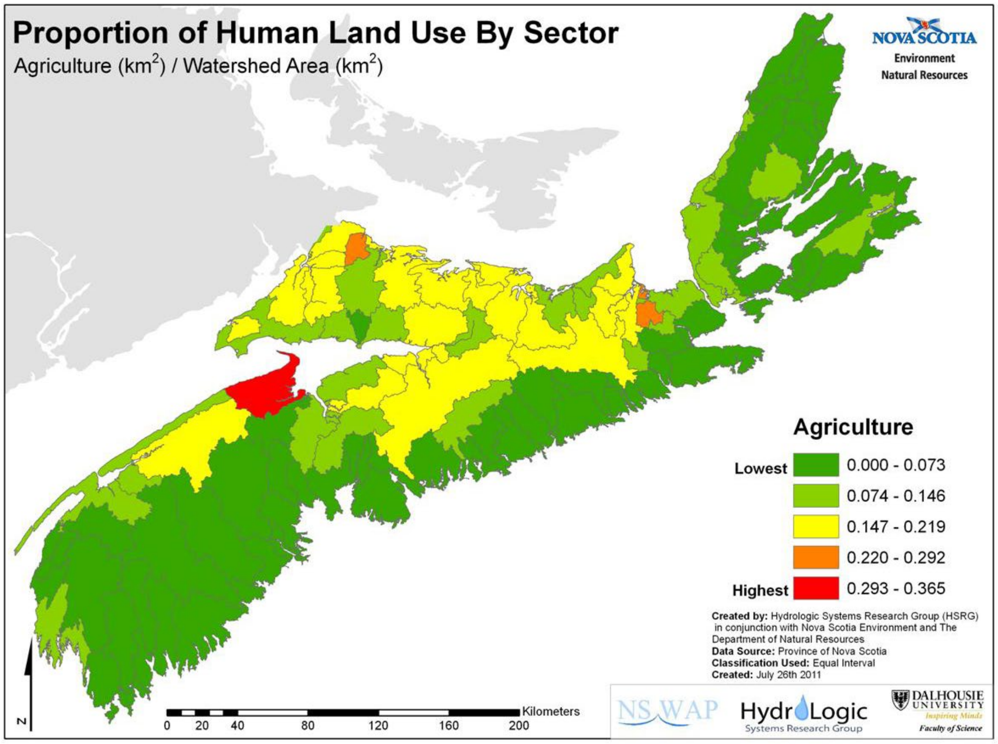
A summary index of Instream habitat was generated using various indices from variables that can influence fish habitat such as human land use, acidification, stream road crossings, road density, and portions of stream bound by human activities (NSE 2011). The overall ranking for Musquodoboit River was medium which indicates that while conditions are not at a critical level, fish populations there are likely stable and habitat rehabilitation will likely result in measurable increases in utilization.

This information has been used to provide rationale that fish habitat improvements within Musquodoboit River are worth considering.



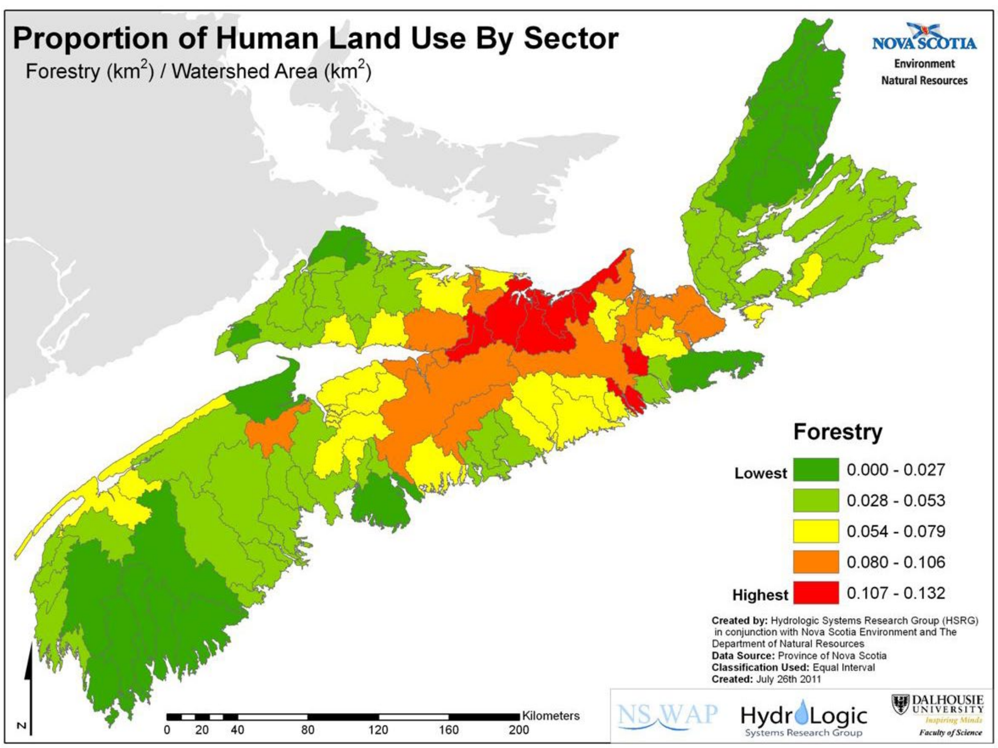
Source: Nova Scotia Watershed Assessment Program (NSE 2011).

Figure 26: Acidification Index, 2011 Nova Scotia Water Assessment Program.



Source: Nova Scotia Watershed Assessment Program (NSE 2011).

Figure 27: Agriculture Index, 2011 Nova Scotia Water Assessment Program



Source: Nova Scotia Watershed Assessment Program (NSE 2011).

Figure 28: Forestry Index, 2011 Nova Scotia Water Assessment Program

6.3.1.4 Alternative 2A – Off-Channel Habitat Construction

In total, 26 locations have been previously identified by MEL within the Musquodoboit River system for potential wetland remediation. These were further reviewed for potential of open water fish habitat offsetting that would augment any wetland remediation, in addition to landowner agreement/access. In total, four locations along the main stem of the Musquodoboit River have been identified.

One set of sites is located along the main stem of the Musquodoboit River to the northeast of the community of Centre Musquodoboit (**Figure** 29). The two parcels of land are delineated separately because land access/permission from the landowner for full habitat creation within the West Block parcel has been acquired; however, the adjacent East Block parcel of land is still used by the owner for cattle grazing and hay production. Therefore, the approach for the East Block parcel is different to limit losses to grazing area and enhance existing stream habitat. Both descriptions are adequate to describe off-channel construction at the other three locations.

Water quality measurements around both blocks as well as the main stem of the Musquodoboit River indicate suitable range of values. For example, samples collected in December 2020 indicated a pH range of 5.94 to 6.78 within the habitat blocks and a pH value of 6.52 within the main stem. Water quality results are provided in **Appendix** E.

6.3.1.5 West Block

The proposed improvements are related to remediating the former wetland that has been channelized and dewatered as a result of agricultural activities. There is a depression within the block that is very near the main stem of the Musquodoboit River. During high flow events, the water table recharges and this area can remain "wet" until water levels recede. Also associated with the parcel is a channelized stream (identified as WC1) that flows along the perimeter.

Surveys to delineate the overall topography are underway, but the land parcel is generally low profile and very near the main stem river elevation. It is proposed that the existing intermittent depression be constructed into a small waterbody as part of a larger wetland complex restoration to create a permanent, large off-channel pond/wetland. The entire land parcel is estimated at over 13 hectares (ha) in size. The estimated off-channel pond size is currently estimated at 4.0 ha (40,000 m^2) but will be refined based on final topographic survey data. The existing drainage from the parcel occurs at three locations due to channelization of the property: WC1, WC2, and the outflow of the small depressed portion of the southwest corner. The intent will be to consolidate, to the extent feasible, the two drainage ditches (WC1 and WC2) into the permanent pond/wetland complex. The proposed waterbody is shown in **Figure** 29.

Figure 29: Musquodoboit River habitat rehabilitation locations, Upper Musquodoboit, NS. West Block parcel is delineated by the channelized WC1 and WC2 ditches. East Block contains the WC3 channel

Estimates of discharge were calculated for each drainage channel (WC1 and WC2 as well as the combined drainage from the West Block parcel (WC1, WC2, and the small wetted area outflow). Estimated mean discharge volumes were prorated by MEL from the St. Mary's River at Stillwater hydrometric station. Drainage basins were created using 0.5 m contours developed from Provincial Lidar data. **Figure** 30 provides the mean monthly hydrology estimates for WC1, WC2, and the full West Block parcel, respectively. Flow duration curves are provided in **Appendix** F which provide the probability of exceedance of various flows by month.

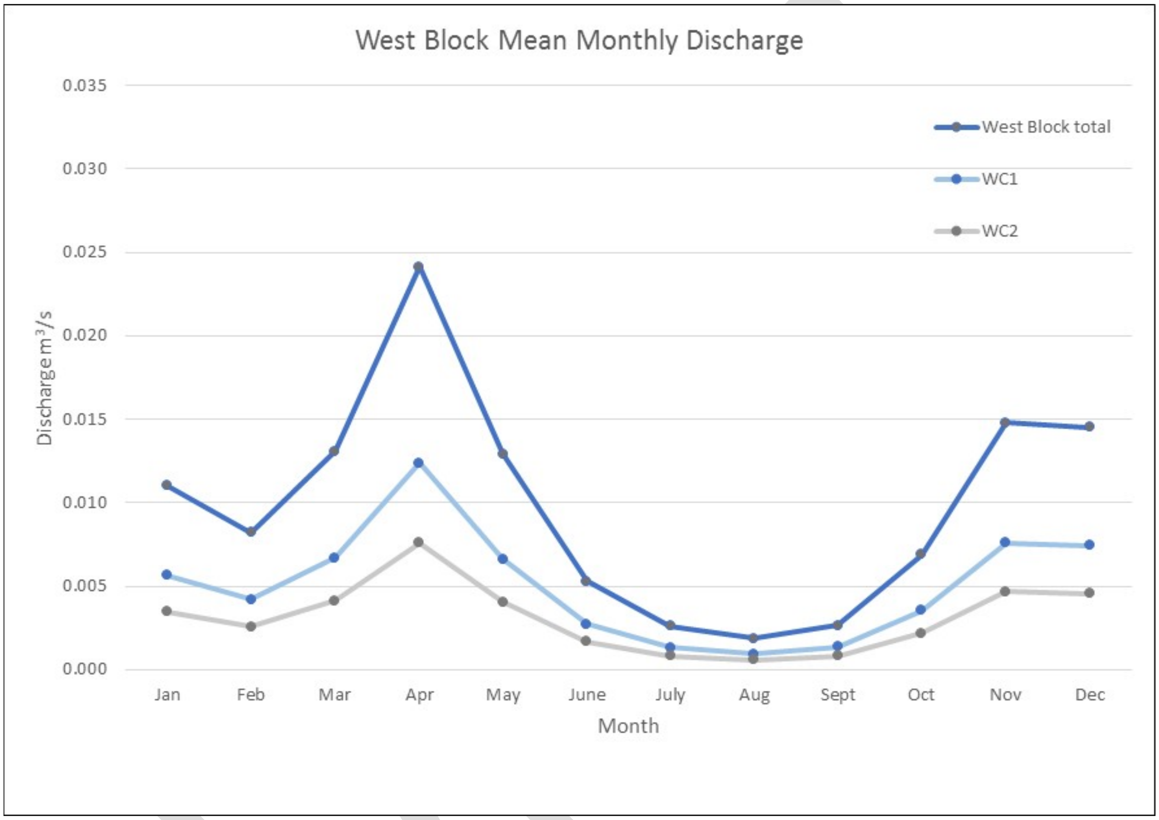


Figure 30: Prorated mean monthly discharge, West Block, Musquodoboit River

The proposed offset will realign/redirect WC2 flows through WC1 and thereby consolidate the existing drainage into one channel. The WC1 channel will be recontoured to provide stable stream habitat which will flow into the excavated pond. The outflow of the excavated pond will contain a small stream with features such as dense boulder clusters and rock weirs, if required, to maintain pond water levels and connectivity with the main steam of the Musquodoboit River. Instream features such as rock structures, gravels, and low head barriers (**Figure** 31) will be installed to maintain wetted perimeters and to re-instate habitat complexity within enhanced stream habitat. While the example in **Figure** 32 shows a weir and boulder outflow constriction designed for much higher flows, it provides a visual example of a typical outflow design. The combined flow from the West Block will then flow from the pond back into the Musquodoboit River. The consolidated flow will allow greater flows for attraction of fish and connectivity.

The river elevation is such that it is currently expected that high river flow events will recharge the permanent pond/wetland and surrounding vegetation. Therefore, the confluence between the pond and river will be designed using a rock weir riffle to maintain structural integrity and connectivity. Final arrangement will depend on final topographic survey information.

Figure 31: Small low-head barriers being installed in a stream to add pool habitat and complexity after hurricane damage

Figure 32: Example of outflow weir (underwater and not seen in photo) and boulder constriction

While is it anticipated that riparian / wetland vegetation will quickly re-establish itself construction is complete, replanting of native tree species may be required to expedite habitat shading.

Rock weir riffle enhancements will require the addition of coarse rock and fine gravel to create a riffle pool type stream profile along the existing channel. Riffle pool spacing would be determined at the next stage of design once additional site information is collected. The stream reach will be designed to be suitable for rearing by several species and potential spawning by Brook Trout and White Sucker.

The ultimate wetted width within the channel will be adjusted by natural processes (e.g., erosion and deposition); however, estimates of channel flow energy will be completed to ensure any installed structure will remain in place. Given the slopes and flows, it would be highly unlikely that structures and substrates would shift substantially. See Section 6.3.3.1 below for methods to ensure any structure will remain stable once installed.

The proposed objective for this enhancement area is the creation of at least **41,000 m²** (4.1 ha) of high-quality pond and stream habitat to offset HADD related to existing stream and open water habitat within and near the Project infrastructure footprint. The exact locations of the measure within the existing West Block will need further adjustment to reflect ongoing topography and flow modeling efforts, but enough area exists within the West Block to provide a high degree of certainty for this alternative. This habitat would be similar to both the lacustrine and watercourse habitat identified as being lost due to the Project and stream features would be similar.

The benefits and uncertainty associated with the proposed pond offsetting measure is primarily associated with the low-lying area where it would be most effectively created. Typically, by mid-summer it is assumed that the water levels in the main stem Musquodoboit River will be lower than the West Block, and that material can be removed without direct interference from flows. Alternatively, excavations could occur during the winter months when travel across frozen ground would reduce impacts of heavy machinery, minimize the need for berm / access construction, and allow easy removal of frozen material, particularly in low-lying areas where the water table would cause possible issues for excavation / removal.

Typical creation of waterbody habitat includes the removal of material from the pond area to a set depth. At this time, it is anticipated that bedrock resistance will not be anticipated, and a maximum depth of 1.5 m will be achievable. The depth will taper toward the shoreline. If possible, the remaining bottom material will be tamped and covered with smaller gravels near the shoreline to prevent excessive aquatic vegetative growth. The deeper sections will not be covered. The shoreline will not be reinforced with material such as rip rap, unless necessary to promote use by other aquatic animals such as turtles. All excavated material will be used onsite in the development of surrounding wetland habitat (e.g., berms to assist in water retention). Riparian revegetation will be completed under the direction of a wetland / vegetation biologist.

A detailed water management and sediment control plan will be required for approval prior to any construction. **Figure** 33 provides an example of a large pond enlargement and sediment controls (e.g., straw matting and silt booms to isolate excavated pond habitat) as part of a typical waterbody offset.

Figure 33: Typical large offset excavation to expand an existing waterbody

Constructing the rock riffle weirs in such a small channel is anticipated to be completed with the use of small machinery (e.g., bobcat) or by hand. Similar to open water excavations, access and placement of rock weirs during the winter months is possible if proper surveys are completed prior to snow / freeze up. This method has been conducted in other offset constructions and avoids the need to remove riparian vegetation, heavy equipment access clearing / construction, and costly revegetation activities.

Further investigations are ongoing and additional information would be required, if deemed an appropriate concept, to finalize the design. The concept is also easily scalable to cover larger, or smaller, areas, if required providing topography is adequate. Also, similar designs can be incorporated into the remaining three parcels of land along the shoreline of the Musquodoboit River for a total of **123,000 – 164,000 m^2** of high-quality pond and outflow stream habitat.

6.3.1.6 East Block

The East Block parcel of property has been given conservation consideration by the current landowner; however, they are currently utilizing the land for cattle grazing and hay production. Therefore, remediation of the channelized stream is currently confined to the existing alignment. However, given the current state of the channel (**Figure** 34), it is envisioned that riparian re-establishment can greatly enhance the habitat suitability. The existing channel is devoid of any riparian cover and any cattle/machinery is not restricted from the watercourse. The full length of channel (500 m) will have fencing erected on either side of the channel at an estimated distance of 5 m from the bank full width (final location of fencing will need approval from the landowner). While is it anticipated that riparian vegetation will quickly re-establish itself when cattle and hay production within the buffer zone is restricted, replanting of native tree species may be required to expedite habitat shading.

Figure 34: Watercourse WC3, East Block, Musquodoboit River at bankfull flow

Rock weir riffle enhancements will require the addition of coarse rock and fine gravel to create a riffle pool type stream profile along the existing channel. Riffle pool spacing would be determined at the next stage of design once additional site information is collected. Additional structures such as low-head barriers, wing deflectors, and boulders may also be added to the channel to increase habitat variability and sinuosity. Examples are shown in **Figure** 35. Due to the limited space and likely limited spawning material depths (estimated at less than 0.15 m), habitat will be constructed for Brook Trout and White Sucker spawning and rearing; however, parameters will be within the range used by juvenile Atlantic Salmon, to the extent possible.

Estimated mean discharge volumes were prorated by MEL from the St. Mary's River at Stillwater hydrometric station. Drainage basins were created using 0.5 m contours developed from Provincial Lidar data. **Figure** 36 provides the mean monthly hydrology estimates for WC3. A flow duration curve is provided in **Appendix** F which provides the probability of exceedance of various flows by month.

Figure 35: Typical riverine boulder placements to increase habitat heterogeneity

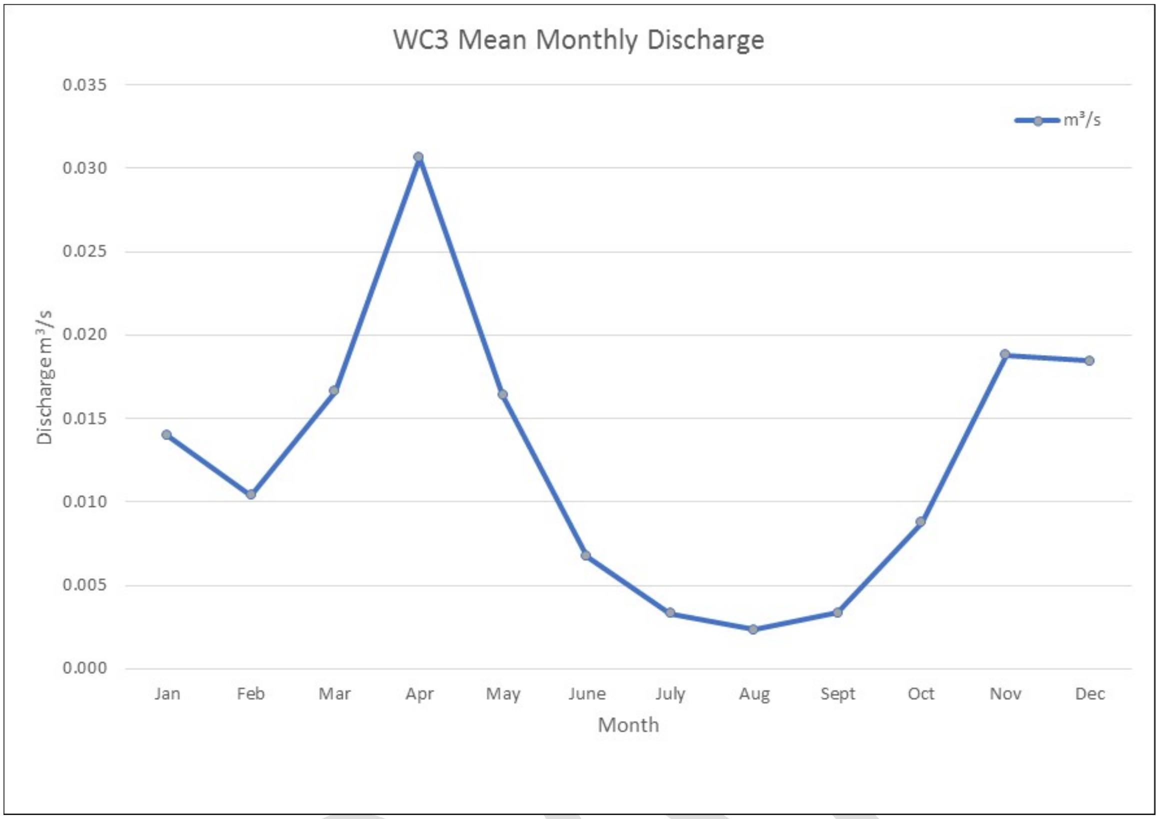


Figure 36: Prorated mean monthly discharge, WC3 East Block, Musquodoboit River

The ultimate wetted width within the channel will be adjusted by natural processes (e.g., erosion and deposition); however, estimates of channel flow energy will be completed to ensure any installed structure will remain in place. Given the slopes and flows, it would be highly unlikely that structures and substrates would shift substantially. See **Section** 6.3.2.1 below for methods to ensure any structure will remain stable once installed.

The river elevation is such that it is currently expected that high river flow events will recharge the lower reaches of WC3 and surrounding vegetation. Therefore, the confluence between WC3 and the Musquodoboit River will be designed using a rock weir riffle to maintain structural integrity and connectivity.

The proposed objective is the creation of at least **500 m²** of high-quality stream habitat to offset habitat impacted within and near the Project infrastructure footprint. The exact location of instream features will require further adjustment to reflect ongoing topography and flow modeling efforts, but sufficient areas exist within the East Block to provide a high degree of certainty for this alternative. Similar to the West Block habitat option, this design can be readily utilized any of the other three parcels near the Musquodoboit River for a total of **1,500-2,000 m²** of high-quality stream habitat.

6.3.2 Alternative 2B - Main Stem Musquodoboit River

Similar to the West and East Blocks of land adjacent to the Musquodoboit River, the Musquodoboit River itself has limited riparian habitat for temperature regulation and cover. With landowner agreements in place, access to the main stem of the river will also be possible for riparian re-establishment as well as instream habitat enhancements.

Riparian cover along the northern shore of Musquodoboit River will be re-established with the use of fencing and revegetation where accessible. Fencing to remove animal access should allow natural plant species such as alders and willow to re-establish. While is it anticipated that riparian vegetation will quickly re-establish itself when cattle and hay production within the buffer zone is restricted, replanting of native tree species may be required to expedite habitat shading.

In addition to riparian habitat re-establishment, spawning and rearing habitat could be enhanced within the main stem.

6.3.2.1 Atlantic Salmon Spawning Habitat Enhancements

Increased spawning and rearing substrate composition within the main stem of the Musquodoboit River would increase areas accessible for these life stages by salmonid species such as Atlantic Salmon and searun Brook Trout. The habitat features to be created will consist of a combination of run and riffle sub-habitats, as these provide maximum spawning and rearing suitability. The general criteria of each habitat type are based on the habitat preferences outlined in Grant and Lee (2004). For example, water velocities will range between 0.1 to 1.0 m/s and water depths less than 2m. Substrates will consist of primarily gravels for spawning and rubble/small boulder for rearing.

Spawning /Rearing Habitat Design

Using the habitat descriptions and the species preference criteria, the general layout and cross sections of each enhanced habitat type will be designed. A cobble-gravel substrate mixture, as described below, will be provided as the primary spawning/rearing substrate as it shows high utilization for Atlantic Salmon. Salmonid spawning substrate is typically comprised of cobble and gravel between 2 to 130 mm in size (Grant and Lee 2004). Since Atlantic Salmon will be utilizing these areas along with Brook Trout, a minimum substrate depth of 300mm will be provided in spawning areas (Bley 1987; Calkins 1989). The thalweg and deeper portions of reaches will also have this material, but larger substrates will also be added to slow water and maintain larger substrates for juvenile rearing. Low-head barriers will also be installed downstream and at the mid-point of each enhanced reach to assist in gravel stabilization, promotion of upwelling, and maintenance of channel features. **Figure** 37 provides an example of in-river installation of spawning / rearing habitat as well as submerged low-head barriers for upwelling.

Cobble substrate is identified as having high spawning and rearing capacity (young-of-year and juveniles) for Atlantic salmon as well as having a high suitability for all brook trout life-cycle stages. Cobble substrate is typically characterized as being in the range of 30 to 150mm in size. **Gravel** substrates show a high utilization for all rearing life-cycle stages of Atlantic salmon and brook trout, including spawning. Gravel substrate is typically characterized as being in the range of 2 to 50mm in size. Similar to cobble substrate, gravel associated with spawning habitat will not be produced from blasted rock. Material will range from rounded to sub-angular. Excess **sand**, **silt** and **mud** have been shown to have lower utilization by salmonid species. It should be noted that while not specifically a preferred spawning substrate on its own, finer material is found within typical spawning substrates for salmonids, including Atlantic salmon, in small proportions.

Figure 37: Typical in-river Atlantic Salmon spawning/rearing habitat isolation and construction. Completed habitat inset.

Figure 38 presents the general gradation of suitable spawning substrate. The proportions of finer material (percentages less than 10mm and 1mm diameter) are consistent with spawning material compositions that produce relatively high egg-to-fry survival (>60%) in salmonids (Tappel and Bjornn1983).

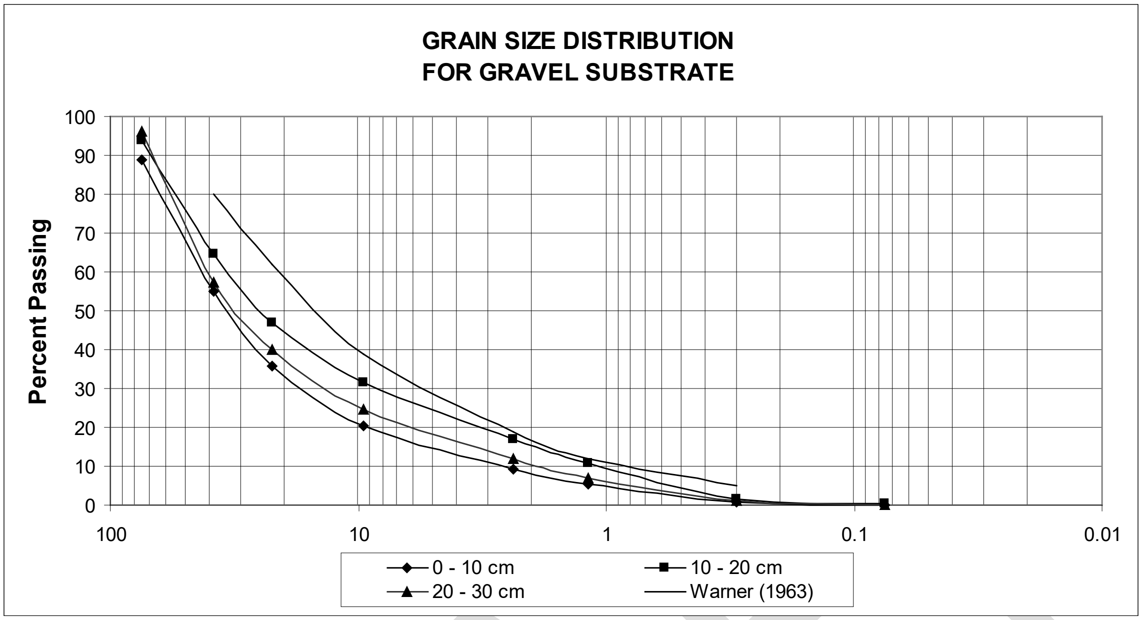


Figure 38: Recommended spawning gravel distribution

This spawning material gradation has been applied to various local salmonid spawning habitat improvements including St. Lawrence River, Granite Canal, Northeast River, and Salmon Cove Newfoundland and Labrador and will be applied to these spawning reaches as well. It should be noted that the overall percentage of sand and silt within previous material added to both Northeast River and Salmon Cove Rivers was reduced from eight percent to three percent in recent spawning enhancements. This was done because there will be a natural collection of smaller material sizes over time and less finer material during placement will limit higher suspended sediment during placement. This same reduction in smaller material size classes will also be applicable within Musquodoboit River.

Habitat Construction

Spawning substrates will be applied in identified areas for enhancement over an existing base layer of material. For better utilization success, it is recommended that the cobble and gravel substrates be blended and applied to the same locations. This will provide a range of substrates in concentrated locations rather than lower densities of suitable spawning material throughout.

While some smaller pieces of blast rock may be of the size range of spawning substrate, placed spawning substrate will not be produced from blasted rock and will be sub-angular to rounded.

Surveyed cross sections throughout the area are still pending and will be completed upon final acceptance of the option. For each location identified for spawning/rearing habitat enhancement, the estimated spawning discharge as well as the calculated mean water depth, mean water velocity and habitat slope will be completed based on Manning's equation.

Construction will be via similar methods used recently in other similar enhancements, such as Salmon Cove River and St. Lawrence, NL; winter placement of spawning / rearing material, if possible. This method reduces negative effects of stream access by machinery and loss of riparian habitat. Gravels will be placed during snow/ice cover in the winter months for deposition as the ice melts (January 1 – March 15). Placement of material on ice during winter would allow much more efficient placement as it would be easy to move material into position over the various stream sections. Given the relatively low slopes and shallow nature of the stream sections, gravels placed upon the ice will not be moved downstream before being released through the ice. The disadvantage of this method is that final shaping and distribution of material may be required during summer low flows. Personnel will survey each location and shift gravels using hand rakes if necessary. All material placement will be directed by an experienced biologist in habitat enhancement.

All construction of low-head barriers will be conducted prior to spawning material placement in the preceding mid-summer low flow period in accordance with regulations. Bank stabilization should not be required using this method but if required, it will consist of seeding (typical seed mix such as Canada No.1 Ground Cover Mixture or a mixture of clover and hay seeds). If required, larger vegetation will be transplanted from local sources as well as natural revegetation (in particular alders). Local young trees such as willow and alder will be transplanted near any disturbed areas to assist in stabilization and re-colonization of the disturbed area. All re-vegetation will be under the direction of an experienced botanist.

Substrate Stability Estimate

Any stream enhancement must consider the local flows which could be encountered. Inherent in this approach within a natural watercourse is the knowledge that the material placed will remain. The maximum flows need to be considered with respect to habitat and substrate stability. Typical and high fall flows will be incorporated into the design, as they will determine the appropriate slope and substrate depths in each reach to achieve the preferred range of water depth and velocity for spawning.

The underlying characteristics of any modified/created habitat depend highly on local flow characteristics. That is, the general width, depth and slope of modified habitat needs to be such that high flows naturally experienced in the system will be transported without excess erosion or damage to created habitat features. As a result, any habitat enhancements within Musquodoboit River will not alter the existing channel dimensions in any way.

Spawning material will be added to the streambed, the hydrology and water depths within Musquodoboit River are assumed to be adequate to allow approximately 300 mm be added. Similar to other river rehabilitation projects completed, the values for mean water velocities and depths will be calculated between the existing and future conditions (i.e. after suitable substrate additions), particularly for the flows associated with spawning and high spring flows (i.e. September-October and April). This will be completed using Manning's equation and simulated water elevations in AutoCAD in order to ensure the addition of spawning/rearing substrates within each reach would not make other physical parameters unsuitable. It will also be completed to ensure that placed substrates would not be flushed out of the system during high flow events. **Table** 14 presents an example of the calculated comparisons between existing and proposed habitat enhancements. In general, the habitat characteristics associated with the augmented habitat would need to remain suitable for spawning/rearing Atlantic salmon and other salmonids.

Typical flow velocities in the enhanced habitat types will be calculated to ensure they are relatively low in comparison to scour velocities (example in **Table** 15). Estimated high fall spawning discharges as well as a high freshet discharge will be used to estimate velocities in designed habitat.

Table 14: Example of summary habitat parameters for any enhanced spawning habitat, Musquodoboit River

Reach	Habitat Parameters							
	Existing Conditions				Proposed Conditions			
	Mean Velocity (m/s)	Mean Depth (m)	Slope (%)	Manning's n	Mean Velocity (m/s)	Mean Depth (m)	Slope	Manning's n
Mean Summer Low-Flow Discharge (___ m^3/s)								
Spawning Transect 1								
Spawning Transect 2								
Spawning Transect 4								
High Freshet Discharge (___ m^3/s)								
Spawning Transect 1								
Spawning Transect 2								
Spawning Transect 4								
Typical High Spawning Flows (___ m^3/s)								
Spawning Transect 1								
Spawning Transect 2								
Spawning Transect 4								

Table 15: Transport velocities of different streambed materials (extracted from DFO 1998)

Material	Diameter (mm)	Transport Velocity (m/s)
Silt	0.005-0.05	0.15 - 0.20
Sand	0.25-2.5	0.30 – 0.65
Gravel	5.0-15	0.80 – 1.20
Fine to Coarse Stone	25-75	1.40 – 2.40
Cobble	100-200	2.70 – 3.90

Calculations of substrate stability and movement potential can be completed under uniform flow conditions (Newbury and Gaboury 1993). The potential incipient particle diameter is based on a mean surface water slope for each reach which is a conservative oversimplification in most streams. The estimated potential incipient particle diameters for both typical fall/spring and extreme flows will be calculated (see example in **Table** 16). This value would represent a material size whereby smaller sized material placed in these areas might shift.

Table 16: Example of potential incipient particle diameter results at each flow for any habitat reach spawning enhancement, Musquodoboit River

Habitat Design	Mean Water Depth (m)	Slope	Flow (m^3/s)	Incipient Particle Diameter (cm)
Spawning Transect 1			Low	
			Medium	
			High	
Spawning Transect 2			Low	
			Medium	
			High	
Spawning Transect 4			Low	
			Medium	
			High	

The proposed objective is the creation of at least **1,000 – 2,000 m^2** of high-quality riverine spawning/rearing habitat to offset habitat units lost related to existing stream and open water habitat within the Project infrastructure footprint. The exact location of instream features will require further adjustment to reflect ongoing topography and flow modeling efforts, but sufficient areas exist within the Musquodoboit River to provide a high degree of certainty for this alternative.

Material Quantities

Preliminary estimates of the quantities of spawning material required will be calculated using the available data regarding the total area available for spawning enhancement as well as the recommended spawning material depth of 300 mm.

6.4 Alternative 3 - Complementary Measures

Measures to improve existing fisheries knowledge in areas of interest to Indigenous communities could provide information related to possible future habitat rehabilitation options, additional habitat utilization, and/or species distributions / movement patterns in Nova Scotia, particularly in areas near the Project. The exact format of complementary measures will depend on engagement between AMNS representatives and local Mi'Kmaq communities. While complementary measures are typically limited to a maximum of 10% of the offset plan, this option can provide additional avenues for alternative offset options. As shown in **Table** 13, this alternative was ranked as fourth highest due to its flexibility and ability to align with specific interests of stakeholders.

6.5 Alternative 4 & 5 – Restoration of Yet-Determined Degraded Aquatic Habitat

Additional options investigated include the rehabilitation / restoration of degraded aquatic habitats both within and beyond former mining areas including old stream realignments, dewatered / infilled stream reaches, and man-made barriers. Restoration methods are well-known and can be very successful if used in the proper location. Discussions with groups involved in the planning of remediation of former mining areas indicate that additional coordination may be challenging due to land tenure challenges and liabilities; however, alternate locations are currently being pursued through consultations with local stakeholders and Indigenous communities. These would be considered if required; however, are a lower overall ranking due to numerous uncertainties with their implementation.

6.6 Alternative 6 – Onsite Watercourse Enhancement / Rehabilitation

Similar to the methods outlined for channels within the West and East Blocks at Musquodoboit River (see **Section** 6.3.1.6), small stream and pond enhancements within the watercourses altered by the Project (WC-5, WC-23, WC-26, WC-27) can be implemented. Structures such as small pond creation/expansion and rock weir riffle enhancements will require the addition of coarse rock and fine gravel to create a riffle pool type stream profile along the existing channel. Riffle pool spacing would be determined at the next stage of design once additional site information is collected; however, with a predicted decrease in MAD, pool features that might increase refugia habitat would be a focus. Additional structures such as low-head barriers, wing deflectors, and boulders may also be added to the channels to increase habitat variability and sinuosity. Examples are shown in **Figure** 35. Due to the limited space and likely limited spawning material depths (estimated at less than 0.15 m), habitat will be constructed for existing forage fish species, White Sucker, and Brook Trout. The proposed objective is the enhancement of at least 8**00 – 1,000 m^2** of high-quality stream habitat to offset habitat units lost related to existing stream habitat within the Project infrastructure footprint.

7.0 Monitoring

As part of a detailed offset plan and once the offset measures have been selected, a monitoring program will be developed in consultation with DFO; and included in the final offset plan and Fisheries Authorization. It is recognized that additional monitoring may be required to confirm predicted extent and magnitude of alterations such as flow reductions and groundwater upwelling locations.

8.0 Consultations

Engagement is a key component of Atlantic Mining Nova Scotia Inc.'s approach to the planning and implementation of its projects and other business activities. A number of engagement initiatives have been undertaken in relation to the Project, with further engagement in progress or being planned. This includes discussions with relevant government departments and agencies, Indigenous communities, stakeholder organizations, and other possible conservation groups with potential offsetting options.

Sections 3 and 4 of the Updated EIS (AMNS 2021b) describe previous and ongoing engagement initiatives related to the Project with Indigenous groups and the public. To continue with open communications on the Project, AMNS is committed to meeting with and/or providing information to stakeholders at the appropriate time to discuss any offsetting plans.

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Appendix A

Wetted Perimeter Validation and Outputs

1.0 Wetted Perimeter Method

The comparison of predicted changes in flow within identified streams to DFO guidelines (DFO 2013) is straightforward in terms of determining whether changes are beyond 10% of the Mean Annual Discharge (MAD). Analysis of predicted changes in flow to determine if they result in instantaneous (i.e., daily) flows <30% of the MAD requires daily hydrographs for direct comparison. While direct measurements of daily flows are typically not available on small streams, reasonable estimates can be calculated from nearby long-term gauging stations or modelling for mine water management. Once completed, little else in terms of modelling is required to determine if changed flows exacerbate existing low flow conditions (i.e., frequency or magnitude below 30% MAD).

Similar to the typical lack of measured daily flows on small streams to generate instantaneous discharge hydrographs, habitat measurements on small streams across a range of flow conditions can also be limited. Multiple sets of habitat characterization data such as stream reach cross section, slope, discharge, and water depths/velocities in numerous small streams across various flow regimes can be extremely challenging, costly, and hazardous. This can make the assessment of predicted flow changes due to flow alterations on existing fish habitat quantity and quality challenging without a method to address. The Wetted Perimeter Method (WPM) is a method that can provide reasonable estimates of changes in habitat parameters at various flow levels and has been used to evaluate potential habitat changes as a result of flow reductions caused by projects.

Detailed measurements and observations taken in the field can be used to describe aquatic habitat conditions and determine the hydraulic characteristics of a stream reach. This information, along with stream geometry data, can be used in a common instream flow assessment method called the Wetted Perimeter Method (Newbury and Gaboury 1993). The Wetted Perimeter Method (WPM) is a fixed flow hydraulic rating method based on the hydraulic relationship between flow (i.e. discharge) and wetted river perimeter at selected transect(s) (Stalnaker et al. 1994). While not considered applicable for establishing "universal" environmental minimum flows across regions due to the site-specific nature of wetted perimeter – flow relationships and the assumptions of transect selection (e.g., Linnansaari et al. 2012 and Hatfield et al. 2003), DFO has previously considered WPM as a standard instream flow needs assessment method suitable for low-moderately complex/sensitive projects (Gosse et al. nd). Information on hydraulic geometry can be very useful in instream flow assessment to determine the degree of change in habitat conditions at different spatial scales or habitat types (Caissie and El-Jabi 2003). Using the WPM, the flow corresponding to the wetted perimeter needed to maintain suitable habitats, can be estimated. **Figure** 1 presents a schematic of the WPM relationship and indicates the point of inflection for the habitat transect. The point of inflection is taken as the flow below which dewatering would take place rapidly for the represented habitat.

The cross-sections, or transects, selected to determine the minimum flow for habitat protection are very important in this technique. The selected transects for assessment must stand as an index habitat for the rest of the river or river section being assessed (Stalnaker et al. 1994). Riffles are typically selected because cross sections in these areas exhibit sensitivity of width, depth and velocity to changes in flow. They are usually the shallowest habitat type found and as such, would indicate adequate water levels needed to protect all habitats. Therefore, once a minimum level of flow is estimated for a riffle, it is assumed that other habitat areas, such as pools and runs, are also satisfactorily protected. Because the shape of the channel can influence the results of the analysis, transects are usually located in areas that are wide, shallow, and rectangular.

Since the method uses field measurements at selected transect locations to model alternative conditions at varying flows, assumptions related to the selection of the transect location apply to the WPM:

- the selected transect(s) is a suitable index of habitat for the rest of the river being assessed, i.e., if the minimum flow requirement is satisfied at the chosen sensitive location, it will be satisfied in other habitat types. The greater the number of transect locations, the higher the level of confidence in the minimum flow estimation;

- the point of inflection is a suitable surrogate for acceptable habitat, i.e., flow reductions below that point on the graph will result in loss of habitat quality; and

- all wetted area is equally important as habitat or to satisfy other biological criteria.

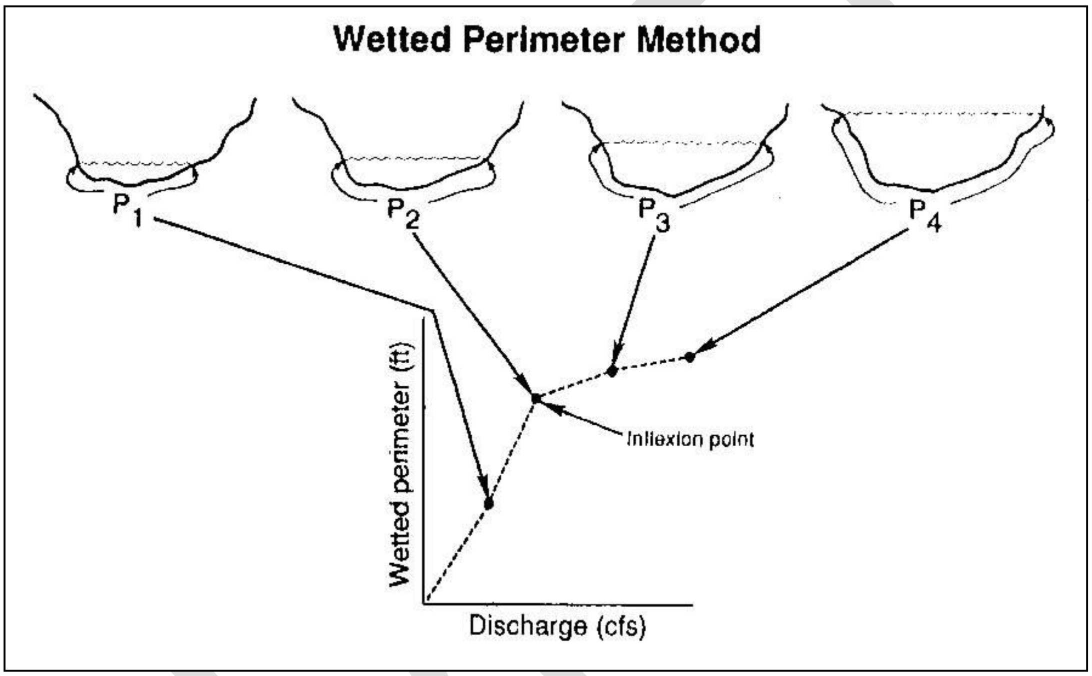


Figure 1: Example of wetted perimeter method to estimate instream flows (Nelson 1980)

Field surveys at representative transects can typically cover a range of natural flows; however, it is very unlikely that a continuous analysis or record of the variety of flow conditions that occur in each reach would be achieved. Consequently, an empirical relationship, commonly called "Manning's Equation", has been developed to describe average flow conditions, albeit with assumptions about the uniformity of flows (see Chow 1988; Linsley et al. 1988; Newbury and Gaboury 1993). Manning's equation can be applied to estimate extreme values (unsafe to physically survey) as well as flows not encountered through a field program (Newbury and Gaboury 1993).

Manning's equation is given by

Velocity (m/s) = R2/3 * S1/2 / n where

R = Hydraulic radius (Area / wetted perimeter)

S = slope at transect

n = Manning's Roughness (n).

1.1 Field Data Collection

Direct field measurements of channel morphology, substrate, and slope as well as measurements of water depth and velocity across representative transects can be used to solve Manning's equation for Manning's Roughness (n) at each measured flow condition. Wood Environment & Infrastructure Solutions (Wood) has developed Standard Operating Procedures (SOP) to ensure detailed field measurements are collected at each transect of interest which were used by the field teams during the 2020 Beaver Dam aquatic baseline program. Multiple sets of field measurements for water depth and velocity at each transect at varying flow conditions would assist in confirming the estimation of Manning's n and allow more field data input to the WPM; however, a single field sampling event can provide the necessary data. Additional validation of the WPM is provided below.

1.2 WPM Calculations

Using the calculated Manning's n value based on field measurements, additional wetted widths and velocities/discharges for various water elevation scenarios within the confines of each transect geometry can be completed within the WPM. To accomplish this, accurate transect profiles are created in AutoCAD which are used to model various flow scenarios such as predicted reductions due to Project Operations. The point of inflection can also be determined for each representative transect for comparison to any flow reduction prediction.

To get an estimate of the discharge-wetted perimeter relationship at each representative transect, the location of maximum water depth along the transect is used as the "staff gauge" associated with each simulated discharge. For each transect location, water level is varied around the field measured discharge dataset. Water levels are decreased below measured field discharge in 0.05m increments until the water level is near zero (i.e., dry stream bed). Water levels are also increased above the measured field discharge in 0.10m increments until the water level reaches bank full condition.

If more than one set of field measurements have been completed, modelled water levels can be completed between those measured. The estimated Manning's n value used is taken from a measured field flow nearest that modelled. A review of Manning's n values from multiple field measurements can be completed to determine sensitivity, particularly if water levels are highly variable (Newbury and Gaboury 1993).

1.3 WPM Equation Validations

Manning's n can vary within a stream reach and the resistance to flow varies relative to the size of the stream substrate material (Chow 1988, Newbury and Gaboury 1993). If the depth of flow is much greater than the size of the streambed materials, resistance is primarily due to drag on the substrate surface, but if the depth is shallow, resistance is caused by both drag and physical obstruction to flow and is therefore much higher (Newbury and Gaboury 1993). For this reason, field measurements should be completed near the "flow of interest" if at all possible, to avoid inaccurate roughness estimations in modelling. In most situations related to aquatic habitat alterations, interest is typically focused on lower flows therefore field measurements at low-mid flows can provide a reasonable estimate of the roughness for the flow range of interest. Further details on additional equations to estimate roughness from high flows (e.g., Strickler) is provided in Newbury and Gaboury (1993). Additionally, if modifications to the roughness factor is required beyond those estimated from field measurements, computation using the Cowan procedure is provided in Chow (1988).

The sensitivity of using channel morphology measurements and one field set of water level, depth and velocity measures to model alternate flows/conditions has previously been investigated and validated for both DFO assessments and proponent-driven development investigations. For example, the method was previously used and validated for DFO as a means of estimating/predicting habitat conditions in dewatered streams for habitat remediation (AMEC 2005) and more recently for a flow monitoring program at Big River, Torbay Newfoundland.

1.3.1 DFO Potential Habitat Remediation Guidelines (AMEC 2005)

In 2005, DFO commissioned a study to determine whether fish habitat remediation could be partially achieved at existing hydroelectric facilities through compensation options such as environmental flow releases through dewatered and seldom used spillway channels which were typically former streambeds (AMEC 2005).

The study used WPM and the same process described above to predictively model habitat conditions under possible flow release scenarios/quantities. However, because no flow was occurring in existing spillway channels at the time, channel roughness could not be generated from field flow measurements and therefore the WPM was used with an estimate of Manning's roughness (n) using the Cowan procedure outlined in Chow (1988). This would be considered less accurate as it is based on visual estimates of channel substrate, sinuosity, etc. (Chow 1988) and not on field measurements.

Validation of the modelling approach to estimate aquatic habitat conditions was completed by conducting a series of transect measurements in a river with existing natural flows and comparing existing habitat conditions with those modelled through WPM. Transects were measured in run, rapid, and steady aquatic habitat types and, without using any collected hydraulic information, the WPM model was used to estimate flow conditions for the water level at the time of survey. The modelled conditions (discharge, water depth, and water velocity) were compared to actual measurements at the time of survey. In all cases, the actual measured values fell within the 95% confidence intervals for the equations indicating that the WPM modelling approach can provide a reasonable representation of habitat parameters. **Figures** 2 - 4 are reproduced from AMEC (2005) which show the measured parameter values (in red) related to those generated from the WPM.

Section One Rennies River

Slope: 0.005
Mannings n: 0.06

Depth	Staff	Area	Wetted Perimeter	Wet Width	mean depth	R	mean V (m/s)	Q (m3/s)	
0.000	0.850	8.465	13.348	13.000	0.60	0.634	0.861	7.292	
-0.100	0.800	7.183	12.937	12.642	0.56	0.555	0.788	5.660	
-0.200	0.700	5.937	12.527	12.284	0.48	0.474	0.709	4.207	
-0.300	0.600	4.726	12.117	11.926	0.39	0.390	0.622	2.940	
-0.400	0.500	3.552	11.706	11.567	0.30	0.303	0.526	1.867	
-0.500	0.400	2.413	11.296	11.209	0.22	0.214	0.415	1.002	
-0.600	0.300	1.335	8.602	8.555	0.15	0.155	0.335	0.448	
-0.700	0.200	0.534	7.599	7.471	0.10	0.070	0.197	0.105	
-0.800	0.100	0.043	1.982	1.976	0.03	0.022	0.090	0.004	
-0.850	0.000	0.000	0.000	0.000	0.00	#DIV/0!	#DIV/0!	#DIV/0!	
-0.530	0.320	1.854	9.055	9.011	0.18	0.205	0.346	0.642	actual measured water level (models not used)

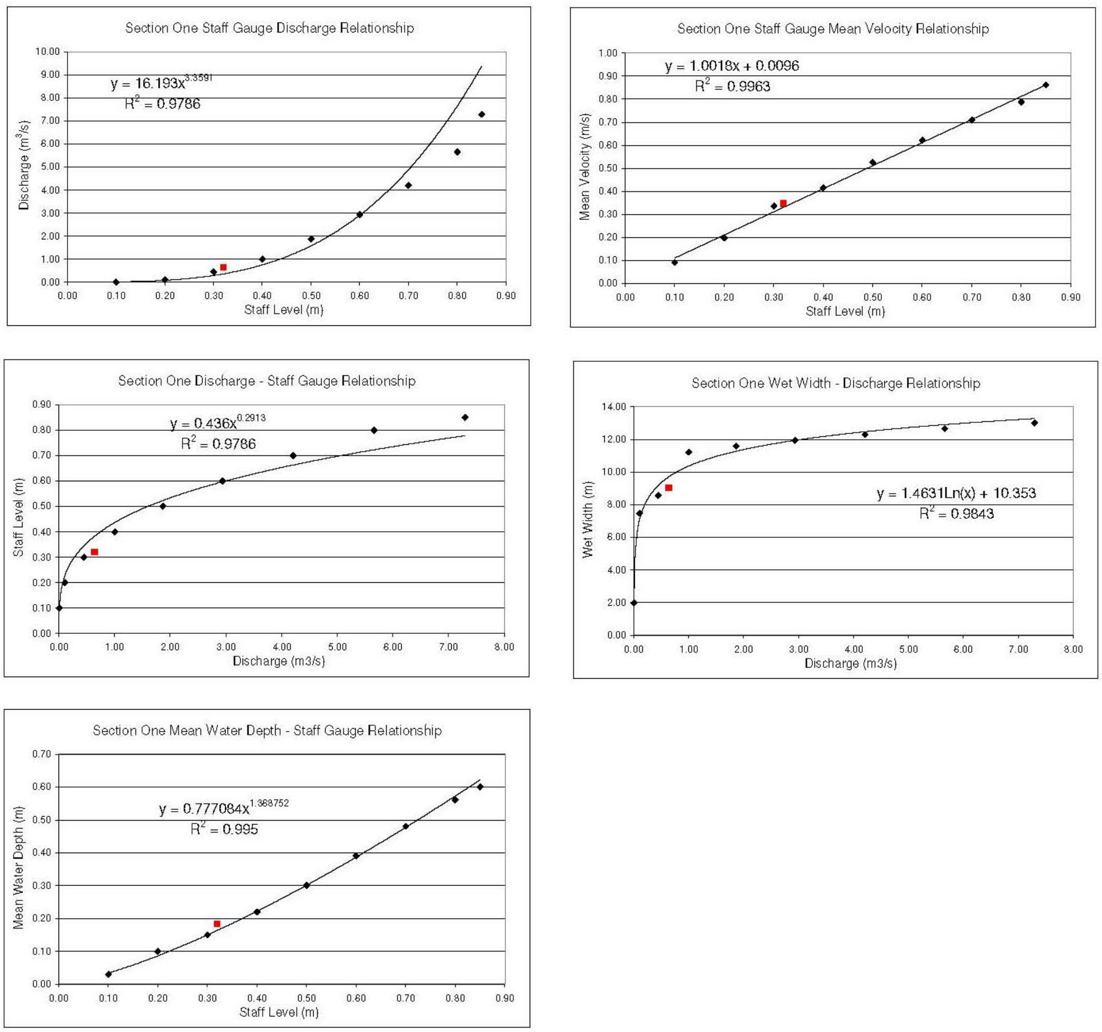


Figure 2: Modelled stream reach cross section, Rennies River Section One (Riffle). Reproduced from AMEC (2005)

Section	Two	Rennies River					Slope:	0.021
							Mannings n:	0.09

Depth	Staff	Area	Wetted Perimeter	Wet Width	mean depth	R	mean V (m/s)	Q (m3/s)	
0.000	1.150	7.793	9.727	8.700	0.794	0.801	1.392	10.847	
-0.100	1.050	6.922	9.457	8.521	0.714	0.732	1.310	9.069	
-0.200	0.950	6.078	9.186	8.342	0.634	0.662	1.225	7.444	
-0.300	0.850	5.253	8.916	8.163	0.554	0.589	1.133	5.952	
-0.400	0.750	4.446	8.645	7.984	0.474	0.514	1.034	4.598	
-0.500	0.650	3.656	8.375	7.805	0.394	0.437	0.927	3.389	
-0.600	0.550	2.885	8.104	7.626	0.314	0.356	0.808	2.332	
-0.700	0.450	2.131	7.833	7.447	0.234	0.272	0.675	1.439	
-0.800	0.350	1.401	7.158	6.868	0.157	0.196	0.542	0.759	
-0.900	0.250	0.797	5.369	5.190	0.101	0.148	0.450	0.359	
-1.000	0.150	0.346	3.860	3.769	0.063	0.090	0.321	0.111	
-1.100	0.050	0.056	1.719	1.690	0.023	0.033	0.163	0.009	
-1.150	0.000	0.000	0.000	0.000	0.013	#DIV/0!	#DIV/0!	#DIV/0!	
-0.770	0.380	1.494	6.437	6.019	0.196	0.232	0.516	0.771	actual measured water level (models not used)

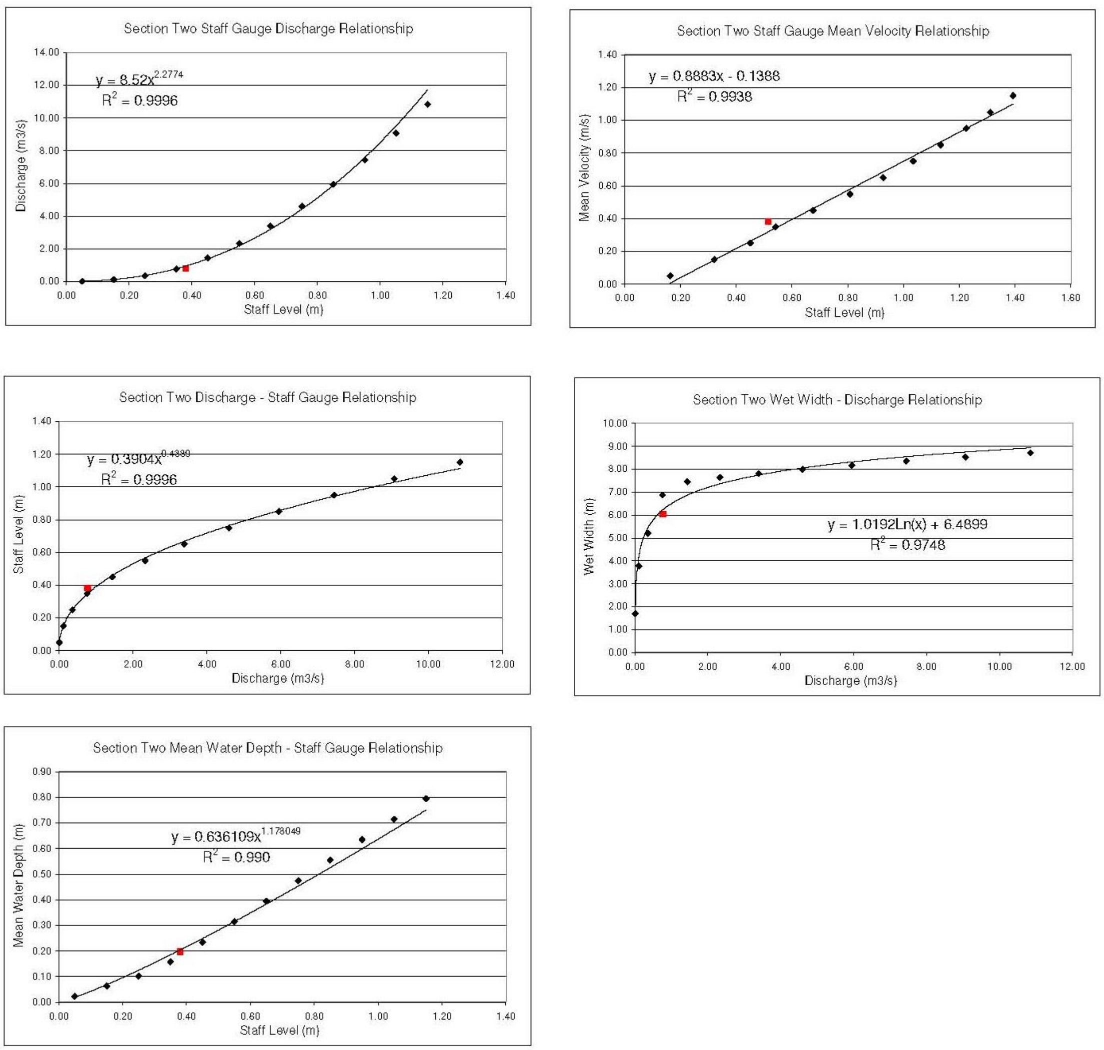
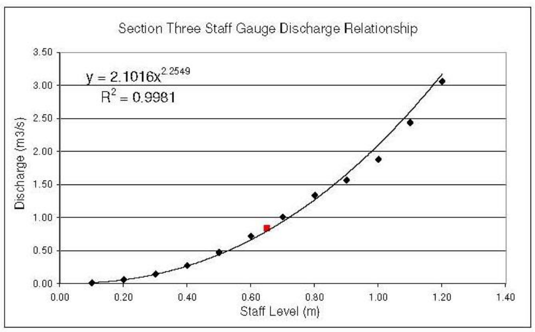
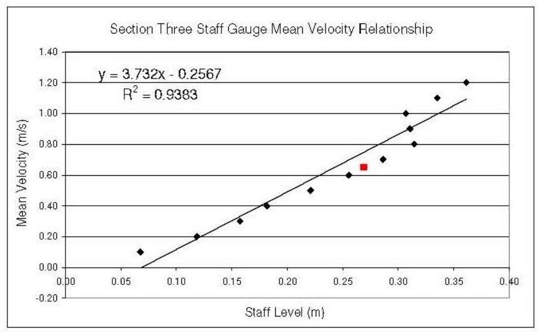
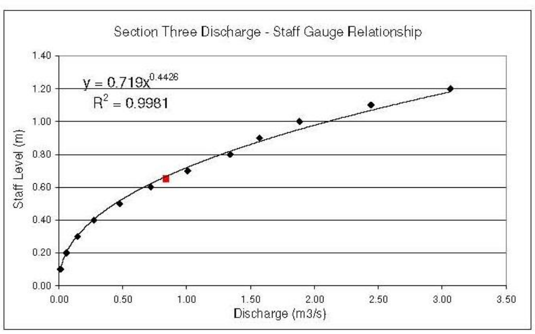


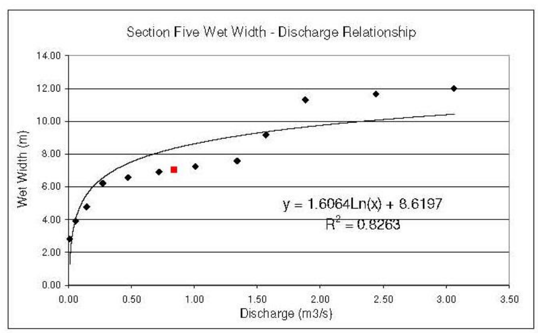
Figure 3: Modelled stream reach cross section, Rennies River Section Two (Run/Chute). Reproduced from AMEC (2005)

Section	Three	Rennies River					Slope:	0.002
							Mannings n:	0.0995
Depth	**Staff**	**Area**	**Wetted Perimeter**	**Wet Width**	**mean depth**	**R**	**mean V (m/s)**	**Q (m3/s)**
0.000	1.200	8.465	12.739	12.000	0.615	0.664	0.362	3.061
-0.100	1.100	7.283	12.275	11.649	0.570	0.593	0.335	2.441
-0.200	1.000	6.135	11.810	11.298	0.480	0.520	0.307	1.881
-0.300	0.900	5.050	9.541	9.158	0.460	0.529	0.310	1.568
-0.400	0.800	4.260	7.897	7.570	0.480	0.539	0.314	1.340
-0.500	0.700	3.520	7.505	7.233	0.410	0.469	0.286	1.008
-0.600	0.600	2.814	7.113	6.895	0.330	0.396	0.255	0.719
-0.700	0.500	2.141	6.720	6.557	0.250	0.319	0.221	0.473
-0.800	0.400	1.502	6.328	6.220	0.173	0.237	0.181	0.273
-0.900	0.300	0.928	4.837	4.771	0.158	0.192	0.157	0.146
-1.000	0.200	0.494	3.945	3.903	0.092	0.125	0.118	0.058
-1.100	0.100	0.153	2.832	2.813	0.040	0.054	0.067	0.010
-1.200	0.000	0.000	0.000	0.000	0.000	#DIV/0!	#DIV/0!	#DIV/0!
-0.550	0.650	3.112	7.289	7.047	0.233	0.427	0.269	0.837 actual measured water level (models not used)









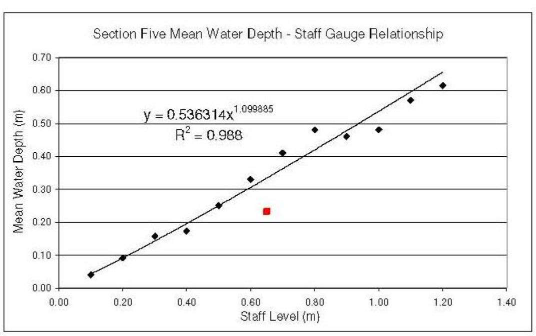


Figure 4: Modelled stream reach cross section, Rennies River Section Three (Steady). Reproduced from AMEC (2005)

1.3.2 Big River Flow Alteration Assessment

As part of a potential drinking water extraction project, an assessment of the possible habitat alteration due to water diversion in Big River Torbay is underway. As part of the program, a series of water level sensors have been installed and are being calibrated for stage-discharge using multiple measures of discharge at varying flows. Representative habitat transects have also been established to be used to quantify the potential habitat alteration. These transects have also had habitat parameters measured under various flow conditions. As a result, a comparison of WPM model results for the discharge–wetted perimeter relationship and field-based discharge–wetted perimeter relationship was completed.

A stream transect at Big River was selected as representative of the habitat within the surrounding stream reach. Wetted width, depth and velocity were measured for various flow conditions, ranging from 0.02-0.42 m3/s. Based on pro-rated hydrology data from a nearby gauged system, 0.42 m3/s is near bank full flow conditions (**Figure** 5). A total of seven field-based measurements (flow events) were gathered between 2020 and 2021.

Figure 5: Photo of Big River transect location at 0.42 m3/s

Three separate discharge-wetted perimeter relationships were developed from the dataset as shown in **Figure** 6; one using the complete data set (i.e., no model estimates generated), one modelled using a low-moderate flow field sampling event (0.14 m^3/s) and a third modelled using a high flow field sampling event (0.42 m^3/s). Comparison among regression equations was completed using analysis of variance (ANOVA) with a significance (p-value) of 0.05. Each equation was log-log transformed to normalize the data. Residuals were checked for normality (Shapiro-Wilks test). Analysis was completed in R Statistical Package (R Core Team 2019).

The individual regression equations generated from the data are presented in **Table** 1 and shown in **Figure** 6.

Table 1: Summary of equations generated from Big River transect field measurements

Equation (model type)	Significant (p-value)	r^2
Measured Points: Log.wetted.perimeter = 0.0938*log.discharge + 0.6689	0.0064	0.8022
Modelled from one low-mod flow (0.14 m^3/s): Log.wetted.perimeter = 0.2711*log.discharge + 0.8451	0.0017	0.9339
Modelled from one high flow (0.42 m^3/s): Log.wetted.perimeter = 0.2244*log.discharge + 0.7438	0.0003	0.9716

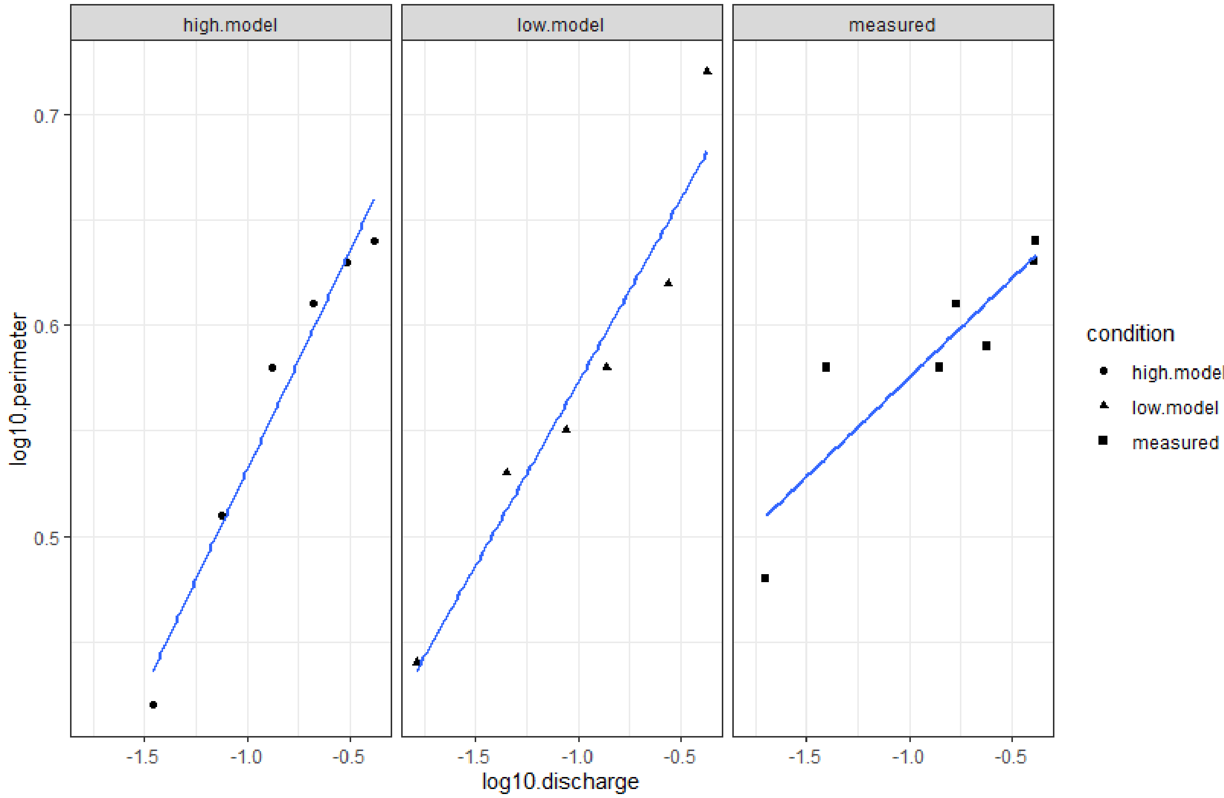


Figure 6: Comparison of discharge-wetted perimeter equations (log-log), Big River Torbay

Results of the analysis indicate significant differences among the three models (p=0.0498), with significant interaction between log-discharge and model type (p=0.0075) with the field-measured model predicting less overall habitat change between higher and lower flows and therefore less habitat loss (i.e., larger wetted perimeter) at reduced flows compared to the modelled equations. Comparison of the modelled equations indicates both provide similar trend in wetted perimeter reductions with lowering flows (i.e., no significant interaction p=0.2772); however, the model generated with the high flow transect information estimates a smaller wetted perimeter at similar low flows.

Table 2 provides wetted perimeter estimates from all three models using similar flows as model inputs. As shown, the transect wetted perimeters at the estimated Big River Mean Annual Discharge (MAD) (0.160 m^3/s) for measured, low-mod flow, and high flow equations are 3.95, 4.03, and 3.74 m, respectively. Likewise, the estimated wetted perimeters at 30% MAD (0.048 m^3/s) are 3.53, 3.46, and 3.04, respectively, showing that the modelled equation using a high flow field measurement provides the most conservative (smallest) wetted perimeter at lower flows.

Table 2: Summary of wetted perimeter estimated from models (measured, low-mod flow, high flow) at various flows

Measured Discharge (m3/s)	Wetted Perimeter (m)		
	Measured Equation	**Low-Mod Flow Equation**	**High Flow Equation**
0.020	3.04	2.54	3.23
0.040	3.37	2.94	3.47
0.140	3.97	3.67	3.90
0.170	4.06	3.78	3.97
0.410	4.48	4.29	4.27
0.420	4.50	4.30	4.28
0.240	4.23	3.98	4.09
0.160 (MAD)	4.03	3.74	3.95
0.144 (90% MAD)	3.98	3.68	3.91
0.048 (30% MAD)	3.46	3.04	3.53

It is noted that even though the equations are significantly different, wetted perimeter estimates at the MAD from the modelled equations are within the 95% confidence interval of the measured wetted perimeter value (3.71-4.16 m) and at 30% MAD, the estimated low-mod flow wetted perimeter is within the 95% confidence interval of the measured wetted perimeter value (3.24-3.80 m).

If the difference in wetted perimeter between the MAD and 30% MAD is arbitrarily used to represent a flow reduction to estimate habitat loss (i.e., a possible HADD) for each equation, the total wetted width reductions are 0.42, 0.58, and 0.70 m for measured, low-mod flow, and high flow equations, respectively. The estimated percent loss relative to the MAD wetted perimeter is 10.6, 14.1, and 18.7%, respectively.

As shown, completing a series of field measurements at a transect used in WPM gives the better estimation of habitat changes (and potential losses) as it incorporates more field information in the equation development. However, if a model is developed using transect geometry information and habitat measurements at a low-moderate flow condition, it can provide reasonable estimates of habitat change; however, habitat changes can be greater. While a model using habitat measurements from a high flow condition can provide estimates of habitat change, the values can generate greater habitat losses compared to measured or low-moderate flow models. However, both models are conservative in their estimated habitat losses in that they provide less remaining wetted perimeters at similar flows and greater overall percent losses, therefore they are reasonable alternatives to estimating habitat losses due to flow reductions.

2.0 List of Supporting Documents

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Appendix of Supporting Data – Indirect Effects on Fish and Fish Habitat

Wetted Perimeter Discharge/Habitat Curves

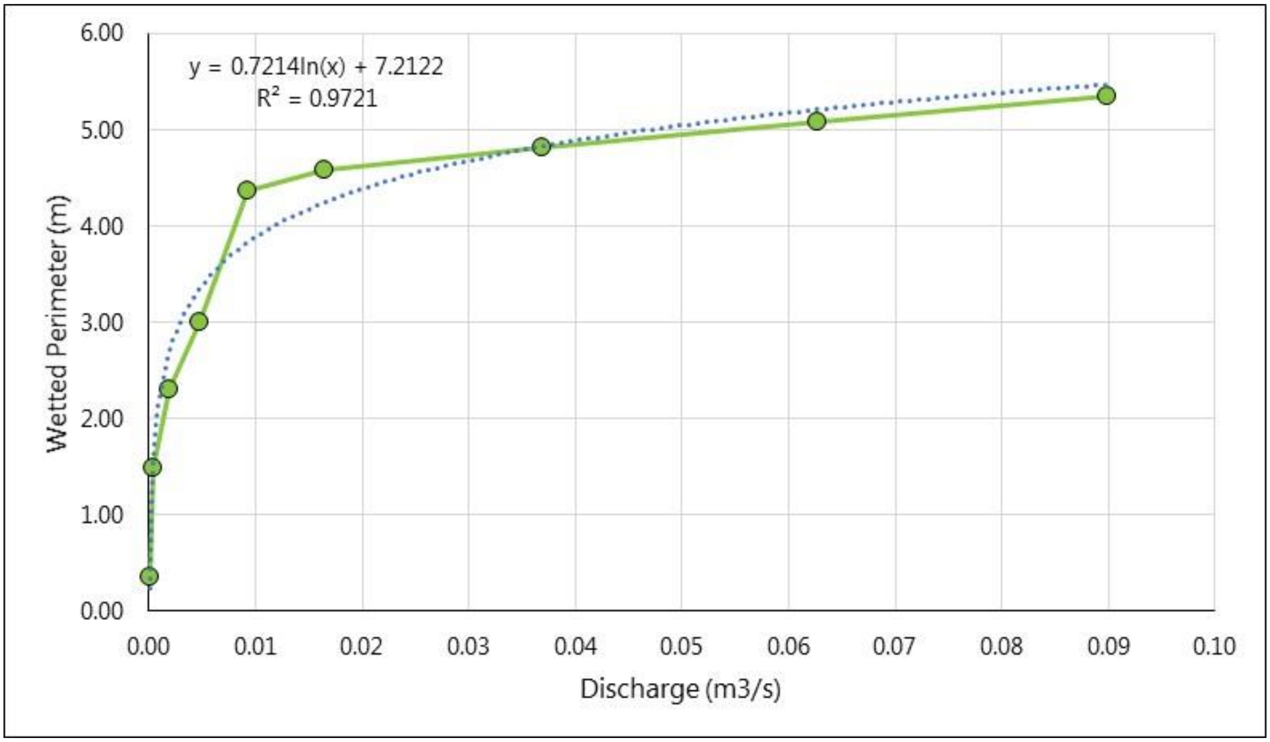


Figure _. Discharge (m^3/s) vs wetted perimeter relationship, transect WC-23, Reach 1, transect 1 (WC23-R1-T1)

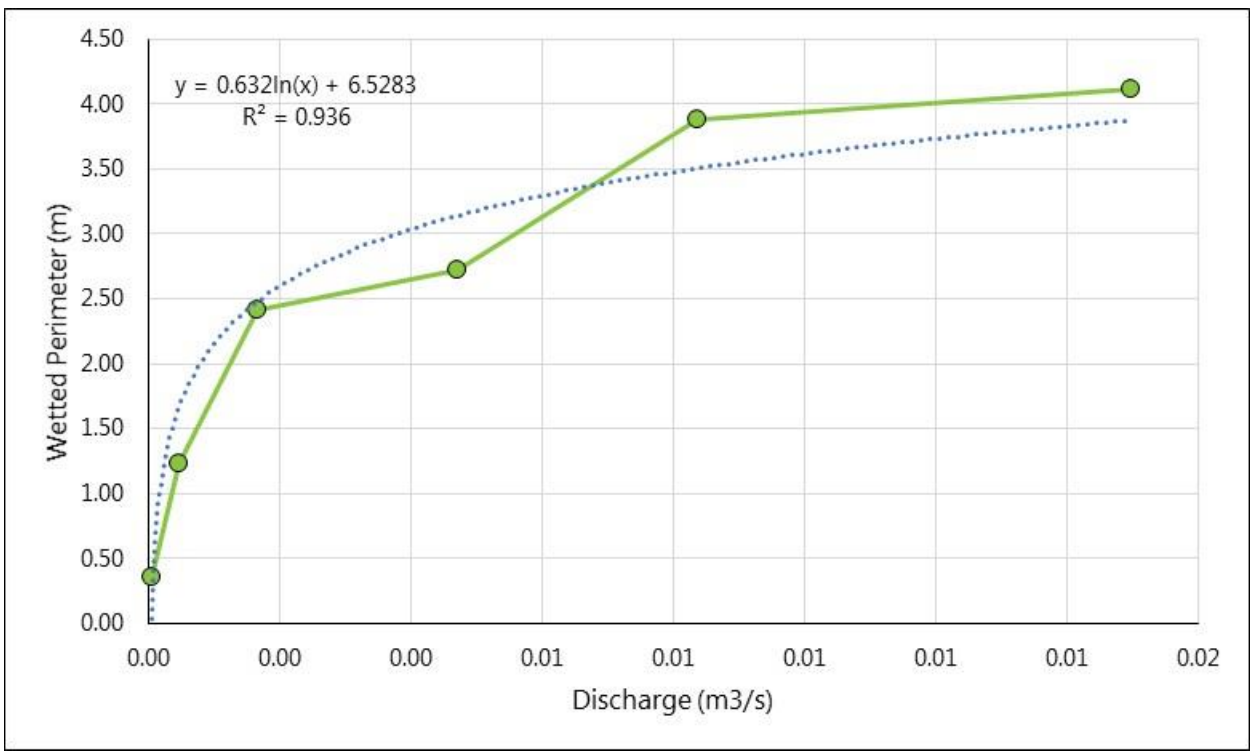


Figure _. Discharge (m^3/s) vs wetted perimeter relationship, transect WC-23, Reach 2, transect 1 (WC23-R2-T1)

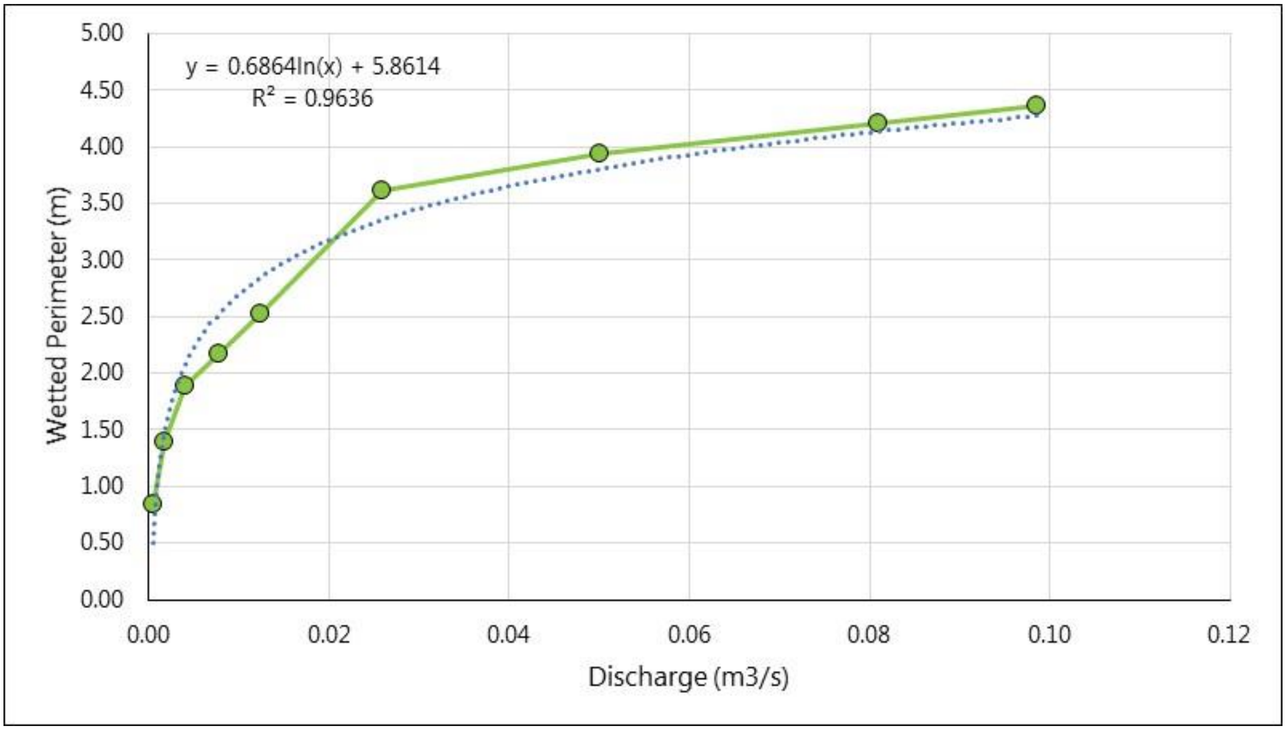


Figure _. Discharge (m^3/s) vs wetted perimeter relationship, transect WC-23, Reach 3, transect 2 (WC23-R3-T2)

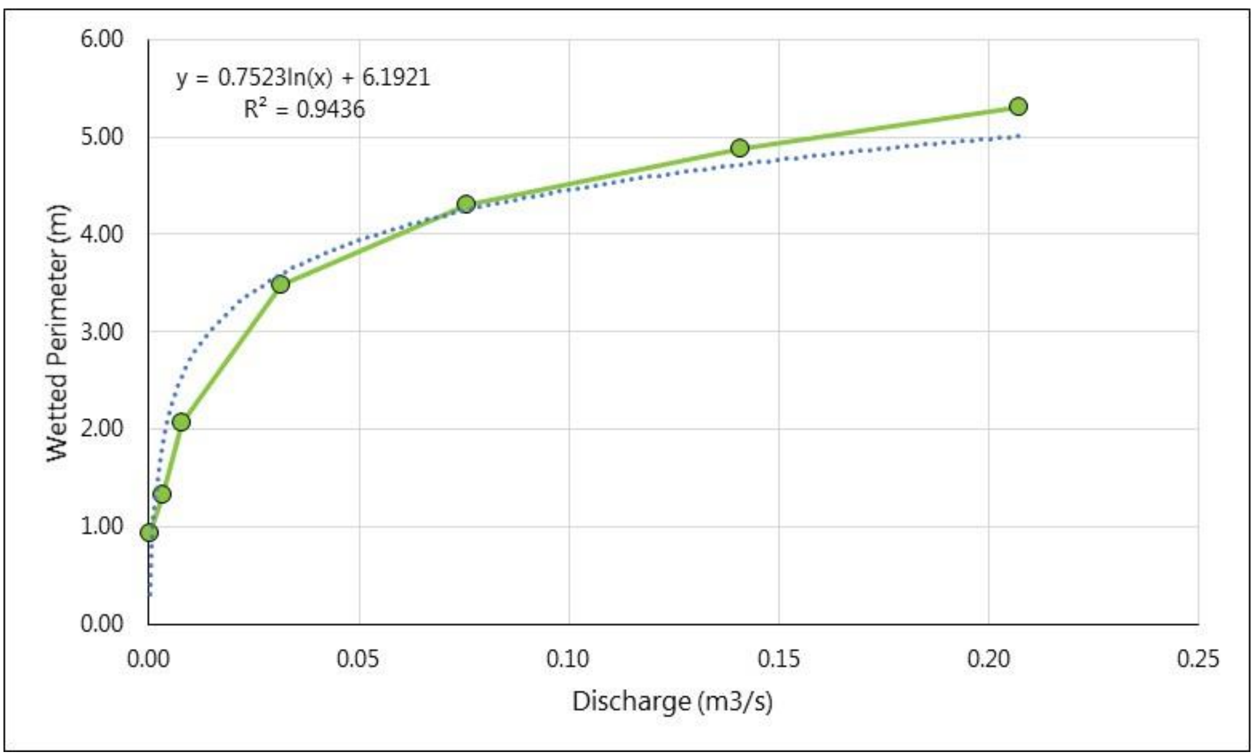


Figure _. Discharge (m^3/s) vs wetted perimeter relationship, transect WC-23, Reach 3, transect 6 (WC23-R3-T6)

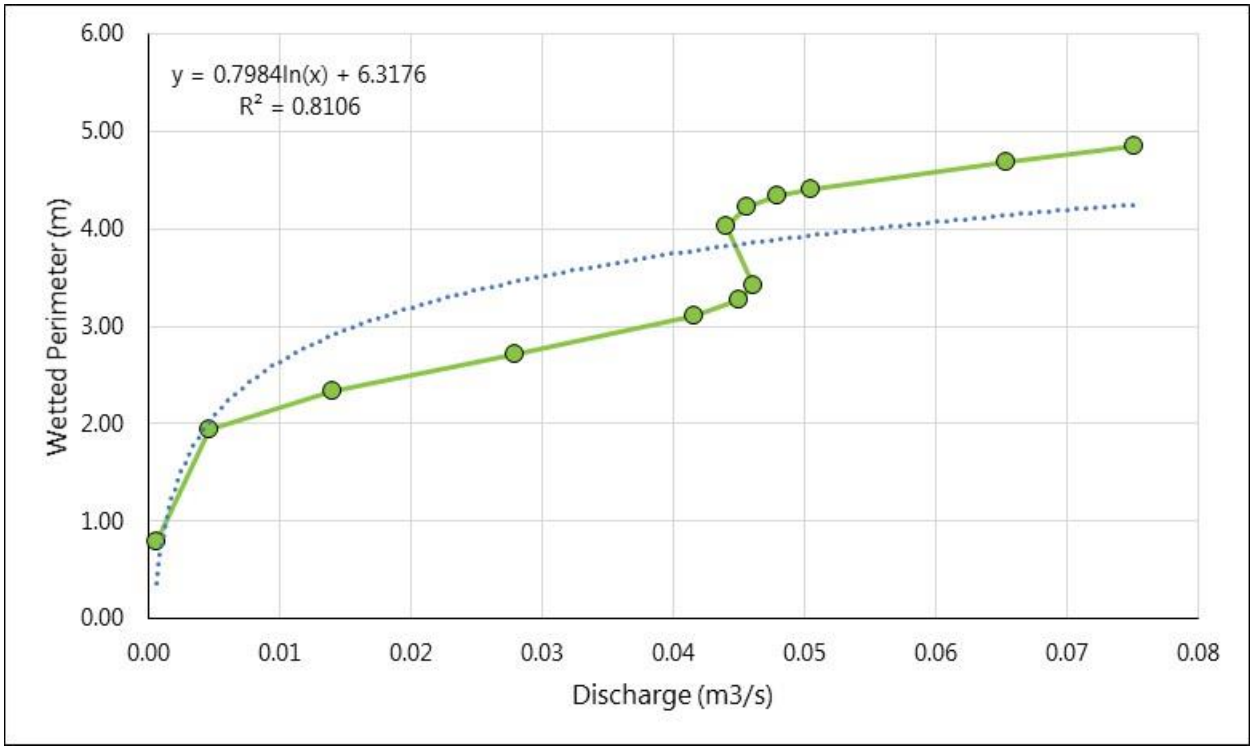


Figure _. Discharge (m^3/s) vs wetted perimeter relationship, transect WC-23, Reach 3, transect 9 (WC23-R3-T9)

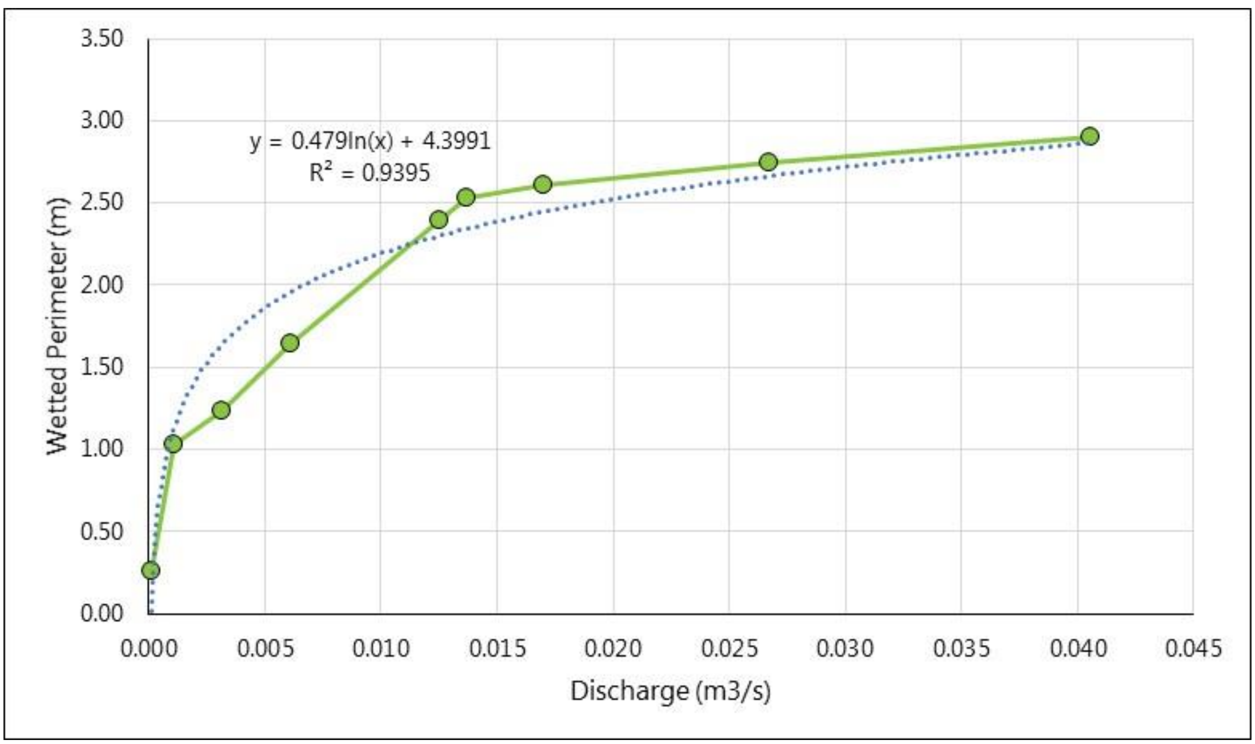


Figure _. Discharge (m^3/s) vs wetted perimeter relationship, transect WC-26, Reach 2, transect 3 (WC26-R2-T3)

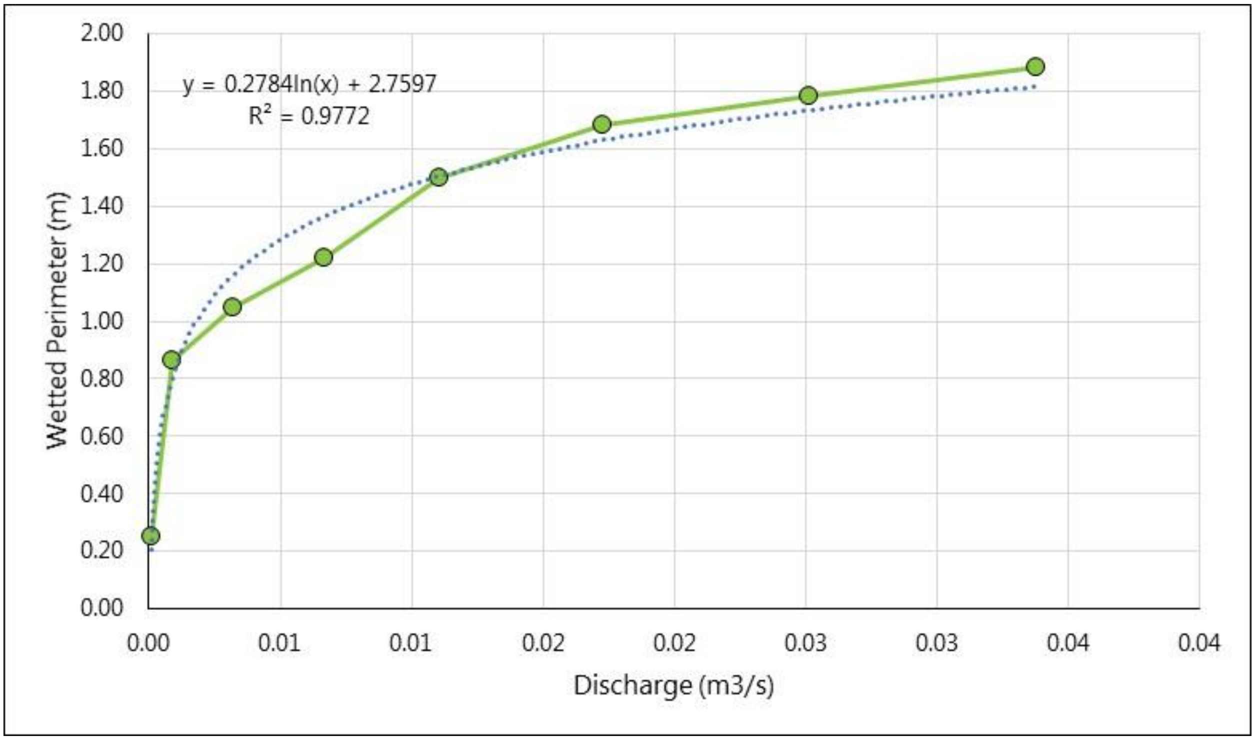


Figure _. Discharge (m^3/s) vs wetted perimeter relationship, transect WC-26, Reach 2, transect 5 (WC26-R2-T5)

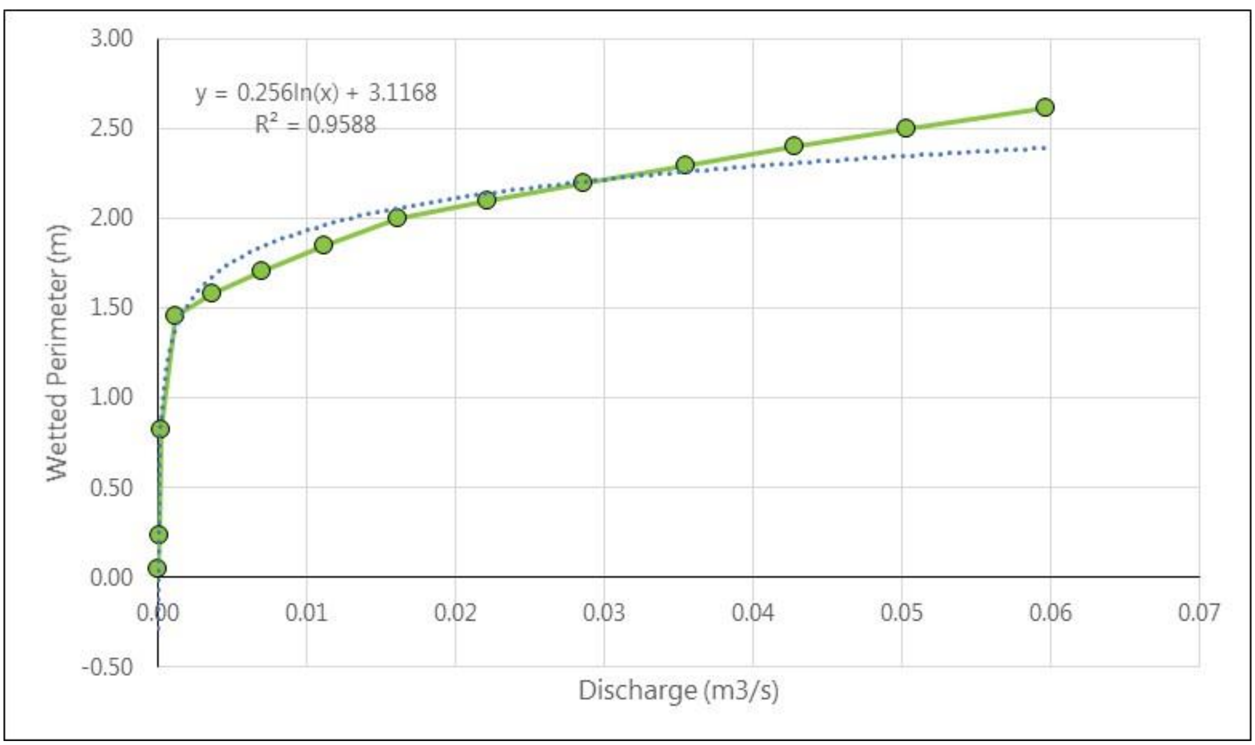


Figure _. Discharge (m^3/s) vs wetted perimeter relationship, transect WC-26, Reach 2, transect 9 (WC26-R2-T9)

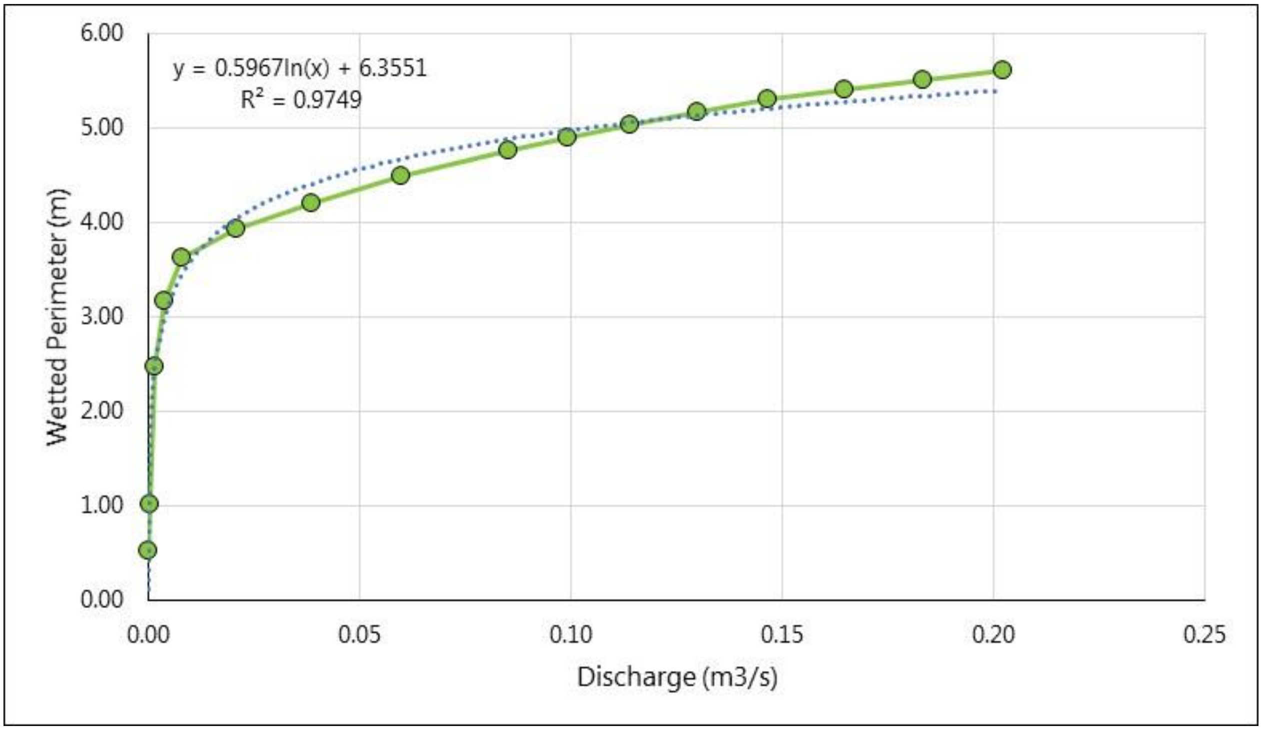


Figure _. Discharge (m^3/s) vs wetted perimeter relationship, transect WC-26, Reach 2, transect 10 (WC26-R2-T10)

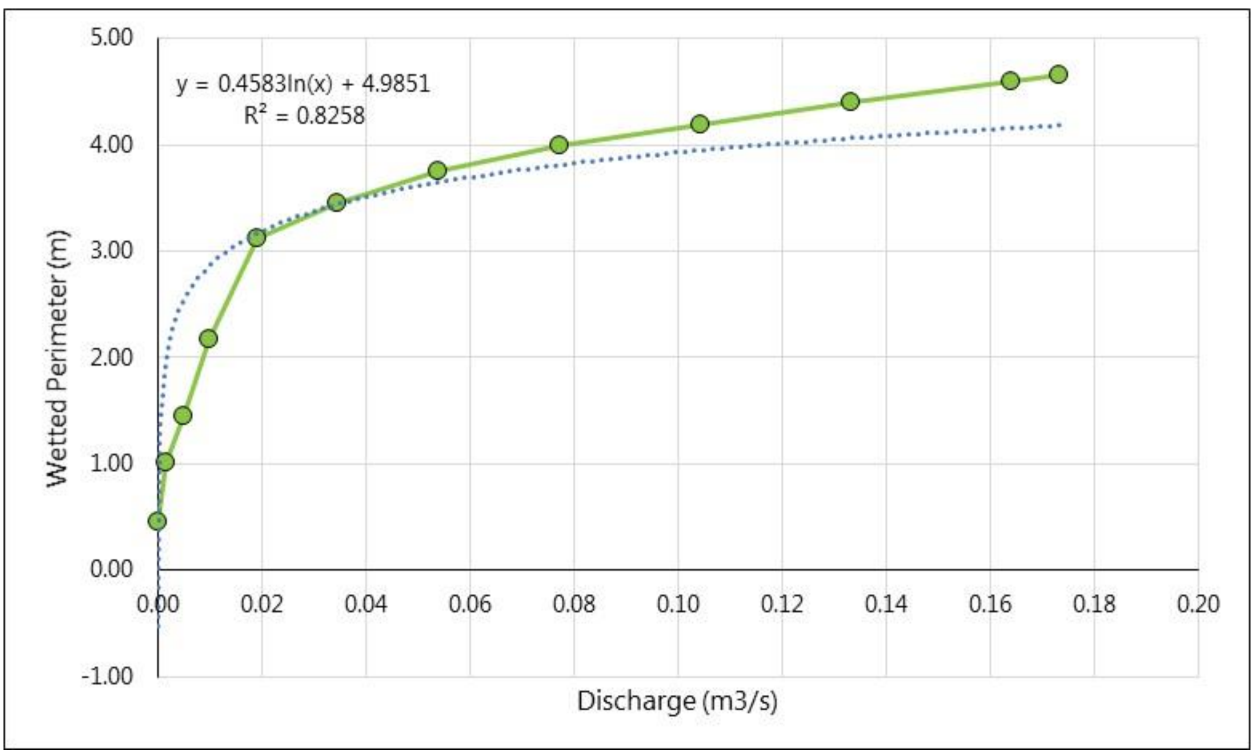


Figure _. Discharge (m^3/s) vs wetted perimeter relationship, transect WC-27, Reach 1, transect 1 (WC27-R1-T1)

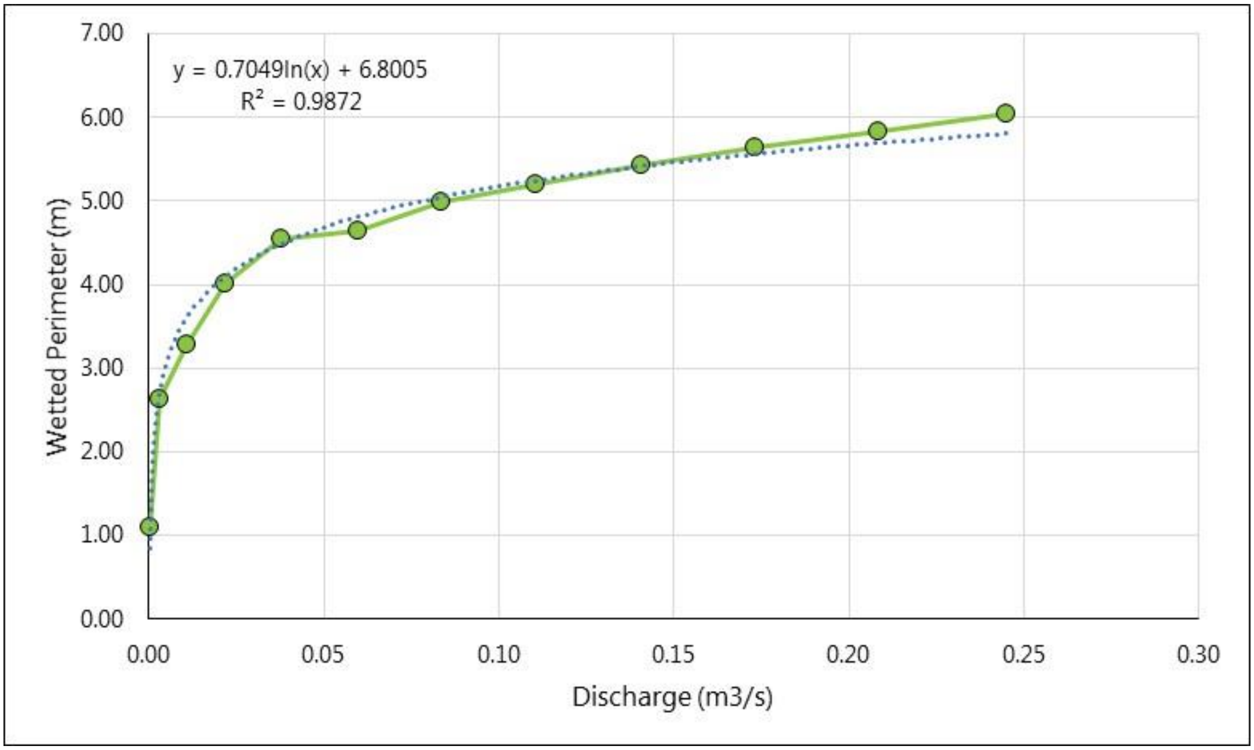


Figure _. Discharge (m^3/s) vs wetted perimeter relationship, transect WC-27, Reach 1, transect 2 (WC27-R1-T2)

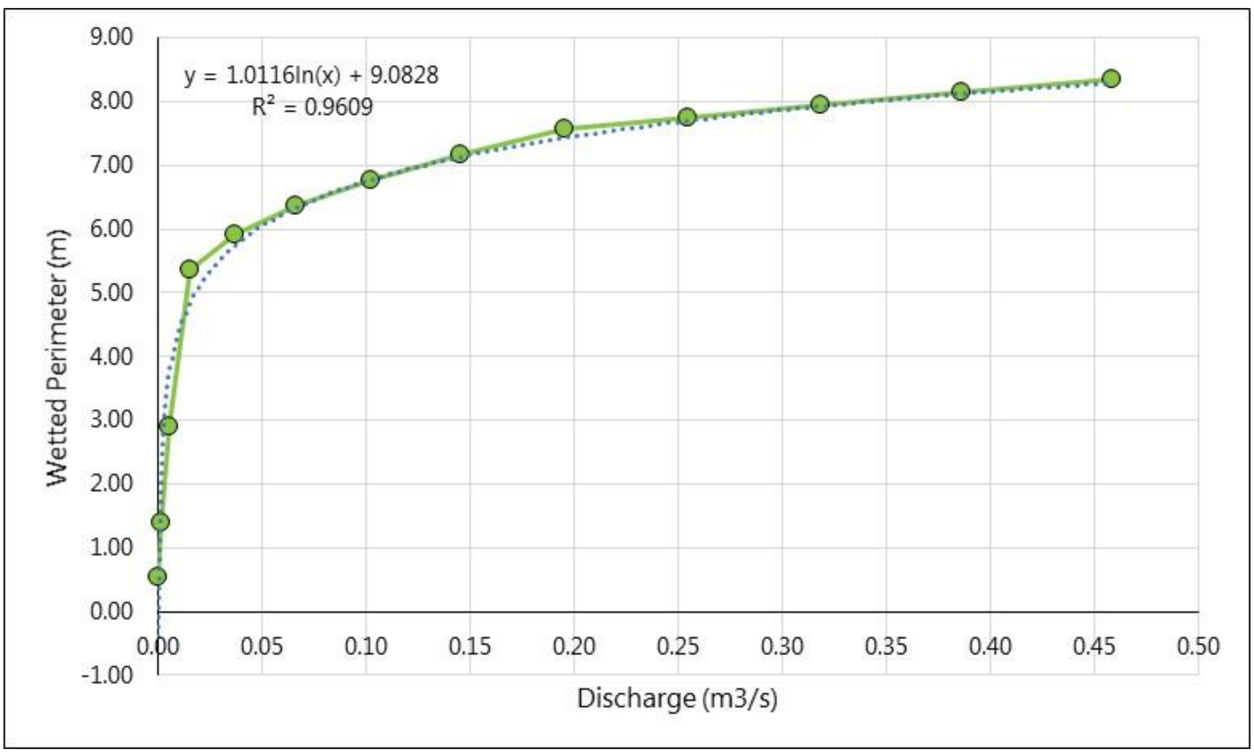


Figure _. Discharge (m^3/s) vs wetted perimeter relationship, transect WC-27, Reach 1, transect 3 (WC27-R1-T3)

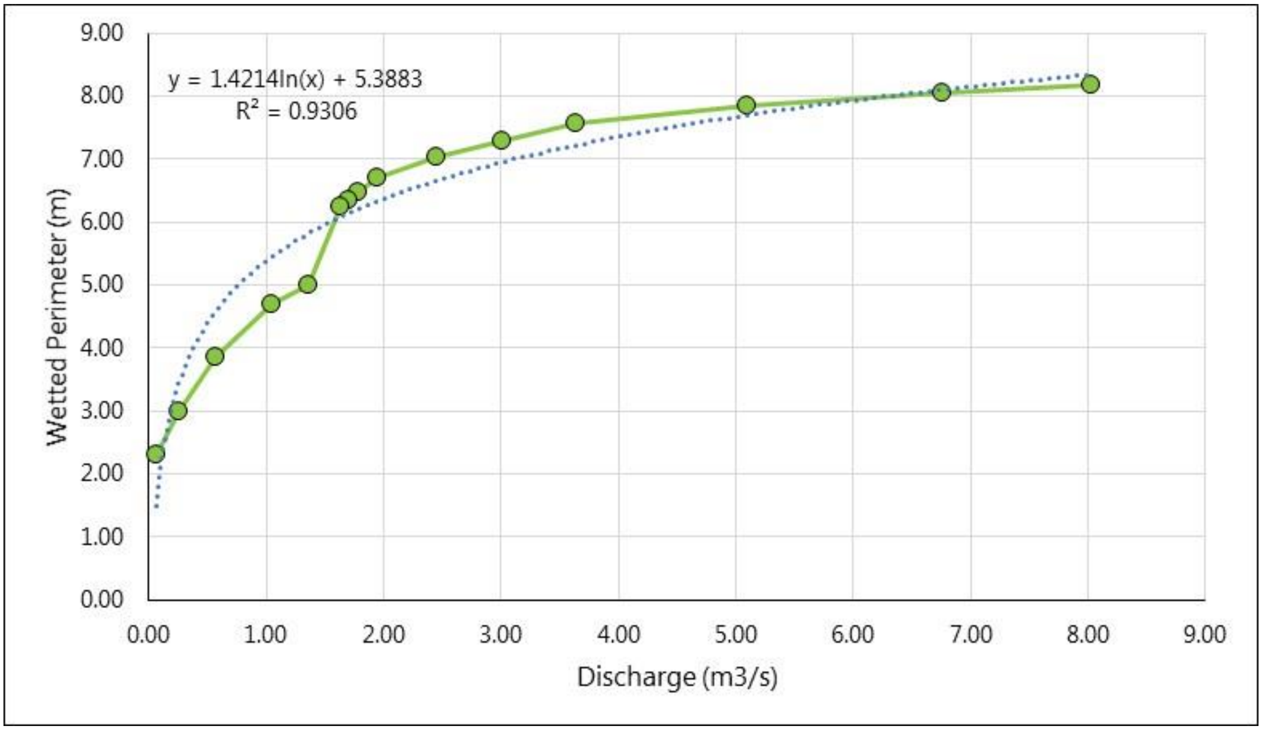


Figure _. Discharge (m^3/s) vs wetted perimeter relationship, transect Killag, Reach Cameron, transect 9 (WCK-RC-T9)

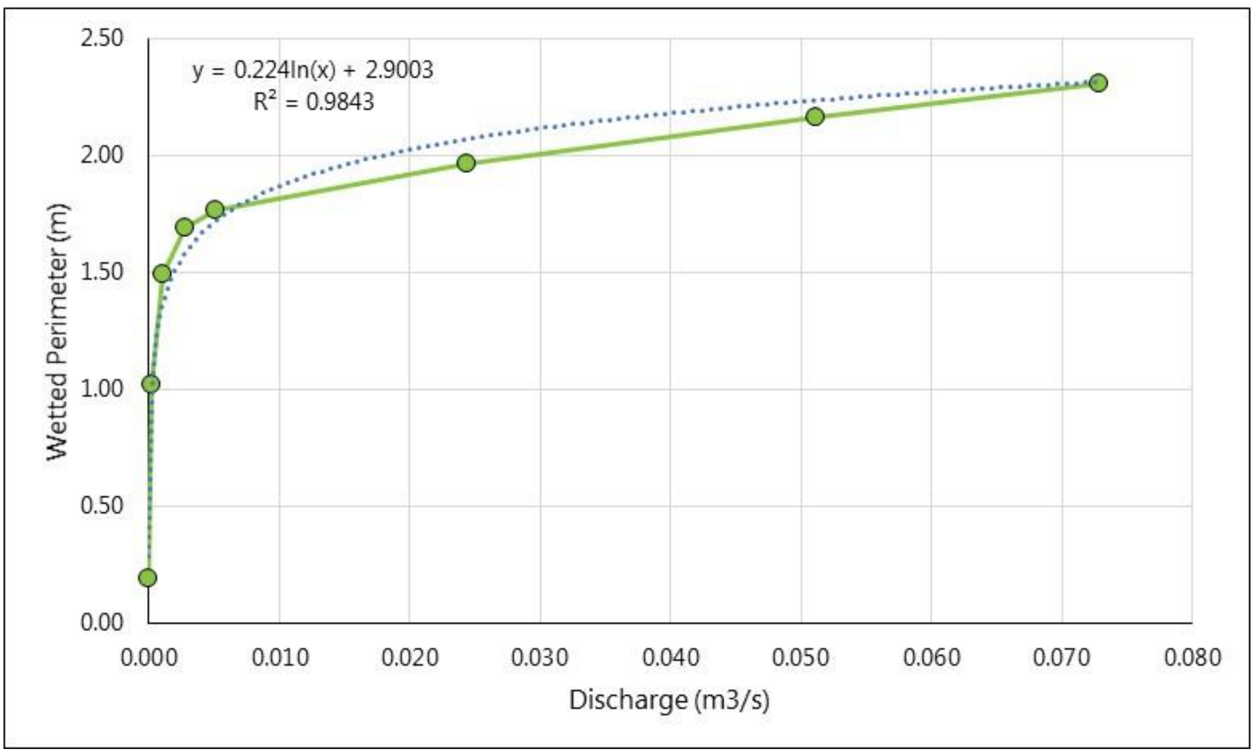


Figure _. Discharge (m3/s) vs wetted perimeter relationship, transect WC-5, Reach 3, transect 2 (WC5-R3-T2)

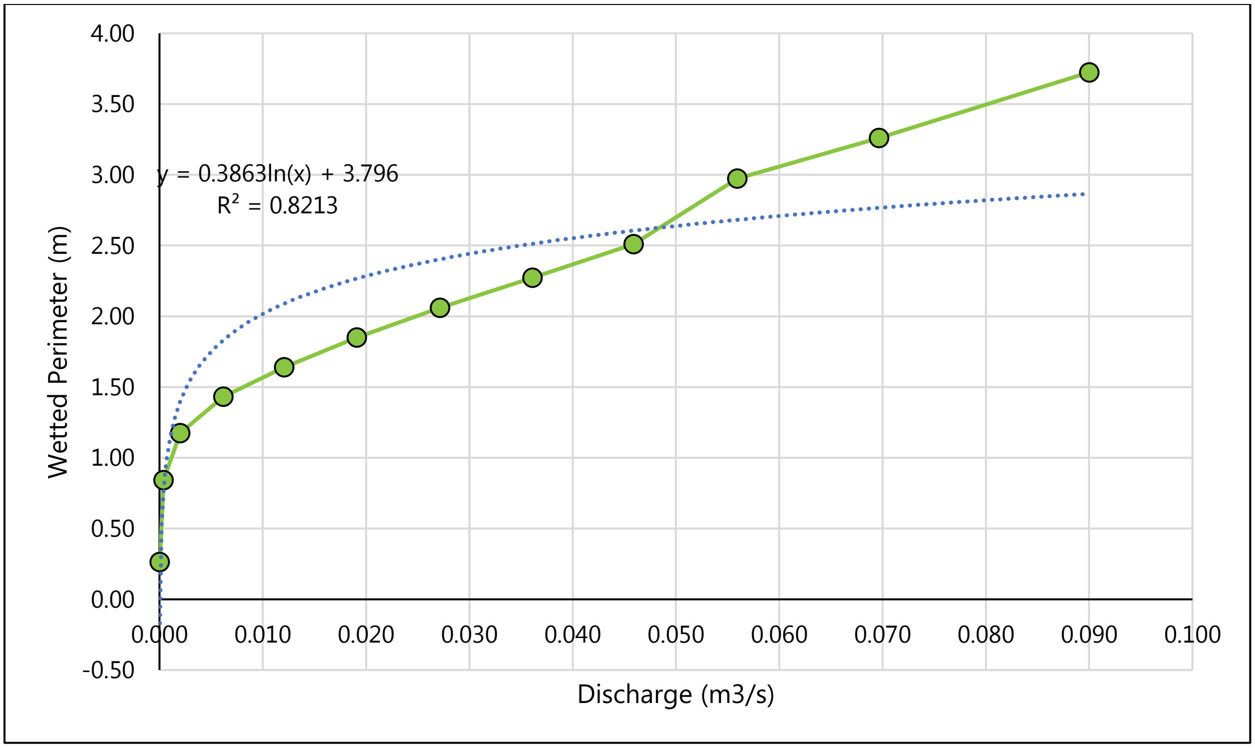


Figure _. Discharge (m3/s) vs wetted perimeter relationship, transect WC-5, Reach 3, transect 4 (WC5-R3-T4)

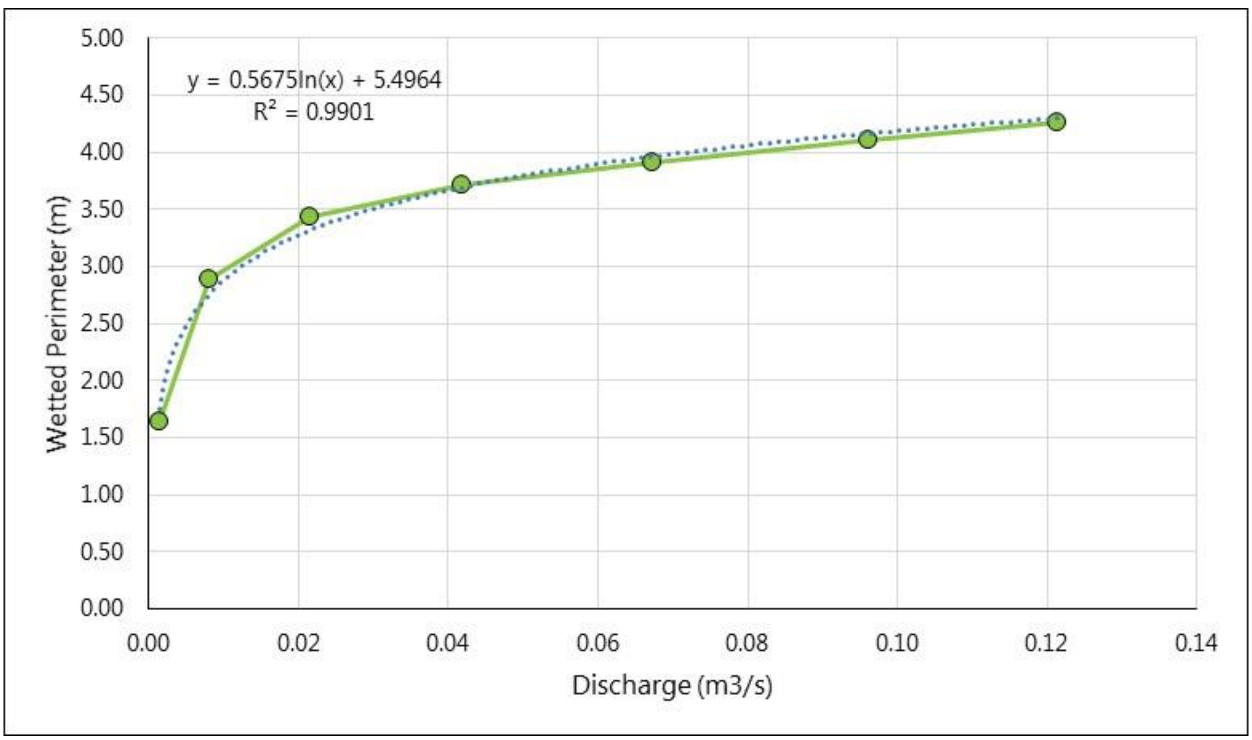
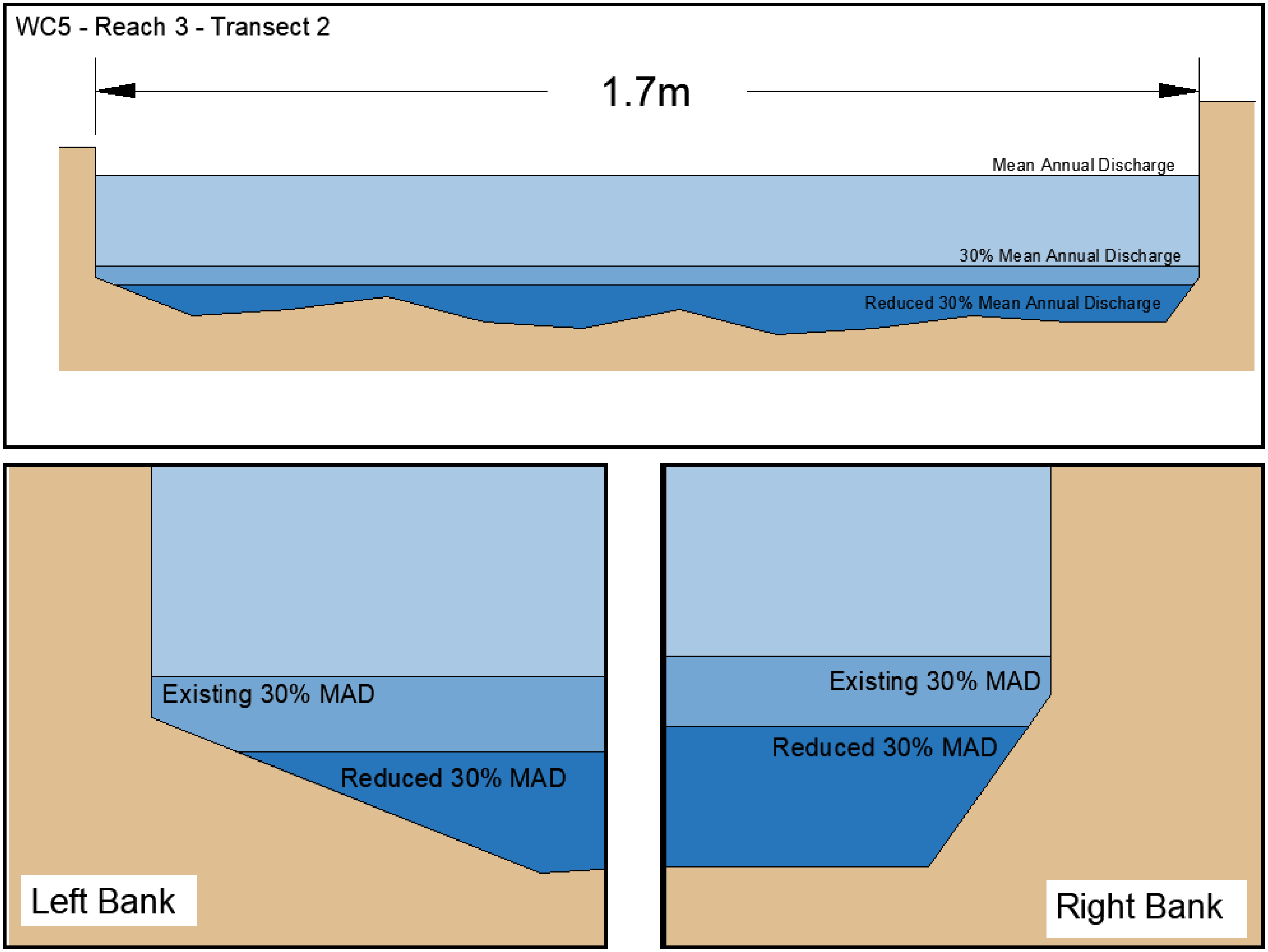
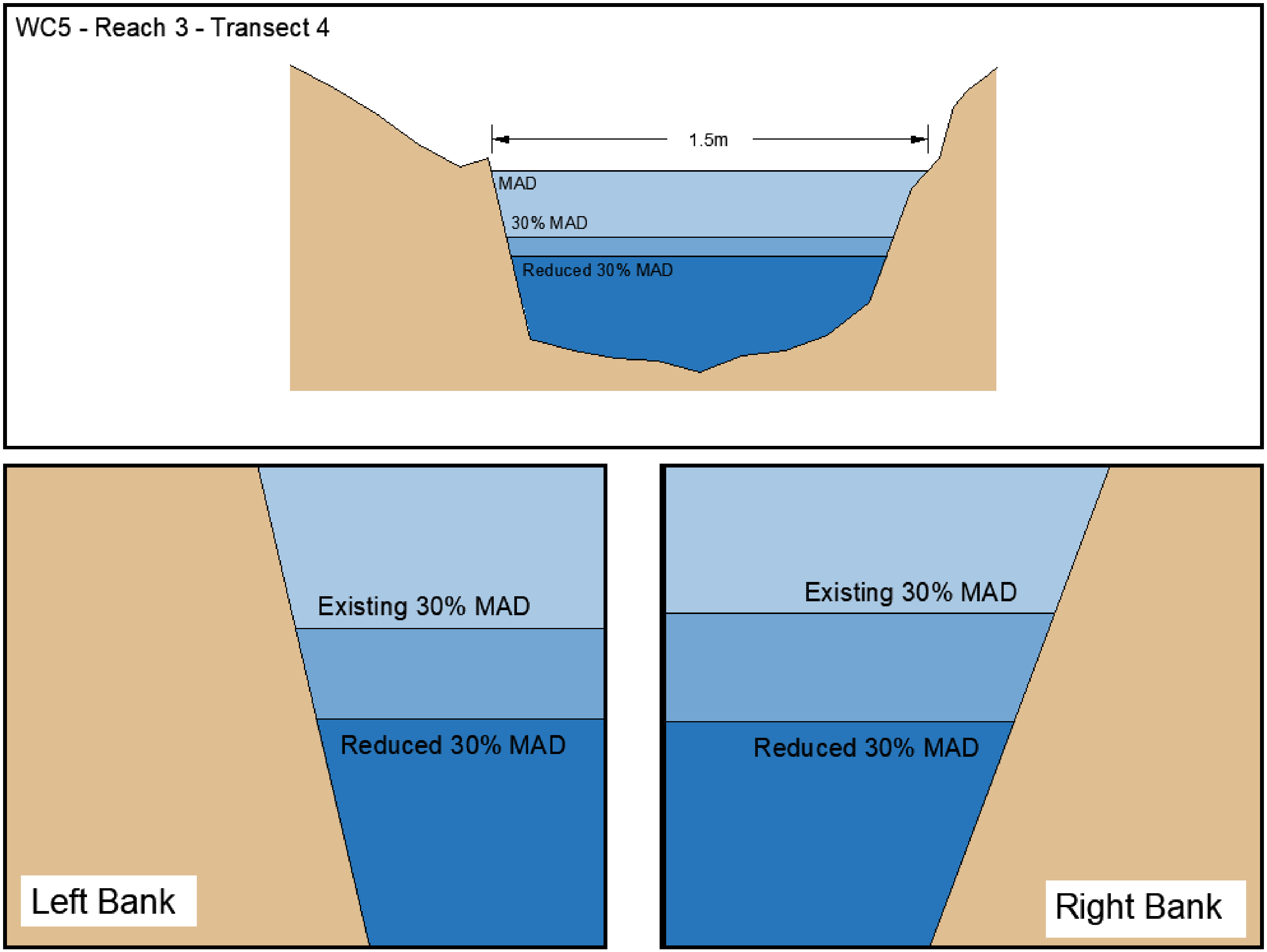
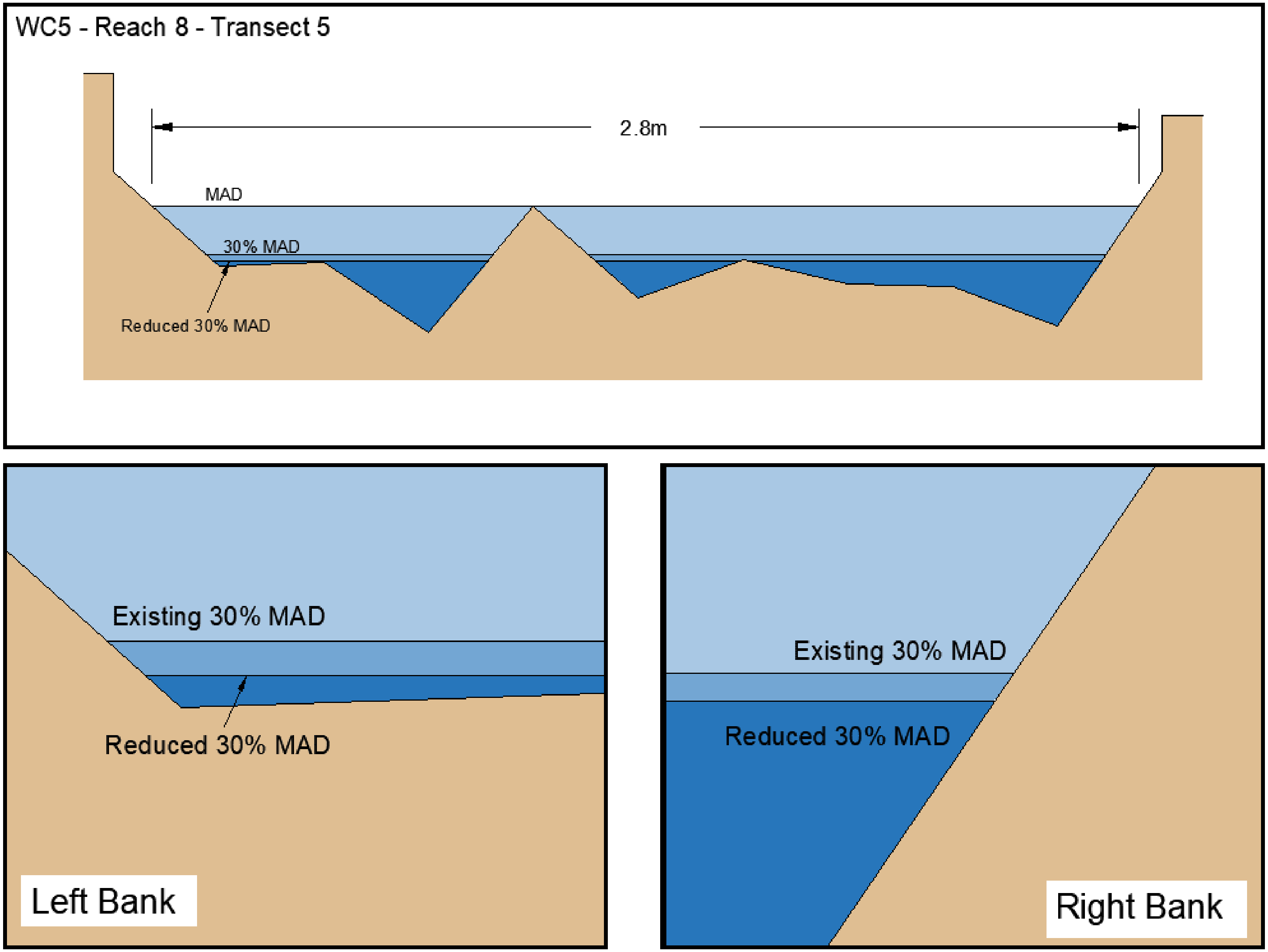
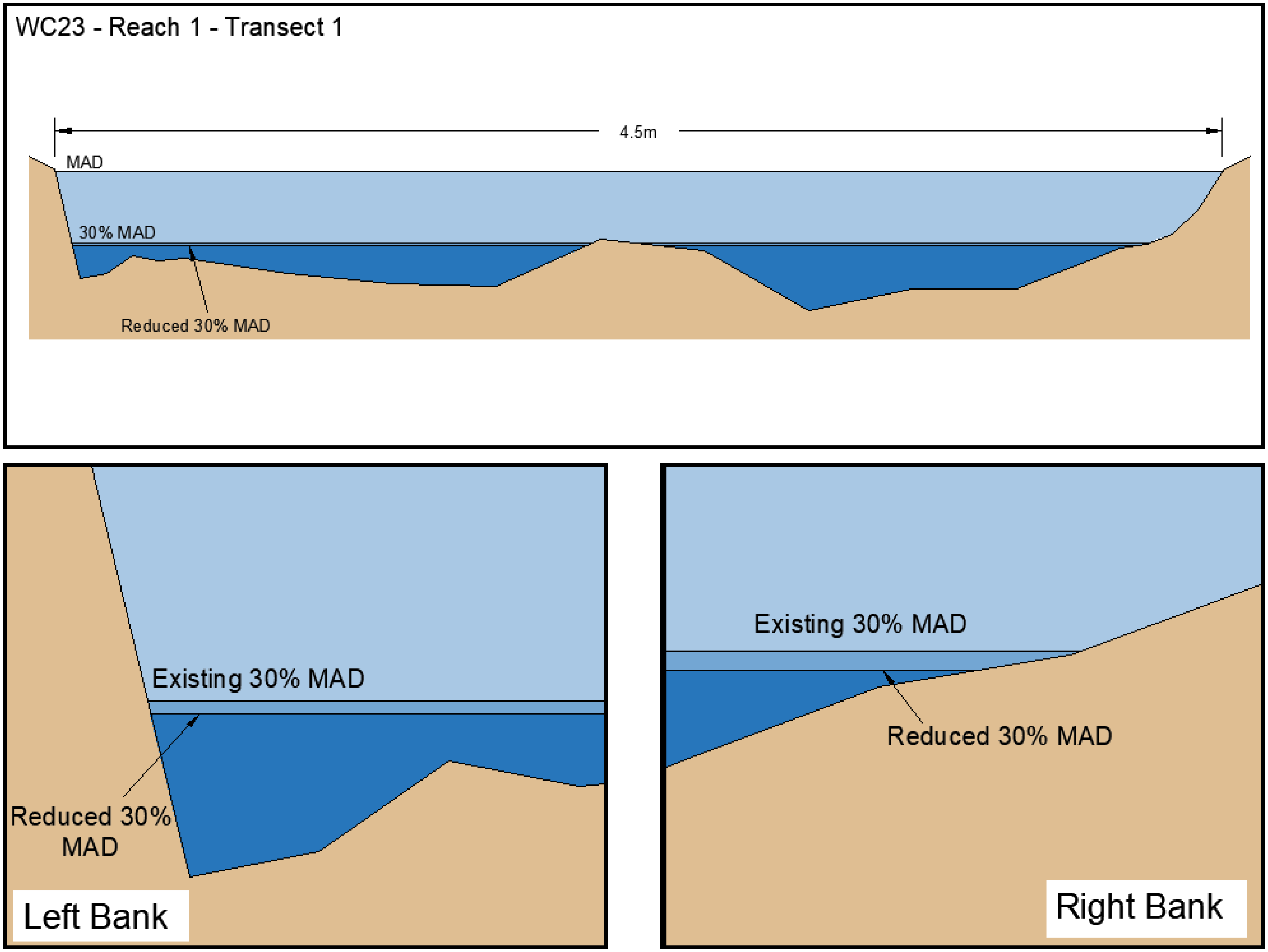


Figure _. Discharge (m3/s) vs wetted perimeter relationship, transect WC-5, Reach 8, transect 5 (WC5-R8-T5)


WC5 - Reach 3 - Transect 2
1.7m
Mean Annual Discharge
30% Mean Annual Discharge
Reduced 30% Mean Annual Discharge
Existing 30% MAD
Reduced 30% MAD
Left Bank
Existing 30% MAD
Reduced 30% MAD
Right Bank

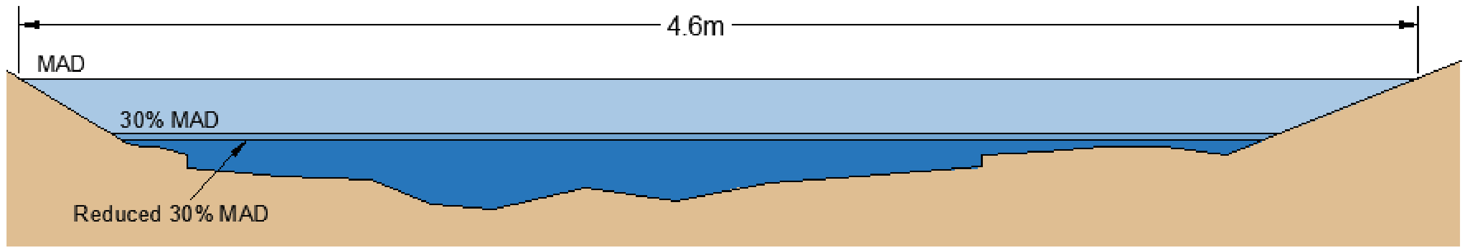

WC5 - Reach 3 - Transect 4
1.5m
MAD
30% MAD
Reduced 30% MAD
Existing 30% MAD
Reduced 30% MAD
Left Bank
Existing 30% MAD
Reduced 30% MAD
Right Bank


WC5 - Reach 8 - Transect 5
2.8m
MAD
30% MAD
Reduced 30% MAD
Existing 30% MAD
Reduced 30% MAD
Left Bank
Existing 30% MAD
Reduced 30% MAD
Right Bank

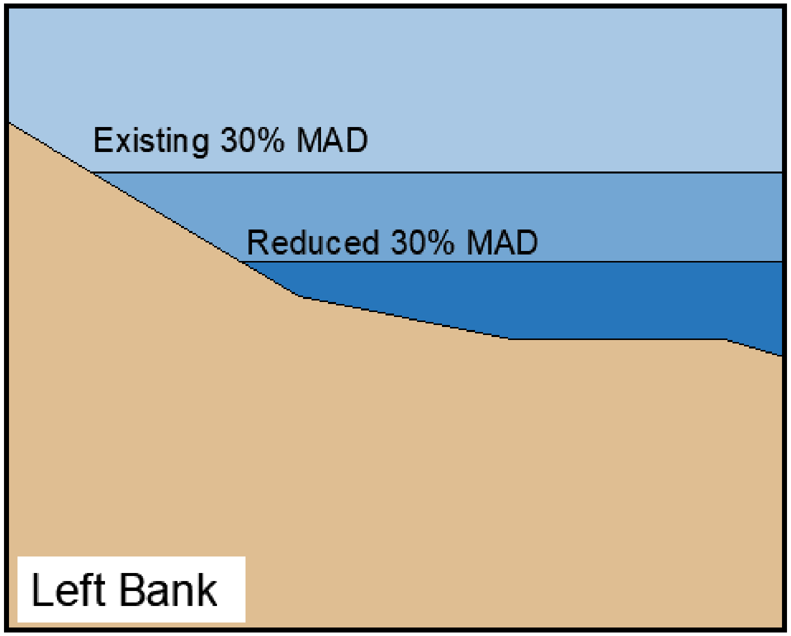


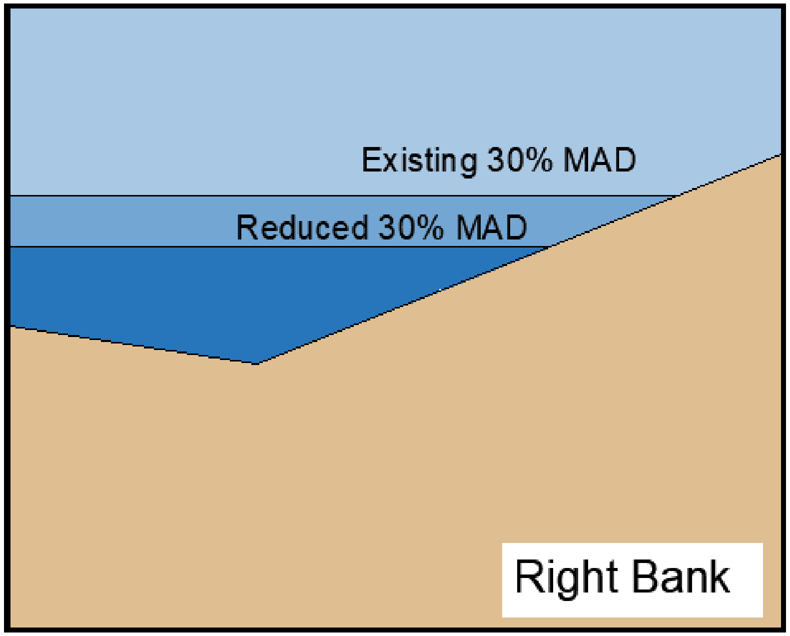
WC23 - Reach 1 - Transect 1
4.5m
MAD
30% MAD
Reduced 30% MAD
Existing 30% MAD
Reduced 30% MAD
Left Bank
Existing 30% MAD
Reduced 30% MAD
Right Bank

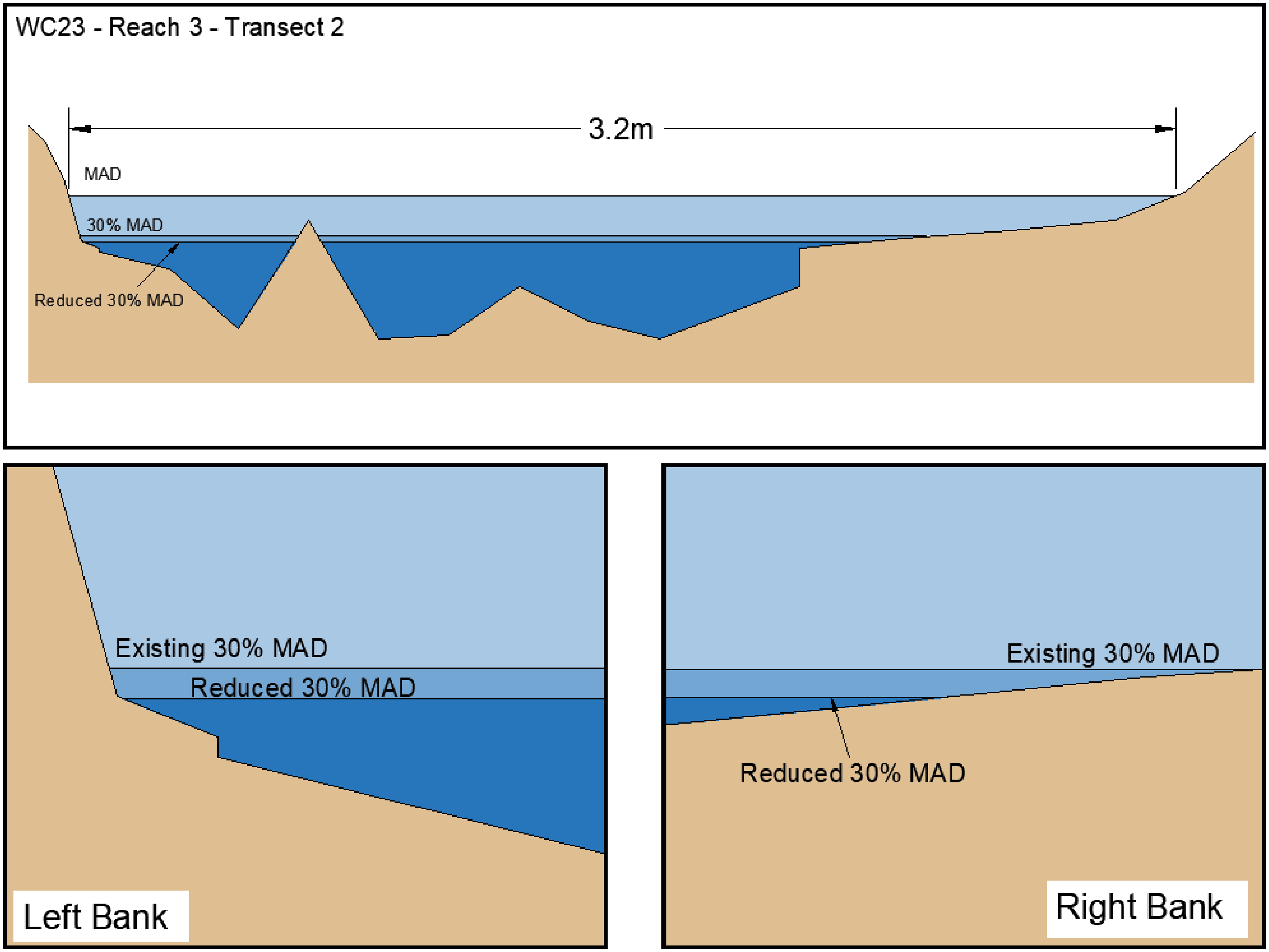
WC23 - Reach 2 - Transect 1



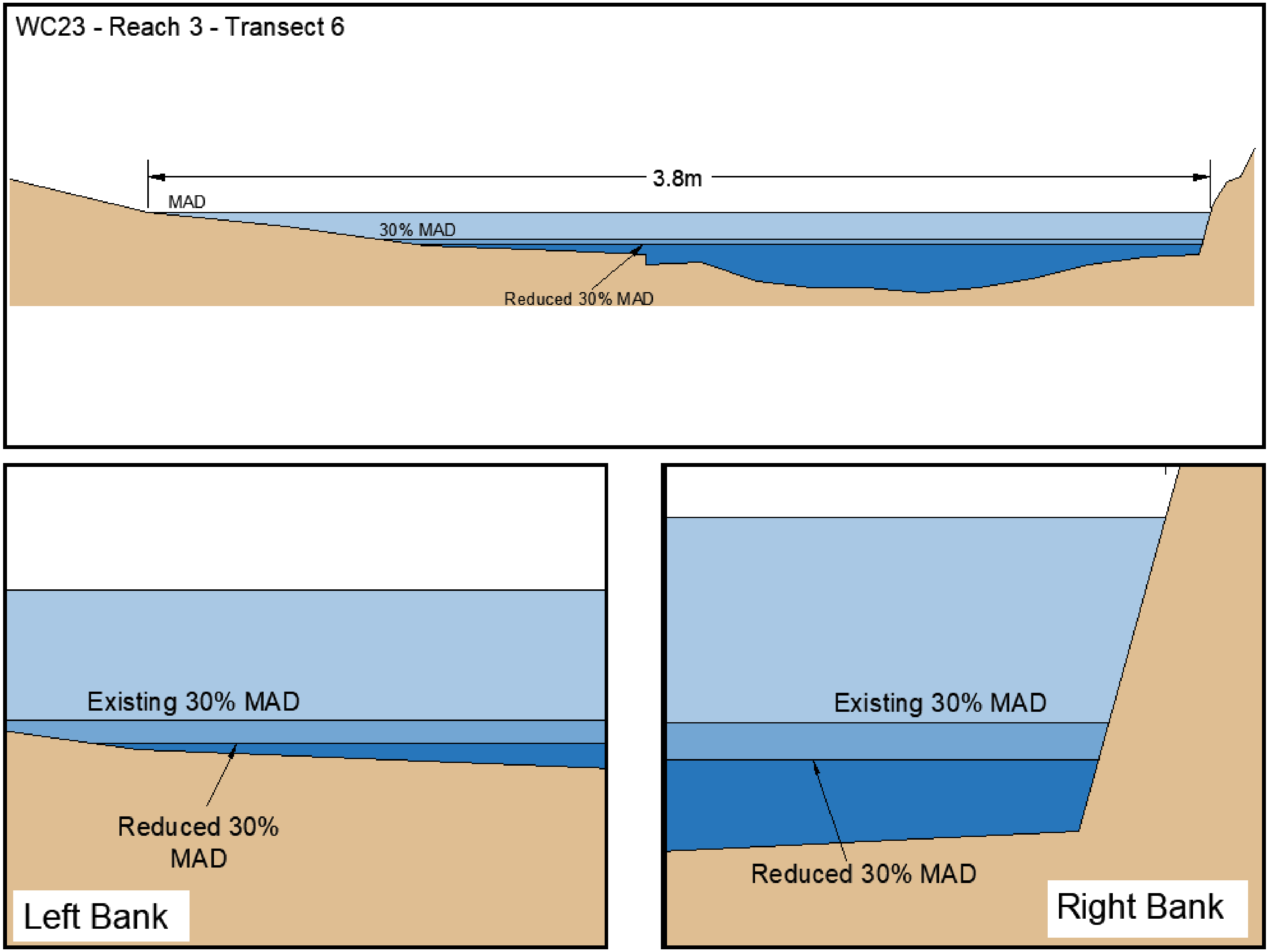
Banks extended, following measured contour, in order to present various discharge values



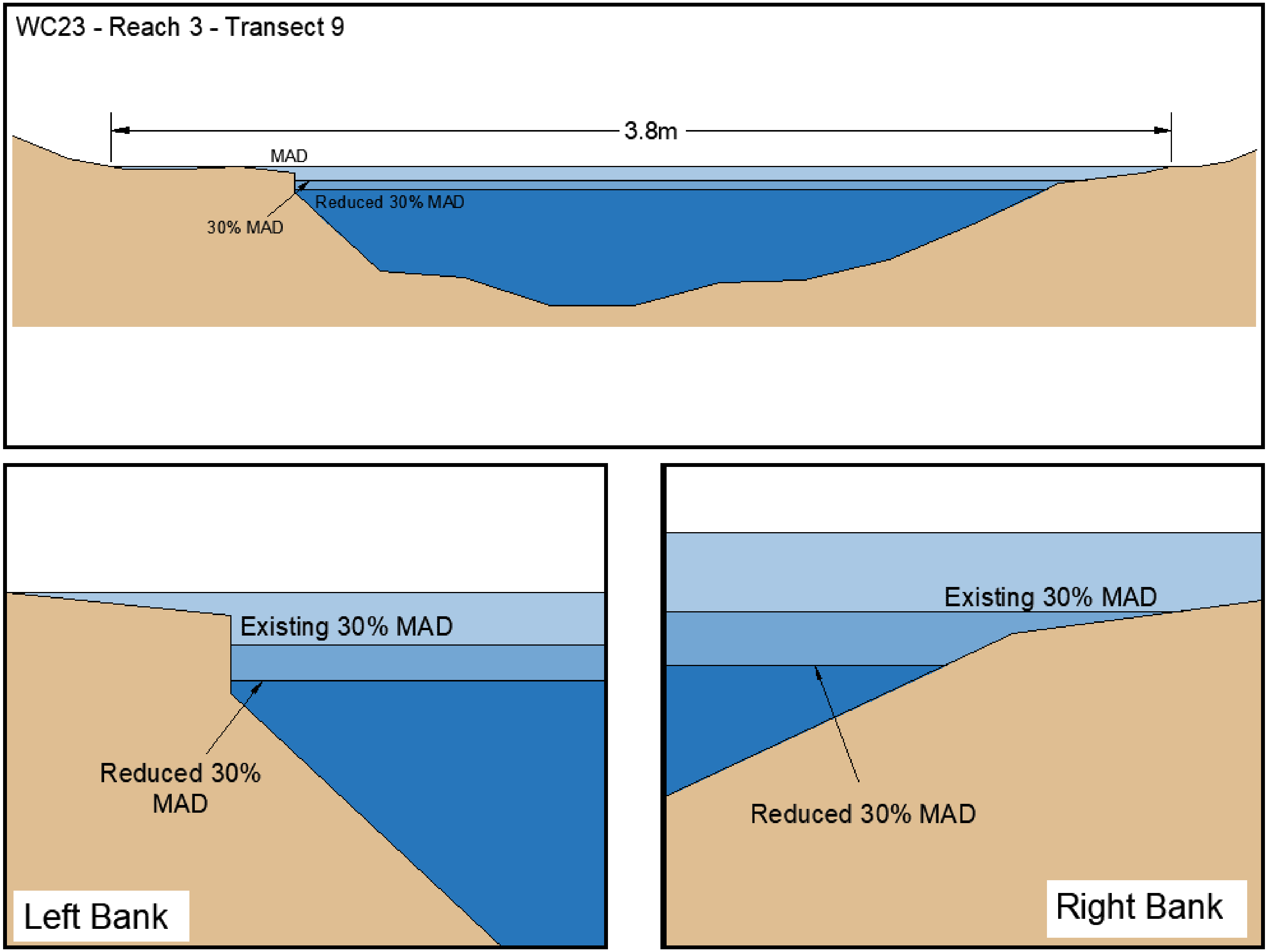




WC23 - Reach 3 - Transect 2
3.2m
MAD
30% MAD
Reduced 30% MAD
Existing 30% MAD
Reduced 30% MAD
Left Bank
Existing 30% MAD
Reduced 30% MAD
Right Bank



WC23 - Reach 3 - Transect 6
3.8m
MAD
30% MAD
Reduced 30% MAD
Existing 30% MAD
Reduced 30% MAD
Left Bank
Existing 30% MAD
Reduced 30% MAD
Right Bank


WC23 - Reach 3 - Transect 9
3.8m
MAD
Reduced 30% MAD
30% MAD
Existing 30% MAD
Reduced 30% MAD
Left Bank
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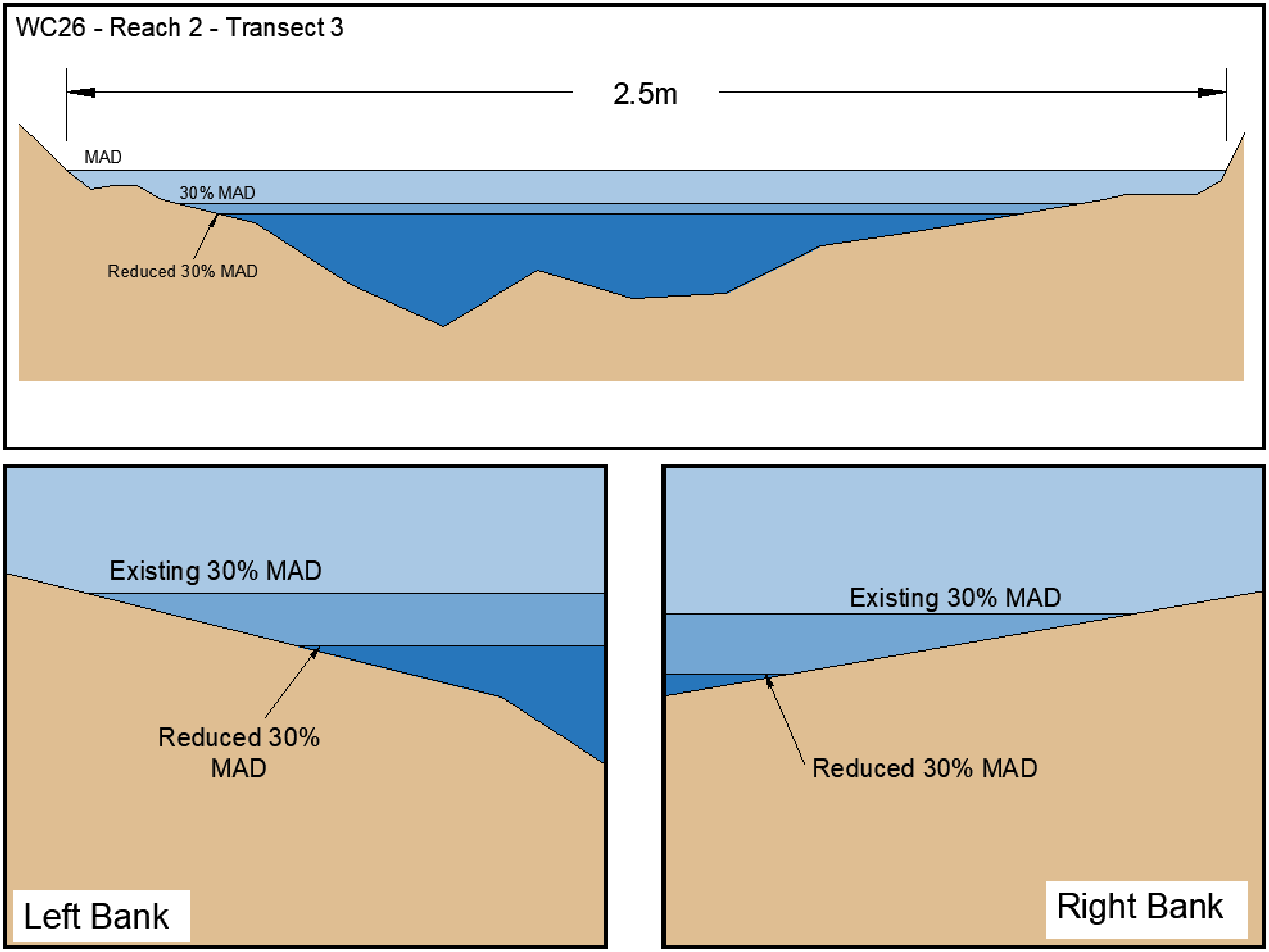
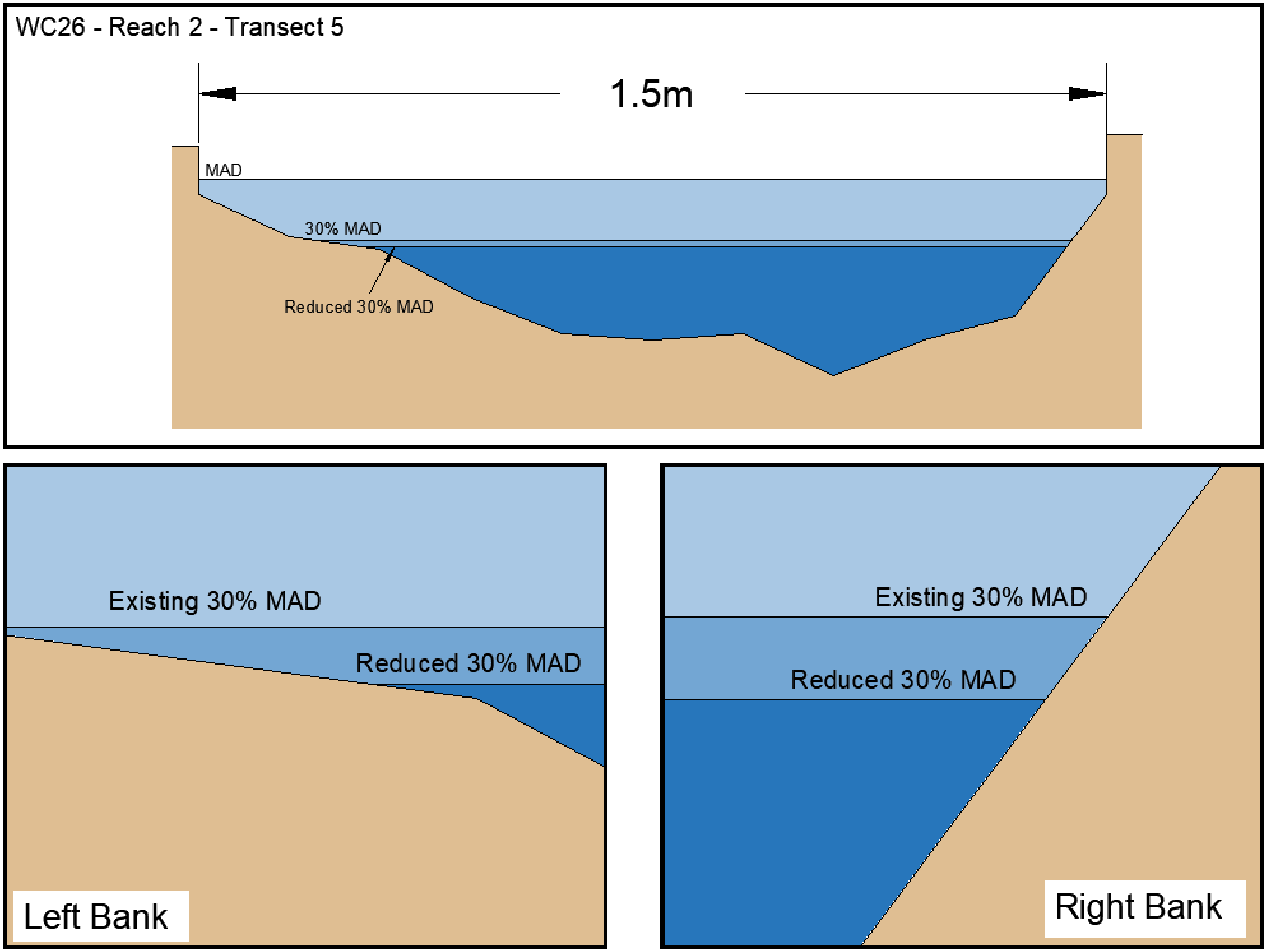
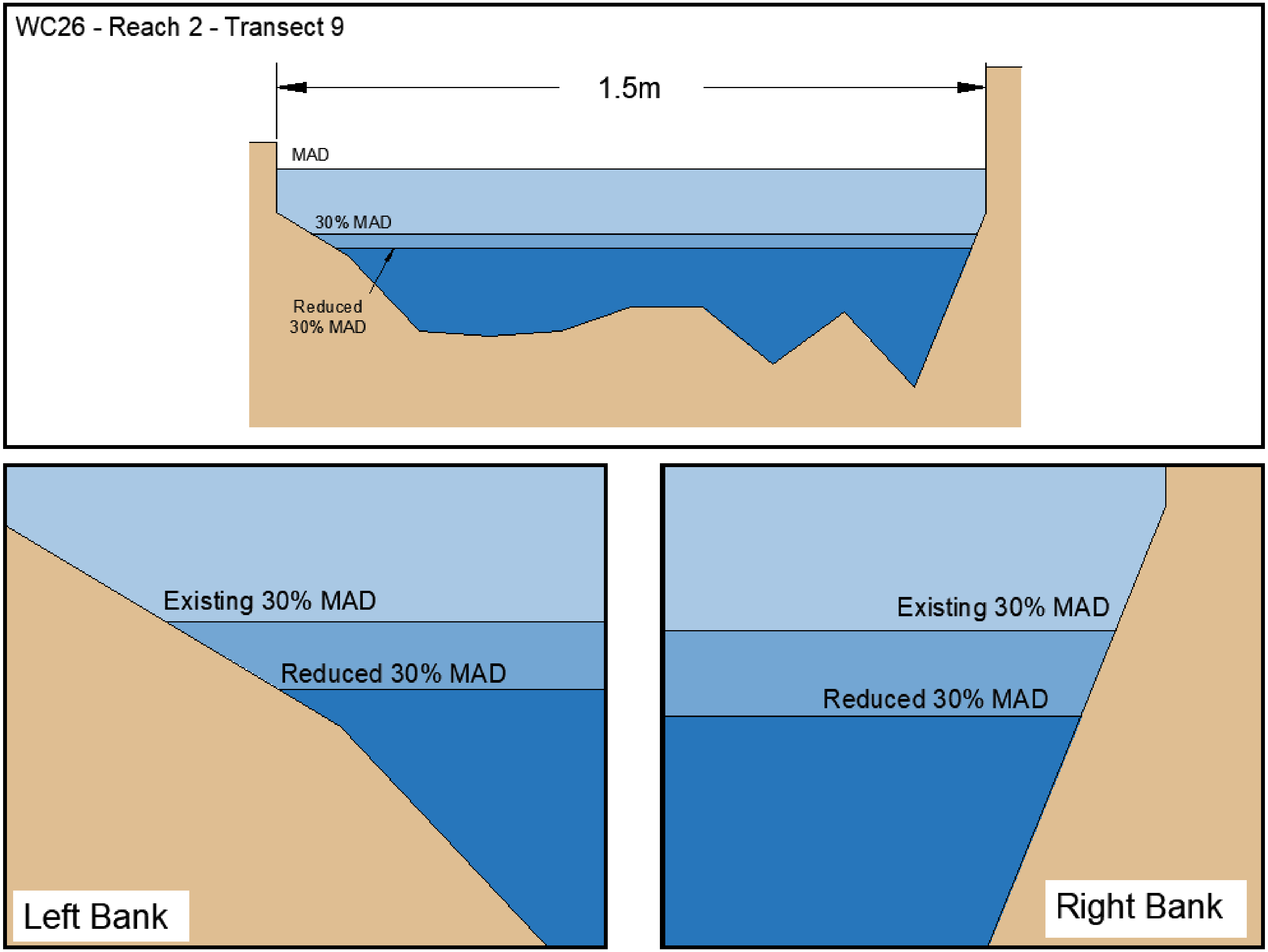
Reduced 30% MAD
Right Bank

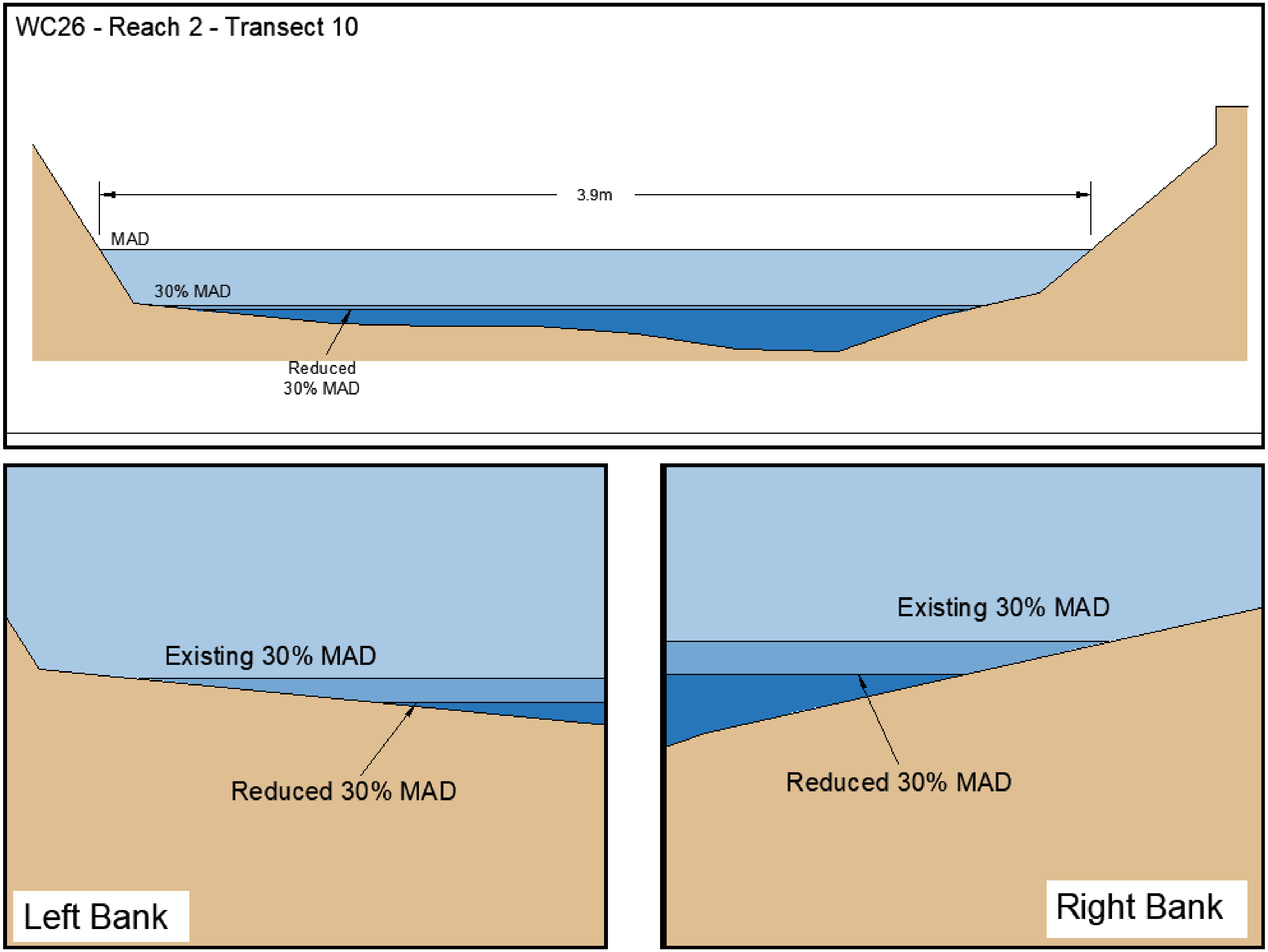


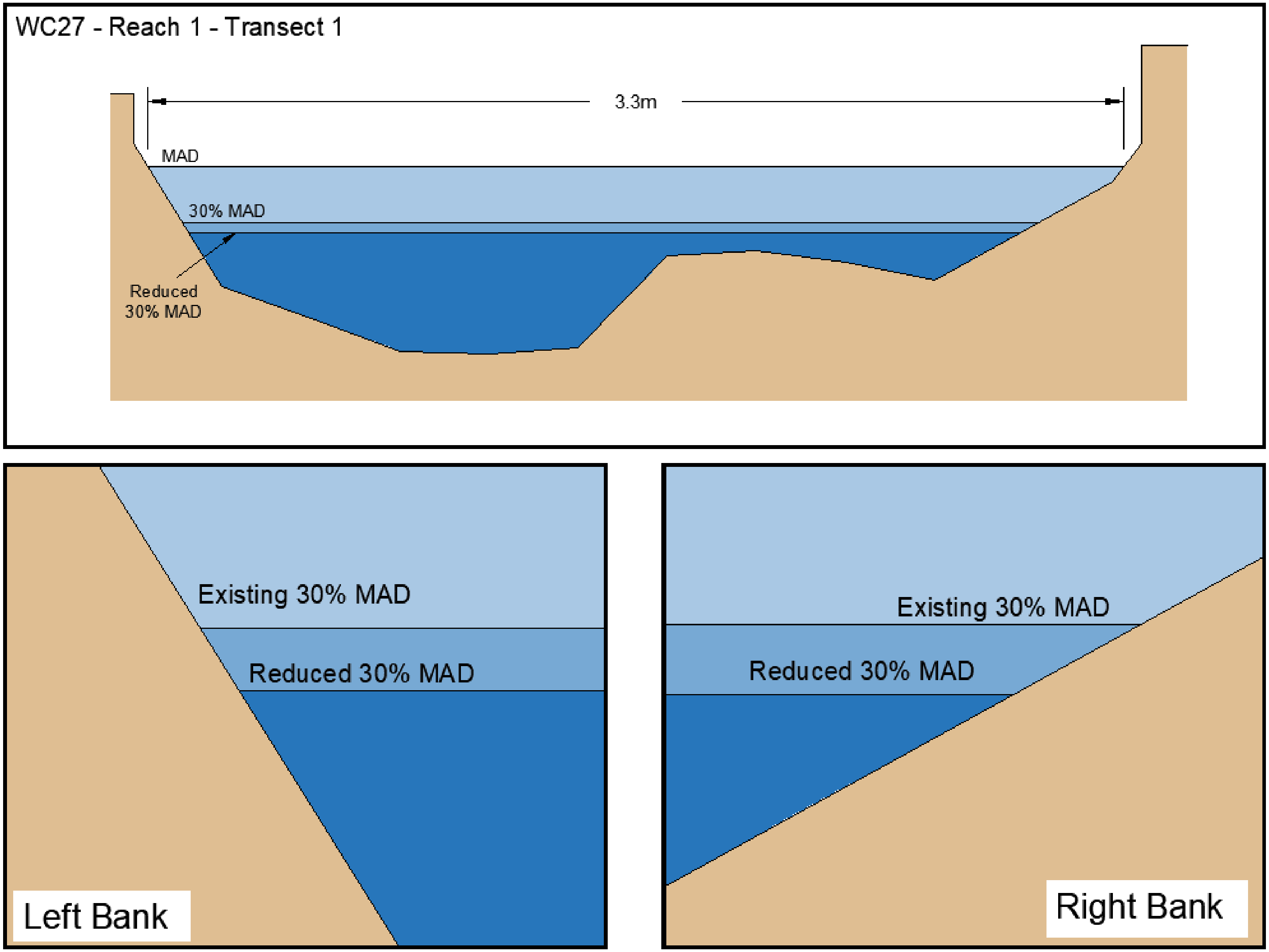
WC26 - Reach 2 - Transect 3
2.5m
MAD
30% MAD
Reduced 30% MAD
Existing 30% MAD
Reduced 30% MAD
Left Bank
Existing 30% MAD
Reduced 30% MAD
Right Bank



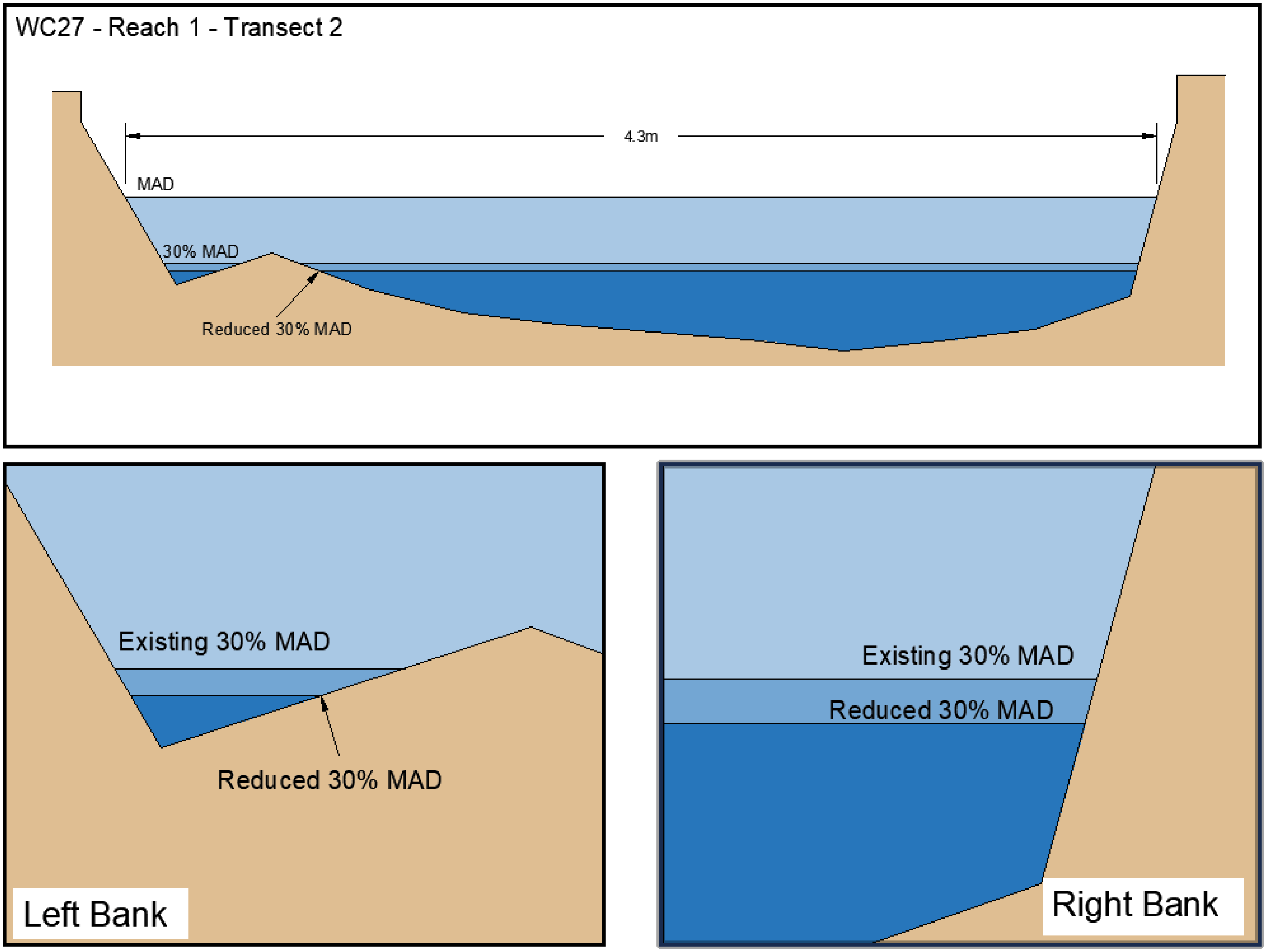
WC26 - Reach 2 - Transect 5
1.5m
MAD
30% MAD
Reduced 30% MAD
Existing 30% MAD
Reduced 30% MAD
Left Bank
Existing 30% MAD
Reduced 30% MAD
Right Bank

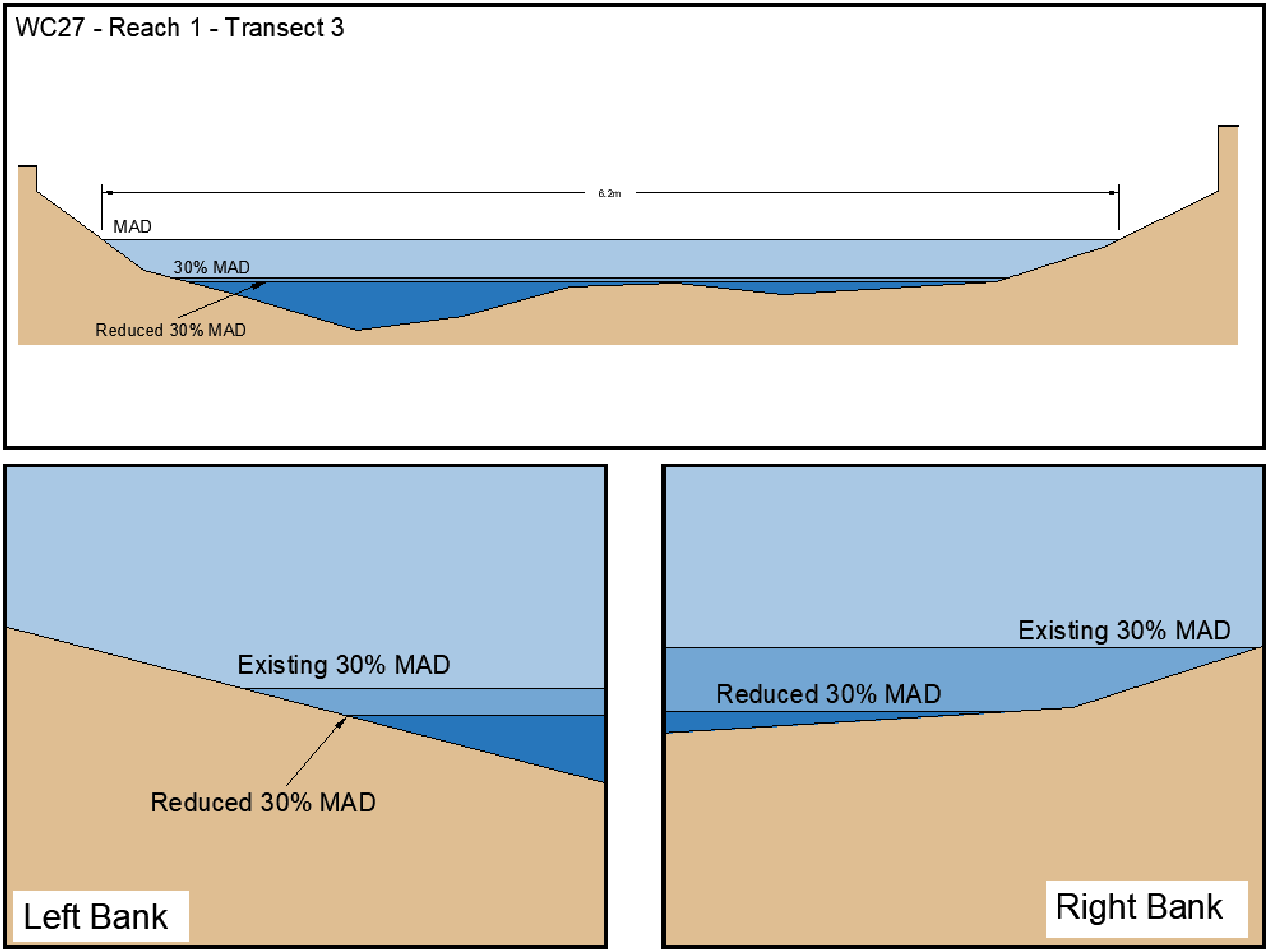

WC26 - Reach 2 - Transect 9
1.5m
MAD
30% MAD
Reduced
30% MAD
Existing 30% MAD
Reduced 30% MAD
Left Bank
Existing 30% MAD
Reduced 30% MAD
Right Bank


WC26 - Reach 2 - Transect 10
3.9m
MAD
30% MAD
Reduced
30% MAD
Existing 30% MAD
Reduced 30% MAD
Left Bank
Existing 30% MAD
Reduced 30% MAD
Right Bank



WC27 - Reach 1 - Transect 1
3.3m
MAD
30% MAD
Reduced
30% MAD
Existing 30% MAD
Reduced 30% MAD
Left Bank
Existing 30% MAD
Reduced 30% MAD
Right Bank


WC27 - Reach 1 - Transect 2
4.3m
MAD
30% MAD
Reduced 30% MAD
Existing 30% MAD
Reduced 30% MAD
Left Bank
Existing 30% MAD
Reduced 30% MAD
Right Bank


WC27 - Reach 1 - Transect 3
6.2m
MAD
30% MAD
Reduced 30% MAD
Existing 30% MAD
Reduced 30% MAD
Left Bank
Existing 30% MAD
Reduced 30% MAD
Right Bank

Appendix B

Haul Road Detailed Mapping

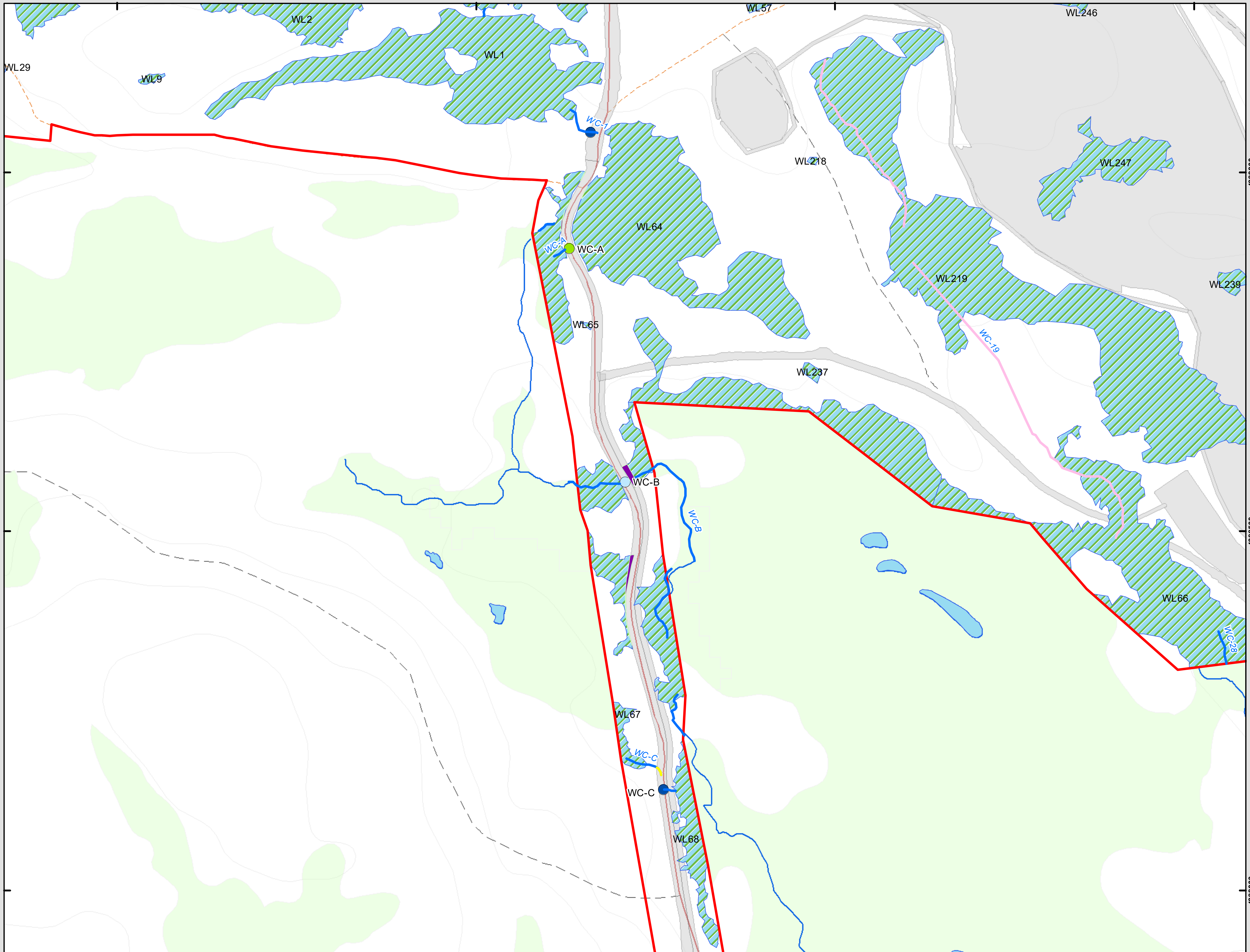


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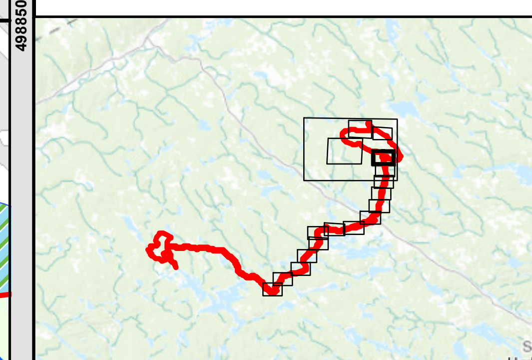
FIGURE 15A

Beaver Dam Mine Project

Anticipated Fish Habitat Impact Areas by Type: Haul Road

- Buried Culvert
- Crushed Culvert
- Functioning Culvert
- Direct Impact: Watercourses
- Fisheries Resources
- Provincially Regulated Watercourses
- NSTDB Mapped Watercourses outside PA
- Direct Impact: Wetland Fish Habitat
- Local Road
- Dry Weather / Seasonal Road
- Track
- Topo Contours (5 m)
- Lake
- Field Delineated Wetlands within PA
- NSE Mapped Wetlands outside PA
- Proposed Infrastructure
- Project Area



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

0 50 100 200 m

1:5,000 Scale when printed @ 11" x 17"

Drawn By: AS
Reviewed By: XX
Date: 2021-04-14

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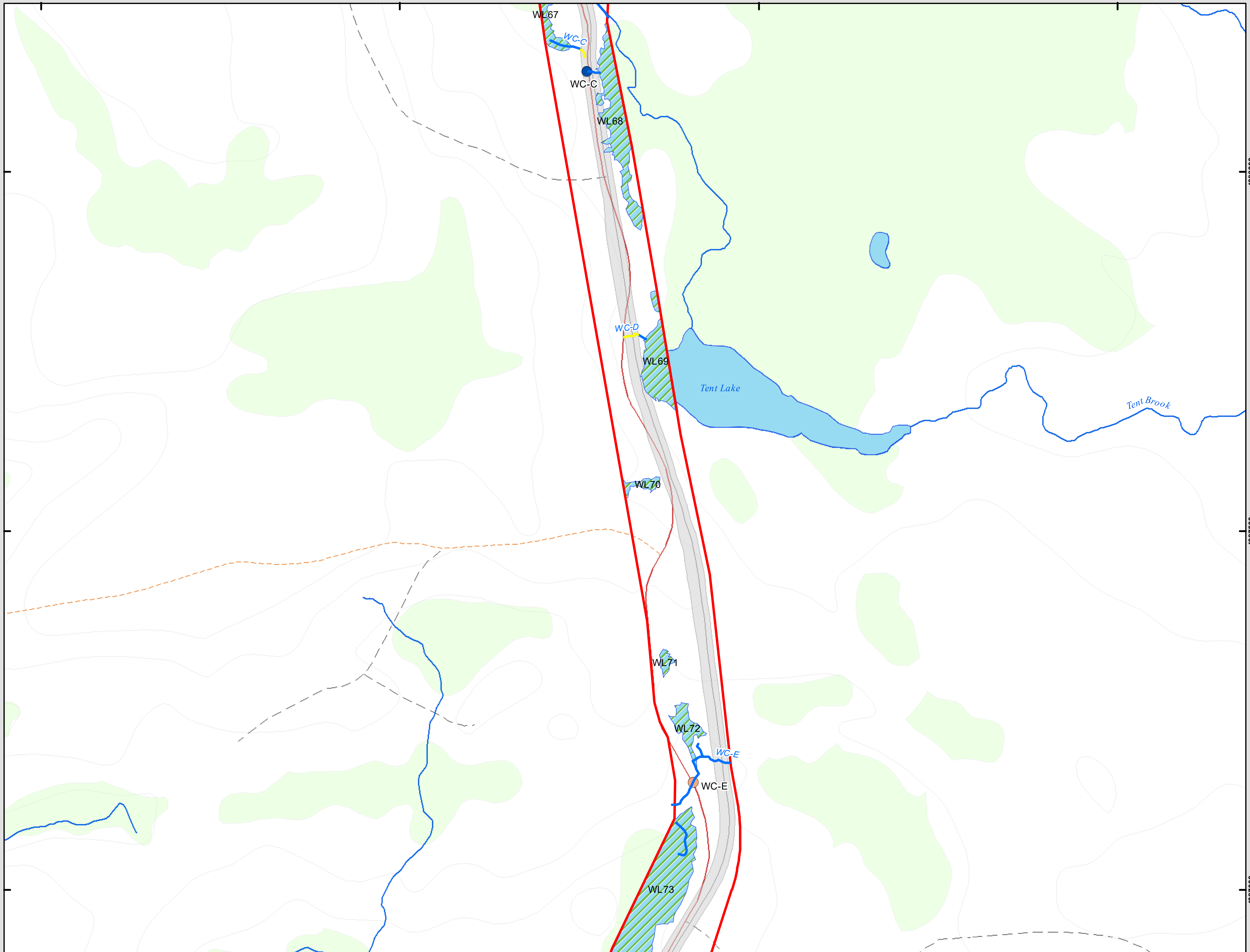

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FIGURE 15B

Beaver Dam Mine Project

Anticipated Fish Habitat Impact Areas by Type: Haul Road

- Blocked Culvert
- Functioning Culvert
- Direct Impact: Watercourses
- Fisheries Resources
- NSTDB Mapped Watercourses outside PA
- Local Road
- Dry Weather / Seasonal Road
- Track
- Topo Contours (5 m)
- Lake
- Field Delineated Wetlands within PA
- NSE Mapped Wetlands outside PA
- Proposed Infrastructure
- Project Area

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

0 50 100 200 m

1:5,000 Scale when printed @ 11" x 17"

Drawn By: AS
Reviewed By: XX
Date: 2021-04-14

Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors,

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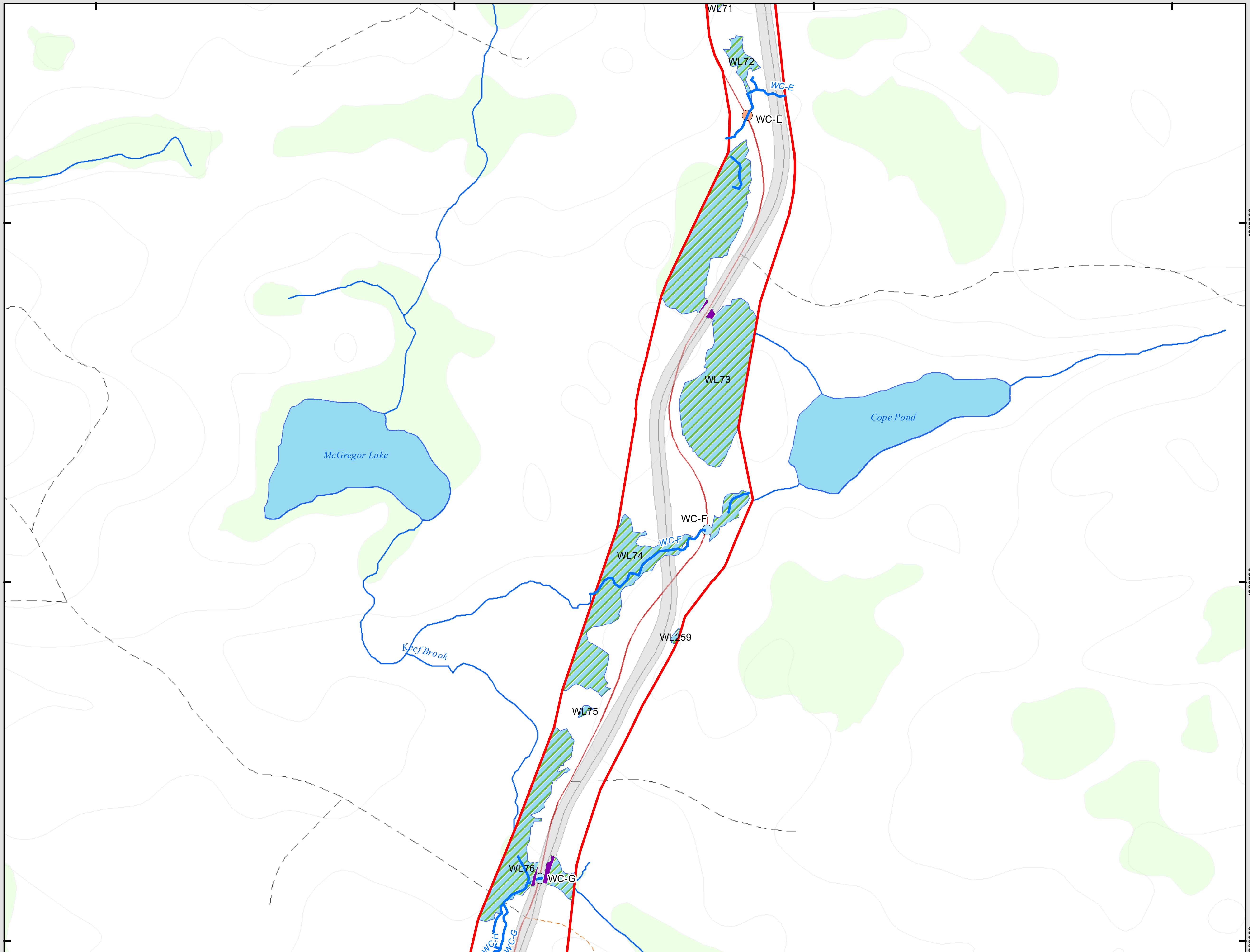
Document Name: BD_EIS_Figure6-9-XFishImpacts



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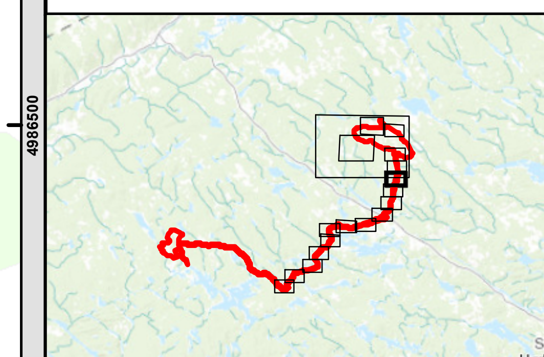
Atlantic Gold

FIGURE 15C

Beaver Dam Mine Project

Anticipated Fish Habitat Impact Areas by Type: Haul Road

- Blocked Culvert
- Crushed Culvert
- Fisheries Resources
- NSTDB Mapped Watercourses outside PA
- Direct Impact: Wetland Fish Habitat
- Local Road
- Dry Weather / Seasonal Road
- Track
- Topo Contours (5 m)
- Lake
- Field Delineated Wetlands within PA
- NSE Mapped Wetlands outside PA
- Proposed Infrastructure
- Project Area



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

0 50 100 200 m

1:5,000 Scale when printed @ 11" x 17"

Drawn By: AS Date: 2021-04-14
Reviewed By: XX

McCallum Environmental Ltd.

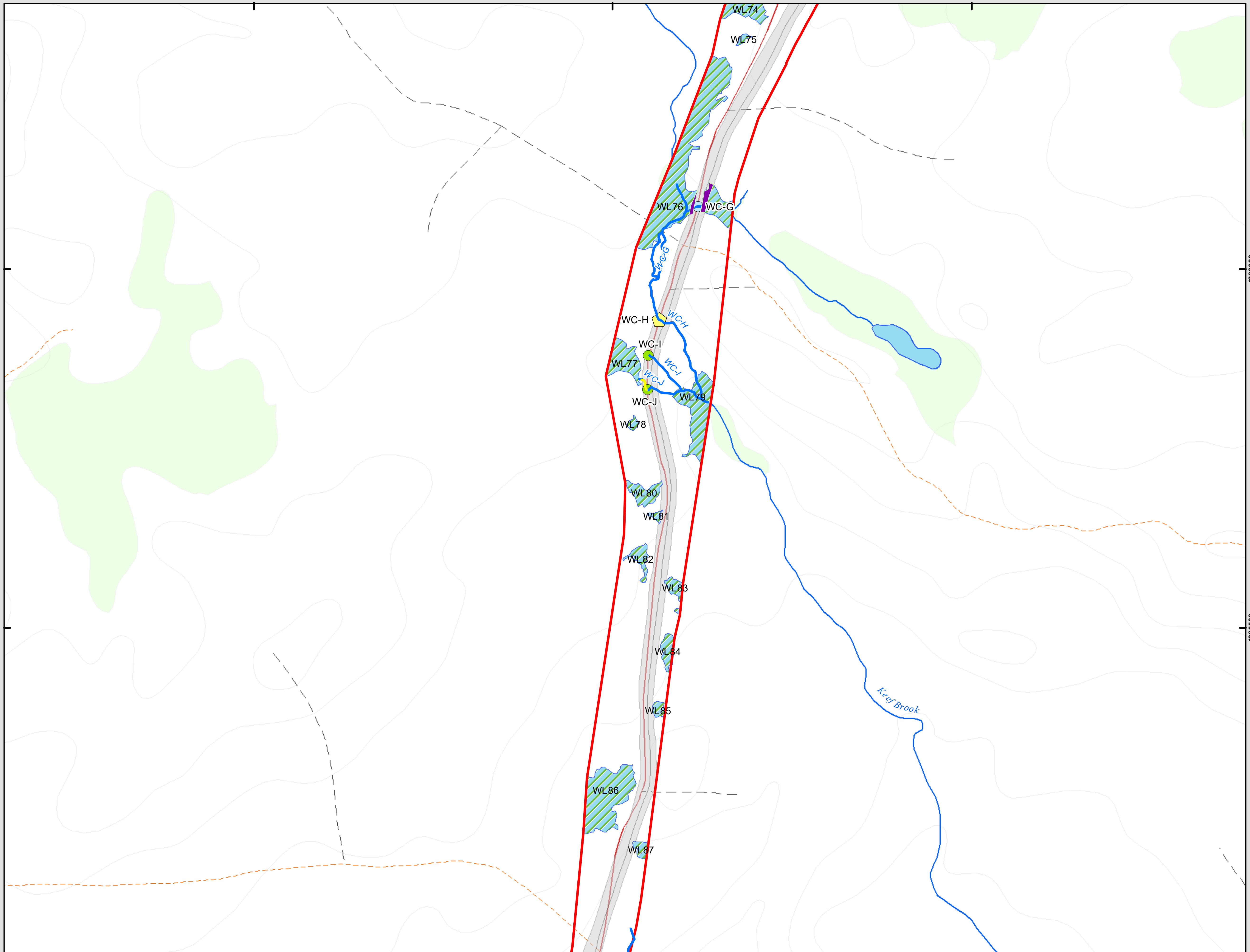


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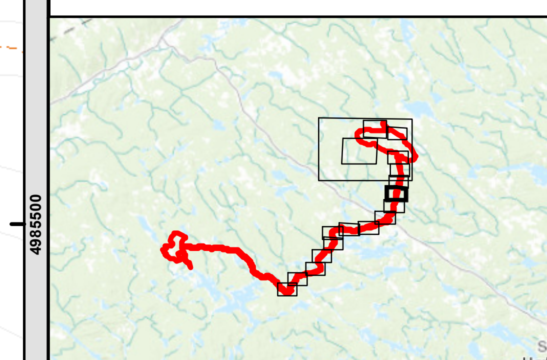
FIGURE 15D

Beaver Dam Mine Project

Anticipated Fish Habitat Impact Areas by Type: Haul Road

- Bridge - no barrier
- Buried Culvert
- Crushed Culvert
- Direct Impact: Watercourses
- Fisheries Resources
- NSTDB Mapped Watercourses outside PA
- Direct Impact: Wetland Fish Habitat
- Local Road
- Dry Weather / Seasonal Road
- Track
- Topo Contours (5 m)
- Lake
- Field Delineated Wetlands within PA
- NSE Mapped Wetlands outside PA
- Proposed Infrastructure
- Project Area



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

0 50 100 200 m

1:5,000 Scale when printed @ 11" x 17"

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Reviewed By: XX

Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors,

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Document Name: BD_EIS_Figure6-9-XFishImpacts

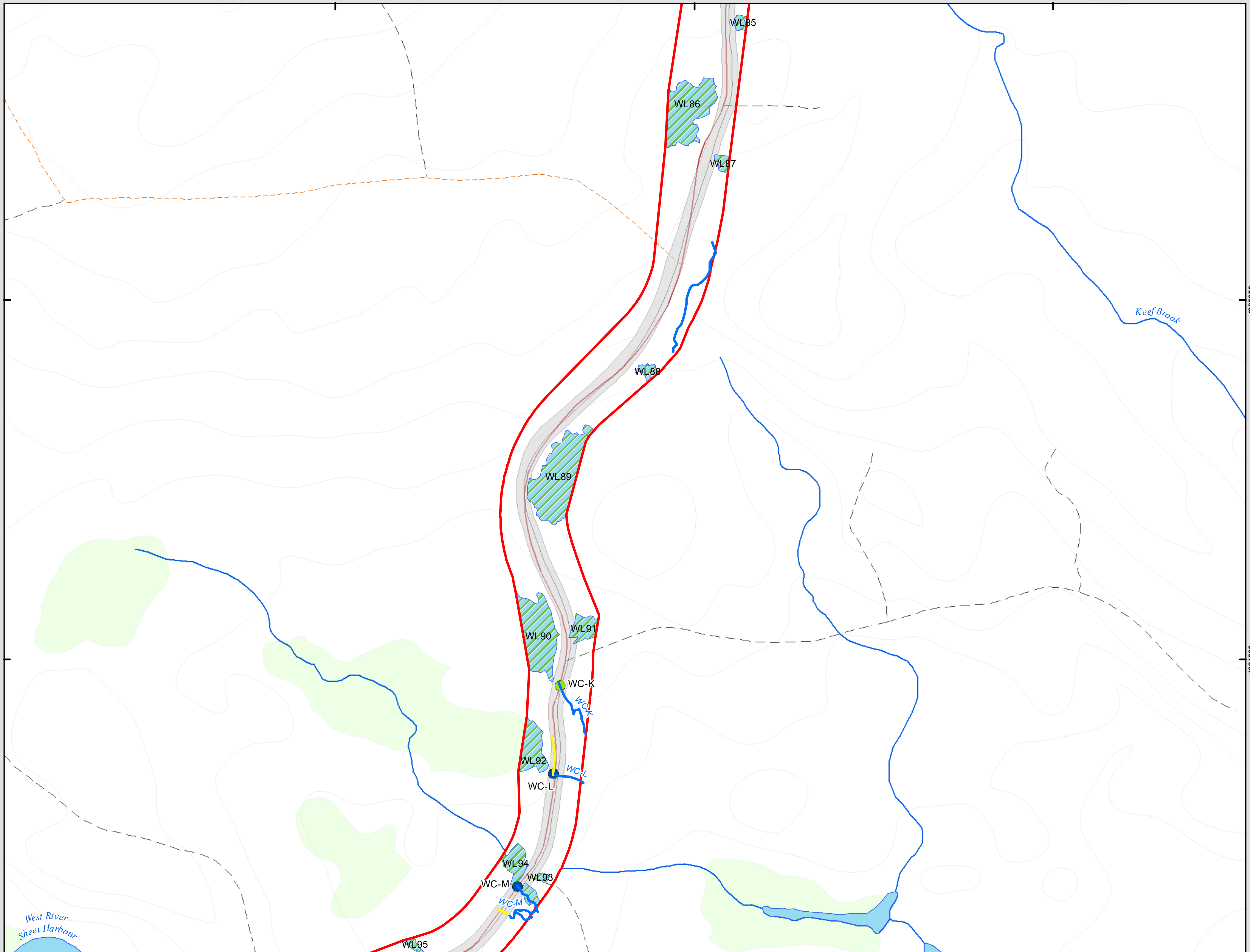

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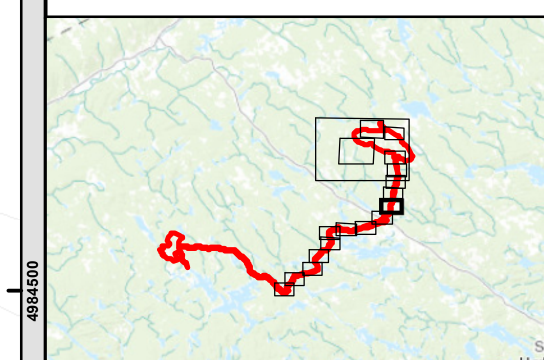
FIGURE 15E

Beaver Dam Mine Project

Anticipated Fish Habitat Impact Areas by Type: Haul Road

- Buried Culvert
- Functioning Culvert
- Direct Impact: Watercourses
- Fisheries Resources
- NSTDB Mapped Watercourses outside PA
- Local Road
- Dry Weather / Seasonal Road
- Track
- Topo Contours (5 m)
- Lake
- Field Delineated Wetlands within PA
- NSE Mapped Wetlands outside PA
- Proposed Infrastructure
- Project Area



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

0 50 100 200 m

1:5,000 Scale when printed @ 11" x 17"

Drawn By: AS
Reviewed By: XX
Date: 2021-04-14

Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors,

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Document Name: BD_EIS_Figure6-9-XFishImpacts

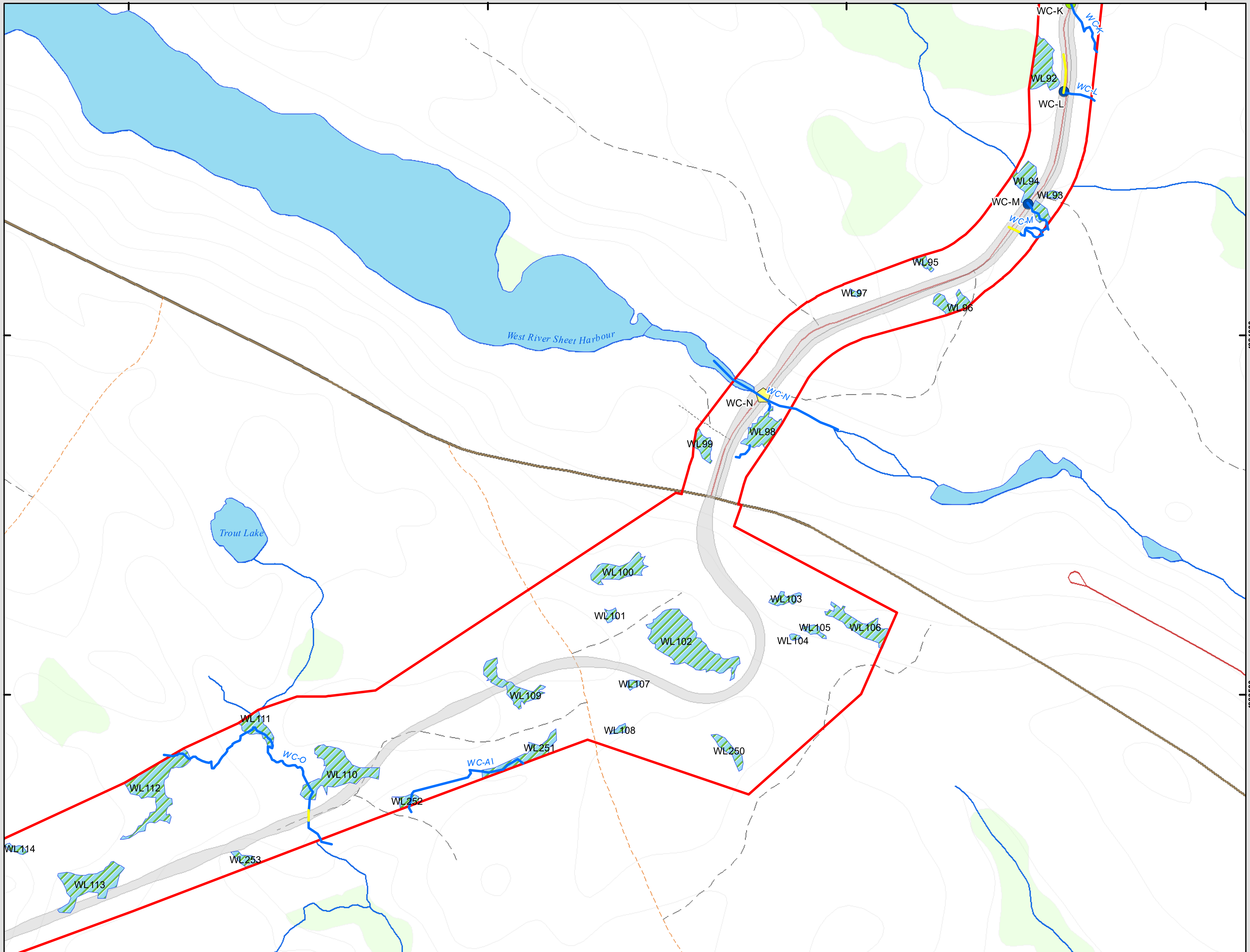

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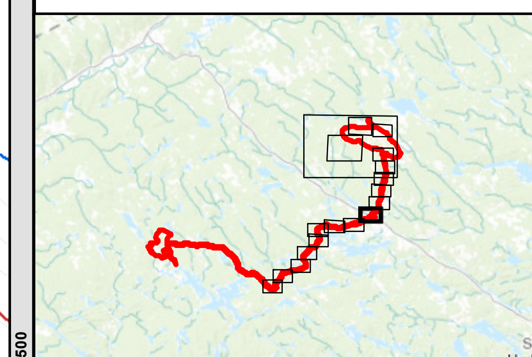
FIGURE 15F

Beaver Dam Mine Project

Anticipated Fish Habitat Impact Areas by Type: Haul Road

- Bridge - no barrier
- Buried Culvert
- Functioning Culvert
- Direct Impact: Watercourses
- Fisheries Resources
- NSTDB Mapped Watercourses outside PA
- Collector Road
- Local Road
- Dry Weather / Seasonal Road
- Diveways (>300 m)
- Track
- Topo Contours (5 m)
- Lake
- Field Delineated Wetlands within PA
- NSE Mapped Wetlands outside PA
- Proposed Infrastructure
- Project Area



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Projection: Transverse Mercator
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Units: Meter

0 50 100 200 m

1:5,000 Scale when printed @ 11" x 17"

Drawn By: AS Date: 2021-04-14
Reviewed By: XX

Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors,

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Document Name: BD_EIS_Figure6-9-XFishImpacts

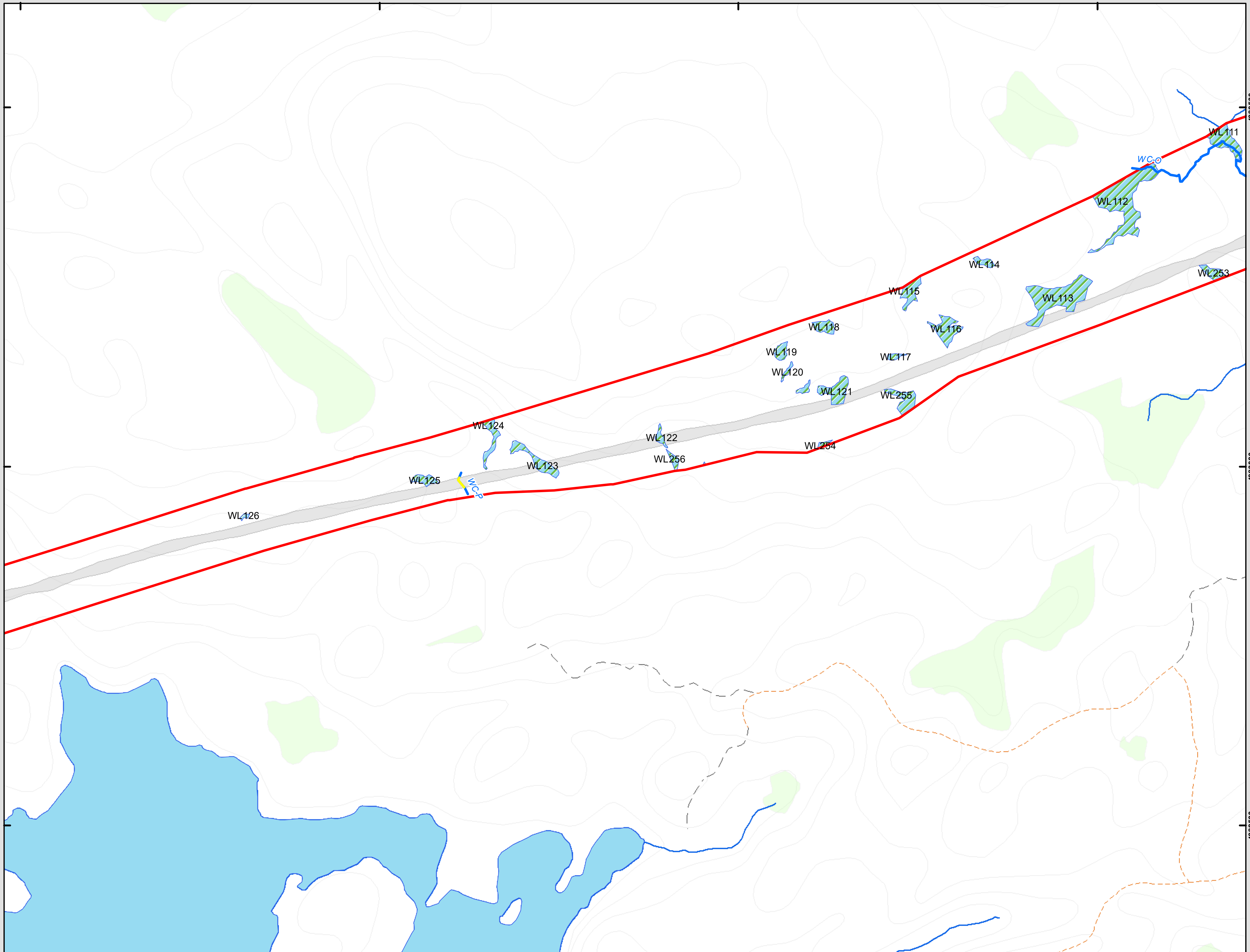

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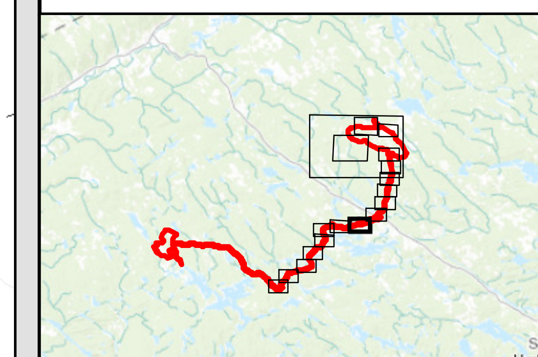
FIGURE 15G

Beaver Dam Mine Project

Anticipated Fish Habitat Impact Areas by Type: Haul Road

Direct Impact: Watercourses
Fisheries Resources
NSTDB Mapped Watercourses outside PA
Dry Weather / Seasonal Road
Track
Topo Contours (5 m)
Lake
Field Delineated Wetlands within PA
NSE Mapped Wetlands outside PA
Proposed Infrastructure
Project Area



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

0 50 100 200 m

1:5,000 Scale when printed @ 11" x 17"

Drawn By: AS
Date: 2021-04-14
Reviewed By: XX

Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors,

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Document Name: BD_EIS_Figure6-9-XFishImpacts

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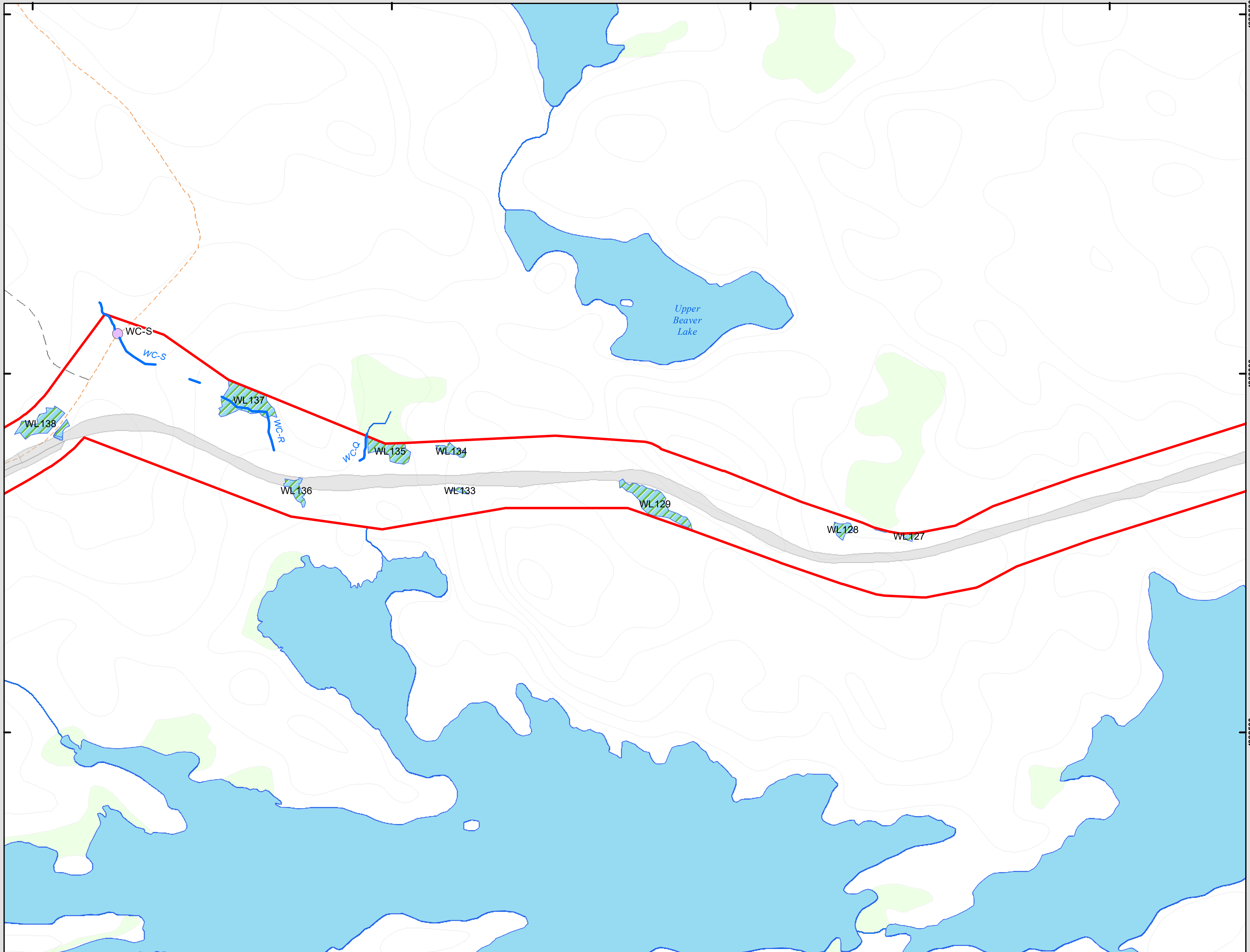
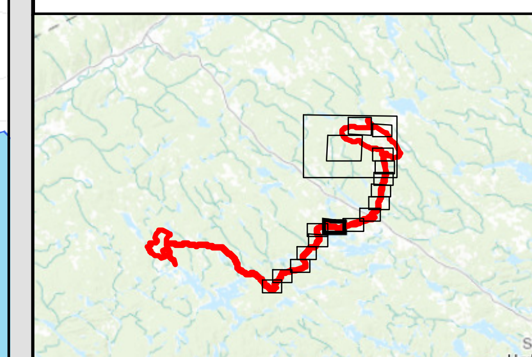
FIGURE 15H

Beaver Dam Mine Project

Anticipated Fish Habitat Impact Areas by Type: Haul Road



Hung Culvert
Fisheries Resources
NSTDB Mapped Watercourses outside PA
Dry Weather / Seasonal Road
Track
Topo Contours (5 m)
Lake
Field Delineated Wetlands within PA
NSE Mapped Wetlands outside PA
Proposed Infrastructure
Project Area



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

0 50 100 200 m

1:5,000 Scale when printed @ 11" x 17"

Drawn By: AS Date: 2021-04-14
Reviewed By: XX

Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors,

McCallum Environmental Ltd.

Document Name: BD_EIS_Figure6-9-XFishImpacts

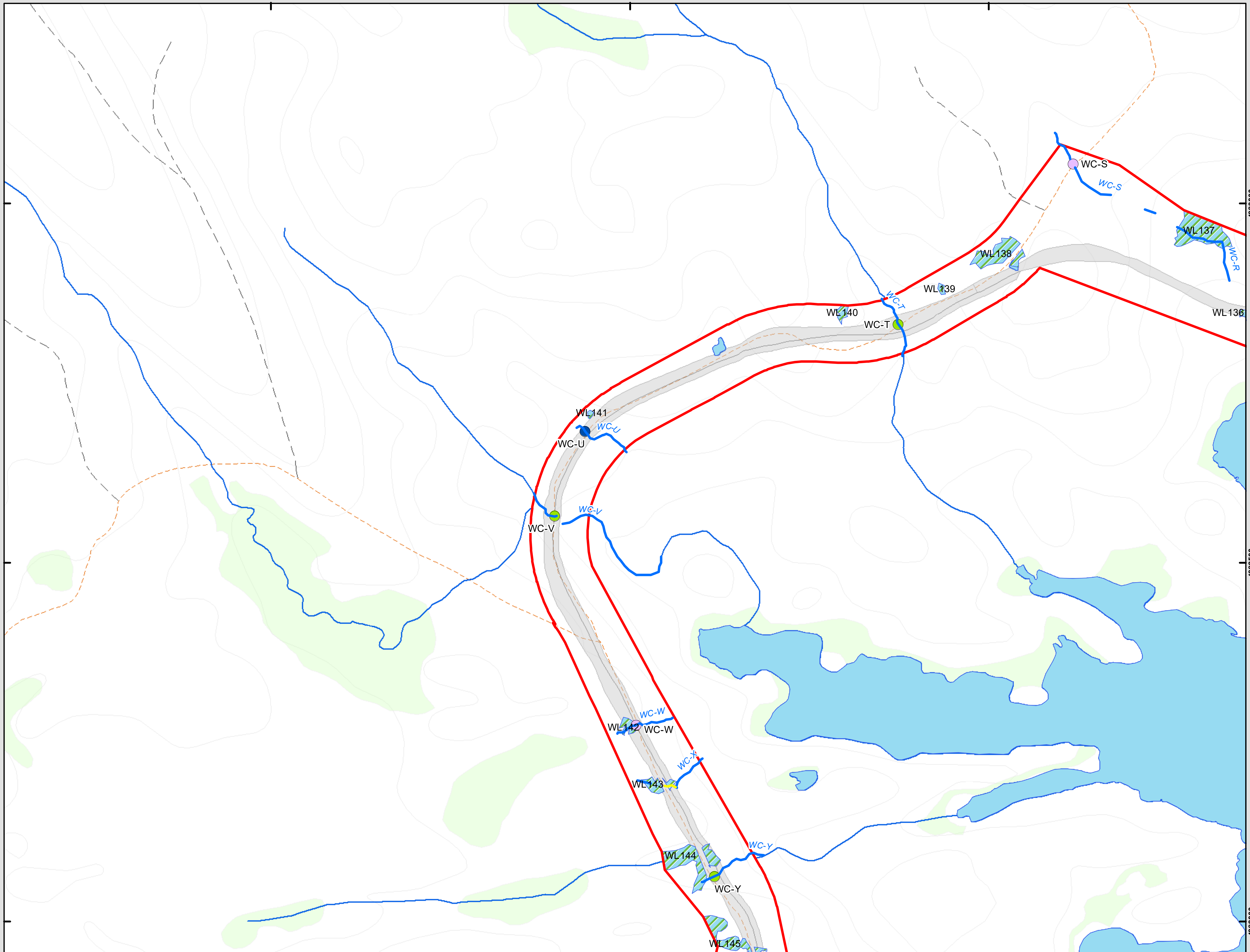


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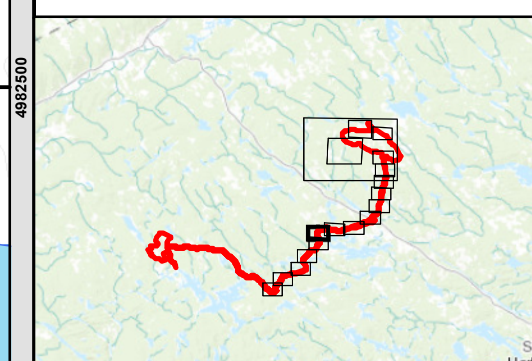
FIGURE 15 I

Beaver Dam Mine Project

Anticipated Fish Habitat Impact Areas by Type: Haul Road

- Buried Culvert
- Functioning Culvert
- Hung Culvert
- Direct Impact: Watercourses
- Fisheries Resources
- NSTDB Mapped Watercourses outside PA
- Dry Weather / Seasonal Road
- Track
- Topo Contours (5 m)
- Lake
- Field Delineated Wetlands within PA
- NSE Mapped Wetlands outside PA
- Proposed Infrastructure
- Project Area



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Projection: Transverse Mercator
Datum: North American 1983 CSRS
Units: Meter

0 50 100 200 m

1:5,000 Scale when printed @ 11" x 17"

Drawn By: AS
Reviewed By: XX

Date: 2021-04-14

Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors,

McCallum Environmental Ltd.

Document Name: BD_EIS_Figure6-9-XFishImpacts

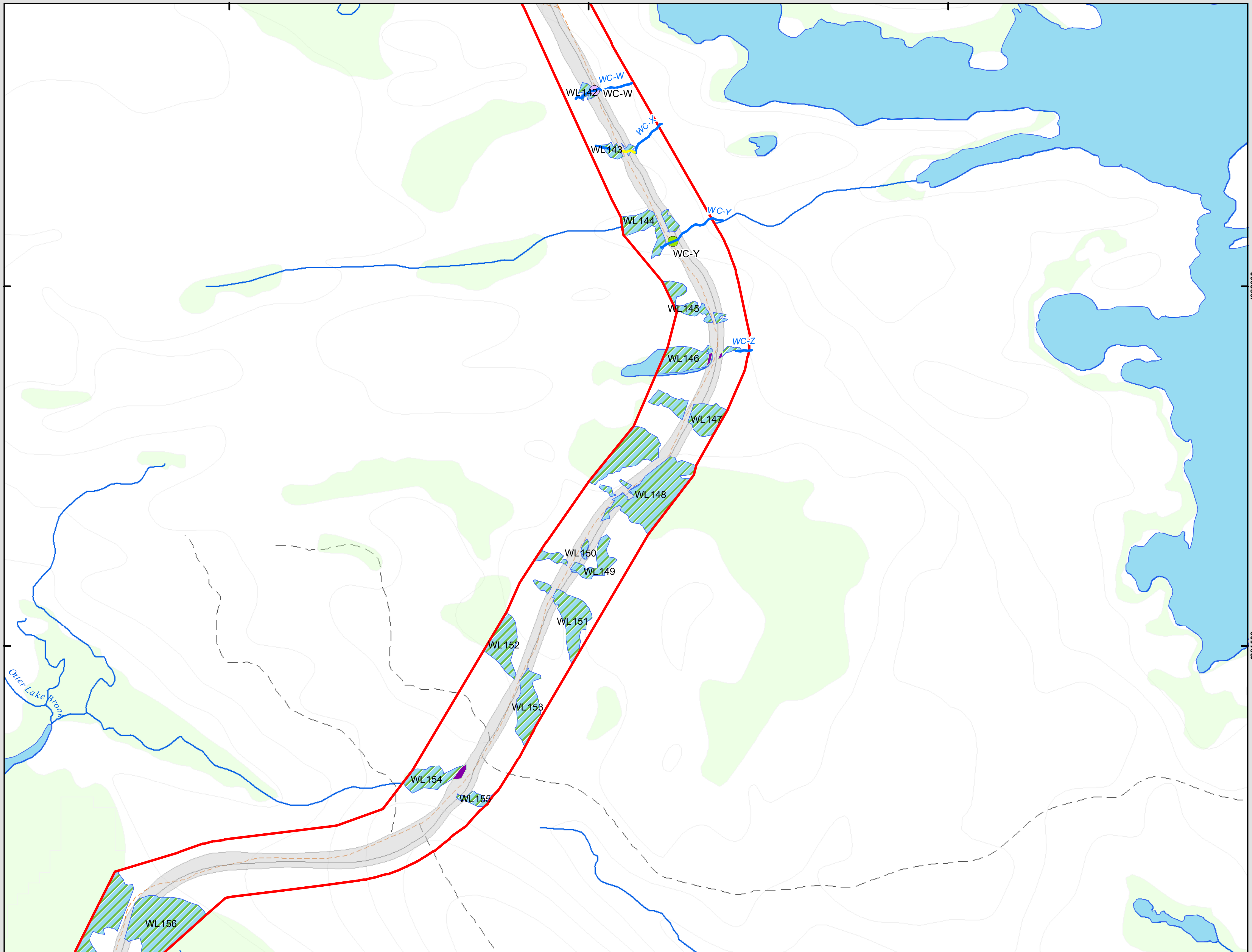

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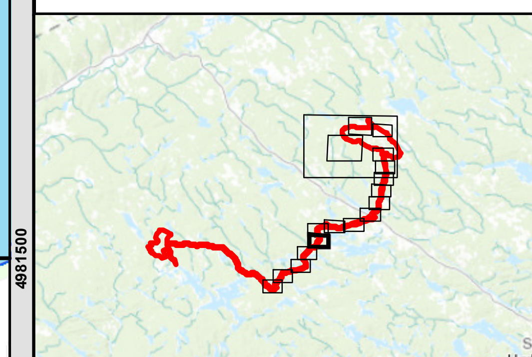
FIGURE 15J

Beaver Dam Mine Project

Anticipated Fish Habitat Impact Areas by Type: Haul Road

- Buried Culvert
- Hung Culvert
- Direct Impact: Watercourses
- Fisheries Resources
- NSTDB Mapped Watercourses outside PA
- Direct Impact: Wetland Fish Habitat
- Dry Weather / Seasonal Road
- Track
- Topo Contours (5 m)
- Lake
- Field Delineated Wetlands within PA
- NSE Mapped Wetlands outside PA
- Proposed Infrastructure
- Project Area



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

0 50 100 200 m

1:5,000 Scale when printed @ 11" x 17"

Drawn By: AS
Reviewed By: XX
Date: 2021-04-14

Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors,

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Document Name: BD_EIS_Figure6-9-XFishImpacts

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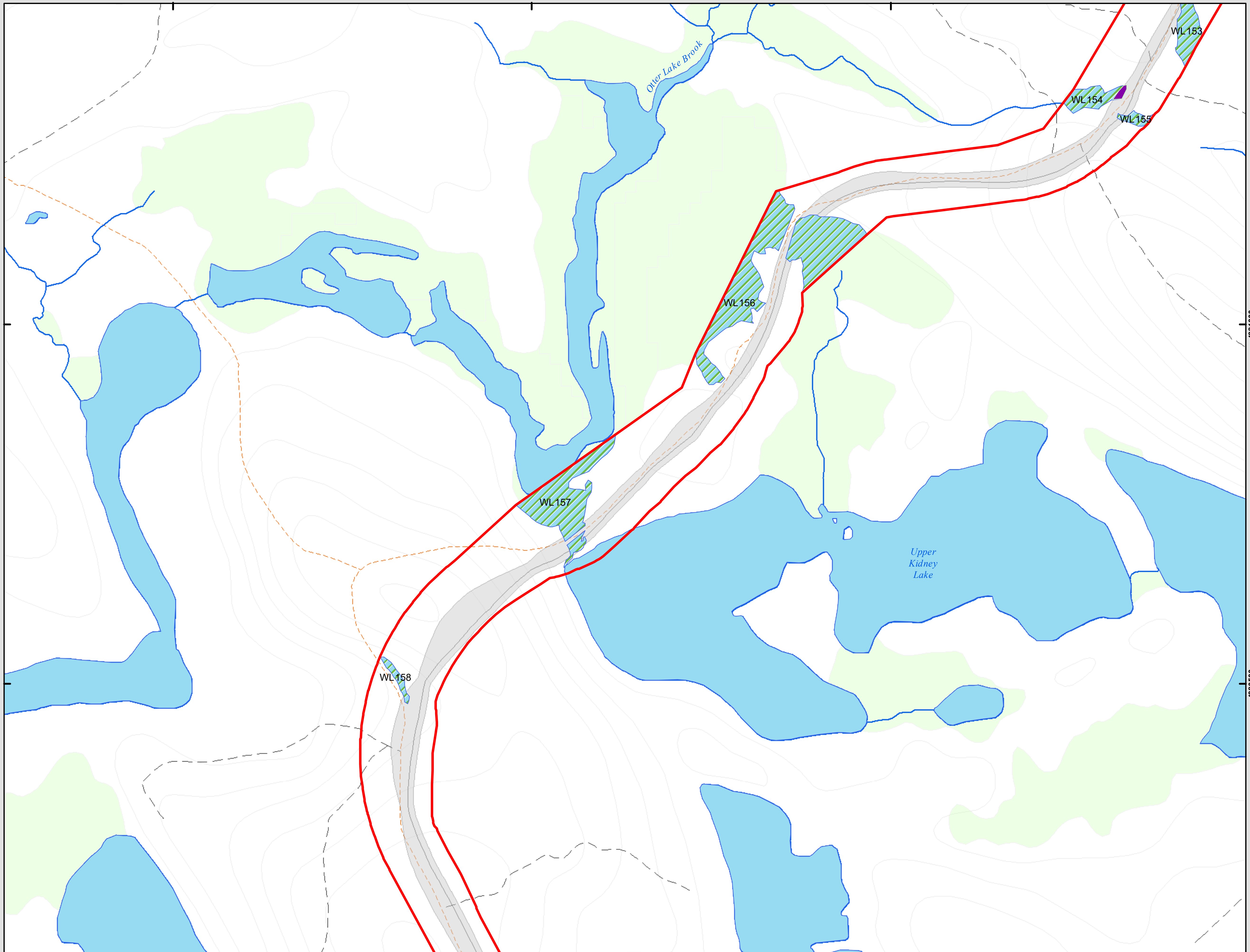
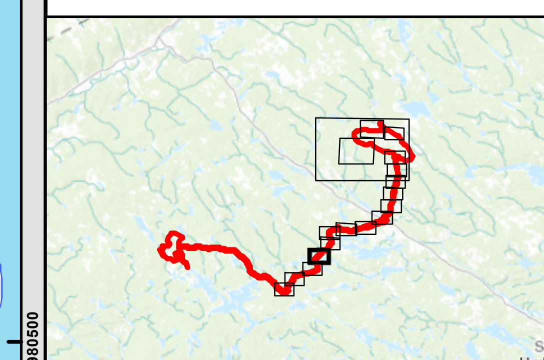
FIGURE 15K

Beaver Dam Mine Project

Anticipated Fish Habitat Impact Areas by Type: Haul Road



- NSTDB Mapped Watercourses outside PA
- Direct Impact: Wetland Fish Habitat
- Dry Weather / Seasonal Road
- Track
- Topo Contours (5 m)
- Lake
- Field Delineated Wetlands within PA
- NSE Mapped Wetlands outside PA
- Proposed Infrastructure
- Project Area



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

0 50 100 200 m

1:5,000 Scale when printed @ 11" x 17"

Drawn By: AS Date: 2021-04-14
Reviewed By: XX

Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors,

McCallum Environmental Ltd.

Document Name: BD_EIS_Figure6-9-XFishImpacts

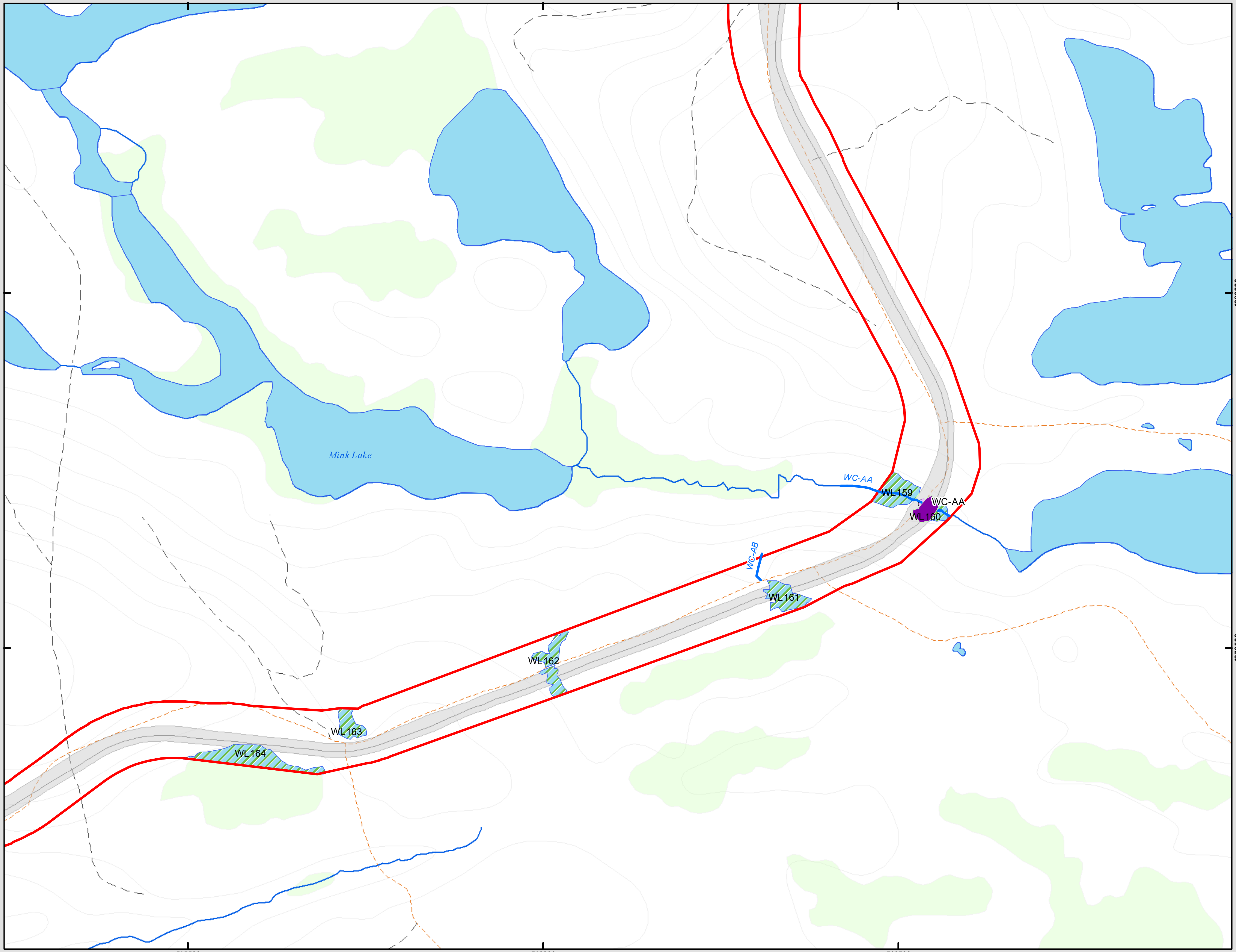


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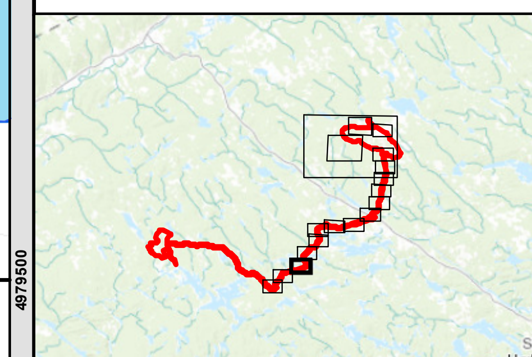
FIGURE 15L

Beaver Dam Mine Project

Anticipated Fish Habitat Impact Areas by Type: Haul Road

- Hung Culvert
- Fisheries Resources
- NSTDB Mapped Watercourses outside PA
- Direct Impact: Wetland Fish Habitat
- Dry Weather / Seasonal Road
- Track
- Topo Contours (5 m)
- Lake
- Field Delineated Wetlands within PA
- NSE Mapped Wetlands outside PA
- Proposed Infrastructure
- Project Area



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

0 50 100 200 m

1:5,000 Scale when printed @ 11" x 17"

Drawn By: AS
Reviewed By: XX
Date: 2021-04-14

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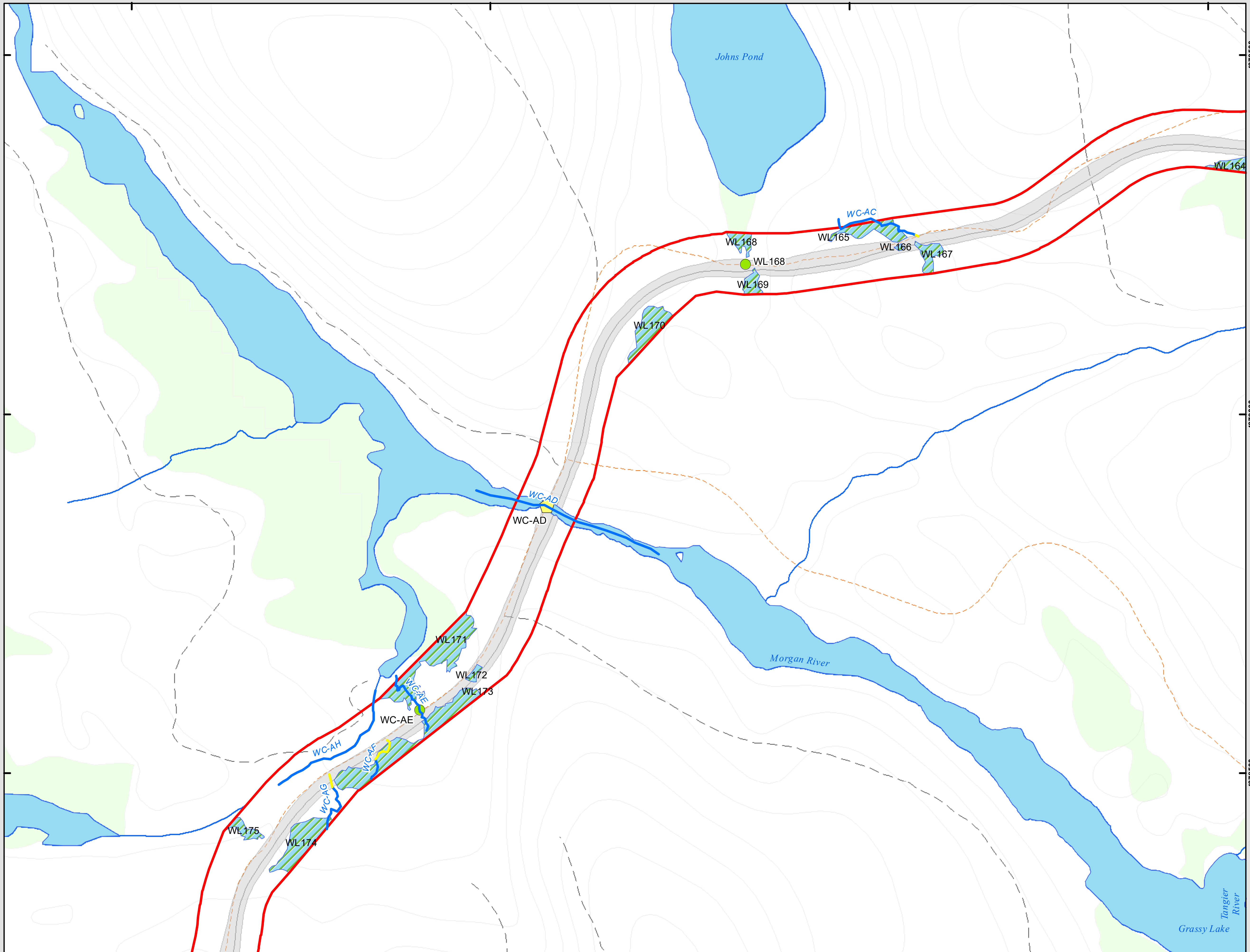
McCallum Environmental Ltd.

Document Name: BD_EIS_Figure6-9-XFishImpacts



Prepared For:

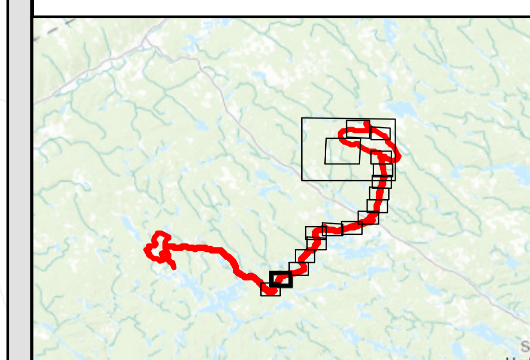
Atlantic Gold

FIGURE 15M

Beaver Dam Mine Project

Anticipated Fish Habitat Impact Areas by Type: Haul Road

Bridge - no barrier
Buried Culvert
Direct Impact: Watercourses
Fisheries Resources
NSTDB Mapped Watercourses outside PA
Dry Weather / Seasonal Road
Track
Topo Contours (5 m)
Lake
Field Delineated Wetlands within PA
NSE Mapped Wetlands outside PA
Proposed Infrastructure
Project Area



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

0 50 100 200 m

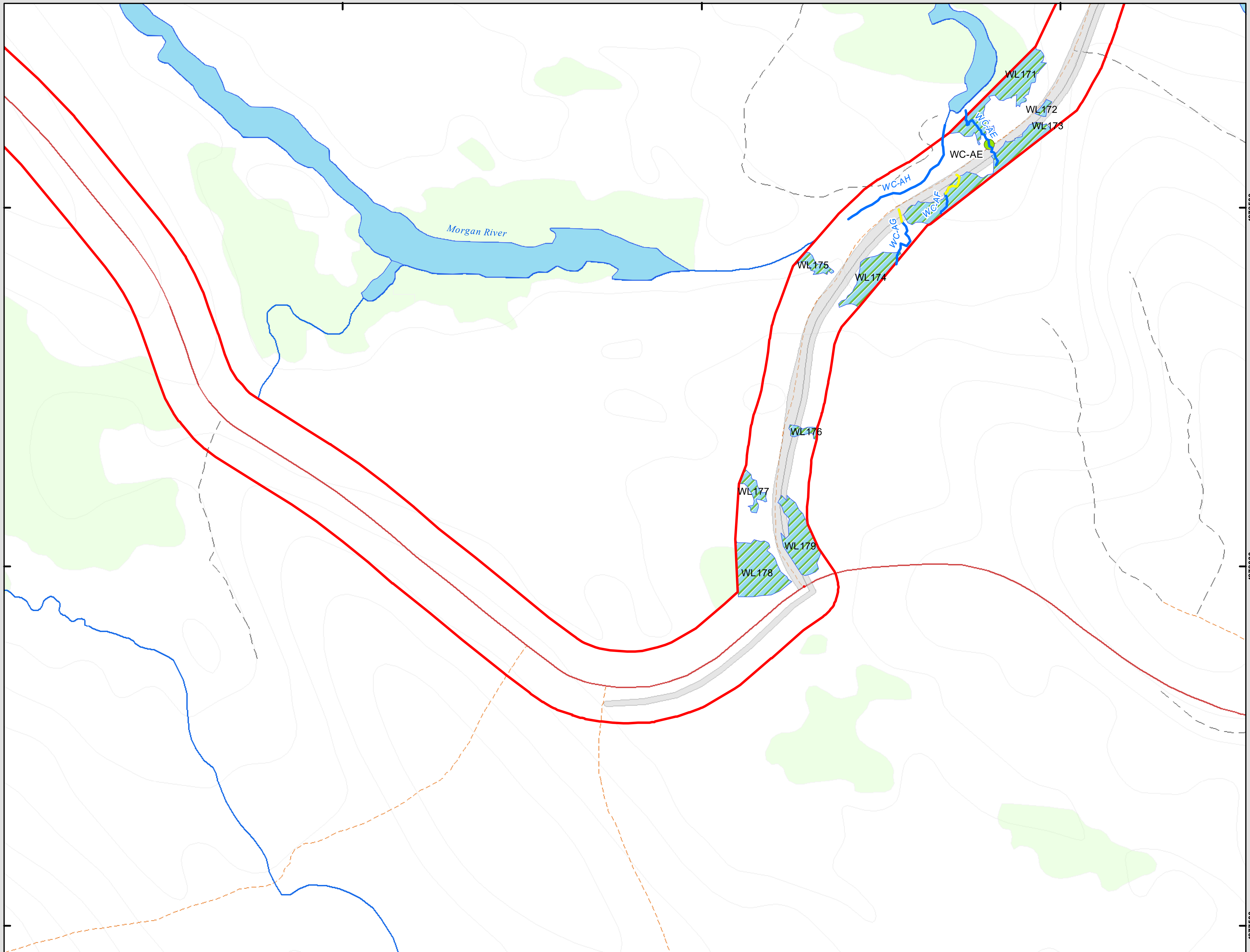
1:5,000 Scale when printed @ 11" x 17"

Drawn By: AS
Reviewed By: XX
Date: 2021-04-14

Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors,

McCallum Environmental Ltd.

Document Name: BD_EIS_Figure6-9-XFishImpacts



Prepared For:

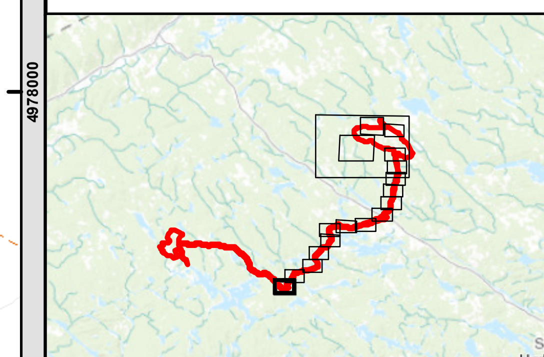
Atlantic Gold

FIGURE 15N

Beaver Dam Mine Project

Anticipated Fish Habitat Impact Areas by Type: Haul Road

- Buried Culvert
- Direct Impact: Watercourses
- Fisheries Resources
- NSTDB Mapped Watercourses outside PA
- Local Road
- Dry Weather / Seasonal Road
- Track
- Topo Contours (5 m)
- Lake
- Field Delineated Wetlands within PA
- NSE Mapped Wetlands outside PA
- Proposed Infrastructure
- Project Area



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

0 50 100 200 m

1:5,000 Scale when printed @ 11" x 17"

Drawn By: AS
Reviewed By: XX
Date: 2021-04-14

Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors,

McCallum Environmental Ltd.

Document Name: BD_EIS_Figure6-9-XFishImpacts

Appendix C

Water Balance Analysis

(GHD 2021)

Technical Memorandum

April 13, 2021

To:	Veronica Chisholm, Jim Mallard	Ref. No.:	088664
	<Original signed by>		
From:	Andrew Betts, P. Eng., Chris Muirhead, E.I.T./aj/9	Tel:	519-340-4408
CC:	Phillip Sheffield, Meghan Milloy, Melanie MacDonald		
Subject:	**Cameron Flowage – Baseflow Mitigation Assessment Beaver Dam Mine Water Management Plan Marinette, Nova Scotia**		

1. Introduction

GHD Limited (GHD) was retained by Atlantic Mining Nova Scotia (AMNS) to develop a Mine Water Management Plan (MWMP) for the Beaver Dam Gold Mine (Project) in Marinette, Halifax County (Site). The MWMP is being developed in support of the Environmental Impact Statement (EIS) and Feasibility Study (FS). As a part of the MWMP, all Site contact water runoff will be directed towards the north settling pond for treatment prior to discharge during operating conditions. Under Post-Closure (PC) conditions the Site stormwater runoff will be directed towards the open pit, allowing the pit to fill over the span of approximately 13.1 years (GHD, 2021a). Once the pit has been filled, Site runoff will overflow into the Killag River naturally.

The Water Balance Analysis indicated that the Killag River is expected to see a 2.2% and 1.1% increase in annual runoff volume under End-of-Mine (EOM) and PC conditions. The Water Balance Analysis looks at the Killag River contributing drainage as a whole including overall baseflow reduction. This memo will look at the potential localized impact to baseflow on a smaller scale, focusing on baseflow reduction within Cameron Flowage due to drawdown from the open pit.. The impacts to baseflow presented in this memo do not change the predicted increase in annual runoff volume predicted in the Water Balance Analysis. This technical memo will assess the potential impacts to the baseflow of Cameron Flowage on a local scale, the potential impacts during the period of time that the pit is being filled, and how those potential impacts will be mitigated.

2. Baseflow Assessment – Operating Conditions

During operating conditions, the open pit will be excavated to an approximate bottom elevation of -45 metres above sea level (masl), which is below the water surface elevation of Killag River/Cameron Flowage. The typical water surface elevation of the Killag River/Cameron Flowage (as measured at nearby monitoring stations) ranges from approximately 128 masl to 124 masl depending on the time of year. As such, some groundwater that would naturally discharge to Cameron Flowage as baseflow will be intercepted by the open pit. Adjacent to the open pit, the groundwater flow direction may switch from being towards Cameron Flowage, to flowing away from Cameron Flowage towards the open pit. Therefore, there is potential for water from Cameron Flowage to migrate through the subsurface and discharge to the open pit, thereby reducing baseflow to the Killag River.

To predict the potential reduction in baseflow to Cameron Flowage, the groundwater flow model (hydrogeologic model) developed for the Site (GHD, 2021b) was applied to simulate the open pit and predict the potential change in baseflow between baseline conditions, and EOM and PC. Through the application of the hydrogeologic model, it is estimated that at EOM Cameron Flowage will experience a reduction in baseflow from baseline conditions of between 38% and 42% for dry and wet conditions, respectively (GHD, 2021b). The total baseflow to the Killag River up to the Killag River Downstream Assessment Point (Downstream Assessment Point is indicated on Figure 4-4 of the Water Balance Analysis (GHD, 2021a)) is expected to decrease between 1.2% and 1.4% for dry and wet conditions respectively. As per the GHD Water Balance Analysis, baseflow contribution throughout the Killag River watershed composes roughly 24% of total streamflow in the Killag River on an average annual basis (GHD, 2021a). Given that the baseflow contribution from Cameron Flowage is a relatively small portion of the total baseflow in the Killag River, the minor impact of baseflow reduction in Cameron Flowage is small relative to the total baseflow in the Killag River, and the impacts of baseflow reduction on total streamflow are found to be minimal. The total streamflow within the Killag River is still expected to increase by 2.2% during EOM conditions due to an increase in the drainage area contributing to the Killag. The Killag River downstream of Cameron Flowage is expected to see a 2% decrease in baseflow due to mine development.

Groundwater discharge (i.e., intercepted baseflow) to the open pit will be pumped to the north settling pond for treatment and storage prior to discharge. The north settling pond will discharge via an open channel, back into Cameron Flowage. The flow path for water pumped from the open pit can be seen on Figure 2-1. To select the discharge location presented on Figure 2.1, the predicted distribution of baseflow reduction along Cameron Flowage was assessed to identify spatial extent along Cameron Flowage where the majority of baseflow reduction is predicted to occur. As shown on Figure 2.2, Cameron Flowage was subdivided into 6 reaches. The simulated baseflow reduction to each reach was calculated to identify the reaches within Cameron Flowage where the majority of simulated baseflow reduction occurs. Table 2.1 presents the simulate baseflow reduction by reach, expressed as a percentage of the total simulated baseflow reduction within Cameron Flowage.

Table 2.1 Simulated Baseflow Reduction Along Cameron Flowage by Reach

Reach	CF-1	CF-2	CF-3	CF-4	CF-5	CF-6	Total
Baseline Baseflow (m^3/d)	-55.57	-34.87	-54.62	-76.15	-146.12	-382.01	-749.34
EOM Baseflow (m^3/d)	-54.86	-32.93	-39.23	-14.99	19.25	-322.95	-445.73
Baseflow Reduction	-0.70	-1.94	-15.39	-61.16	-165.36	-59.06	-303.61
Percent of Total Baseflow Reduction Within Reach	0.23%	0.64%	5.07%	20.14%	54.47%	19.45%	100.00%

As shown in Table 2.1, over 99 percent of the simulate baseflow reduction occurs in reaches CF-3, CF-4, CF-5, and CF-6 at EOM. Reaches CF-1 and CF-2 are predicted to contain under 1 percent of the total baseflow reduction in Cameron Flowage at EOM. Therefore, a CF-3, CF-4, CF-5, and CF-6 are identified as the Cameron Flowage Groundwater Influence zone, in which the majority of baseflow reduction within Cameron Flowage is predicted to occur.

As shown on Figure 2.1, the discharge point from the north settling pond falls was selected to correspond to the upstream limit of the Cameron Flowage Groundwater Influence Zone, coinciding with the upstream extent of reach CF-3. By discharging water pumped from the open pit upstream of the Cameron Flowage Groundwater Influence Zone any potential reduction in total flow due to a reduction in baseflow is mitigated because groundwater that discharges to the open pit is re-routed and discharged back into Cameron Flowage upstream of where the majority of baseflow reduction is predicted to occur.

Given that any groundwater intercepted by the open pit will be discharged back into Cameron Flowage upstream of where the majority of predicted baseflow reduction occurs, it is not anticipated that the predicted 38% to 42% decrease in baseflow will result in any appreciable difference in total flow within Cameron Flowage.

3. Baseflow Assessment – Post Closure Conditions

3.1 Pit Filling Conditions

Under PC conditions, the surface water runoff from the Site is to be directed towards the open pit in order to fill the pit over the span of approximately 13.1 years (GHD, 2021a). The pit is expected to be filled to an elevation of 127 masl at which point the pit will overflow into Cameron Flowage. Once the pit has been filled Cameron Flowage is still expected to see a 20% to 24% decrease in baseflow from existing conditions (GHD, 2021b). The anticipated baseflow reduction during this time of pit filling can be assumed to gradually transition from the predicted decrease of 38%-42% during operating conditions to the 20-24% decrease in baseflow predicted under PC conditions. During this time Site runoff will be directed towards the pit in order to allow the pit to fill, resulting in decreased discharge to Cameron Flowage. The 20-24% reduction in baseflow to Cameron Flowage results in a decrease of total baseflow between 0.6% and 0.8% for dry and wet conditions respectively. Given the minor impact of baseflow reduction in Cameron Flowage on total baseflow in the Killag River, the impacts of baseflow reduction on total streamflow are found to be minimal. Despite the reduction in baseflow to Cameron Flowage, the total streamflow within the Killag River is still expected to increase by 1.1% during PC conditions due to the increase in drainage area contribution to the Killag. The Killag River downstream of Cameron Flowage is expected to see a 2% decrease in baseflow due to mine development.

The baseflow from existing conditions is expected to decrease 41% under base case operating conditions from 749 m^3/day to 446 m^3/day (a decrease of 303 m^3/day). In order to mitigate potential impacts to Cameron Flowage the north settling pond will not be decommissioned until the pit has been filled. The pond will be kept full (maximum storage volume of 48,438 m^3) so that during the summer months (when surface runoff decreases and baseflow is a larger proportion of the total flow in Cameron Flowage) the total flow in Cameron Flowage can be supplemented using water from the north settling pond. The north settling pond, with a maximum storage volume of 48,438 m^3, would be able to supplement the Cameron Flowage baseflow by 303 m^3/day for 159 days, a sufficient length of time to ensure the total flow in Cameron Flowage during the summer months is maintained to baseline conditions while the pit is being filled.

To reduce the impacts that the pit filling will have on the total flow in Cameron Flowage the north settling pond will be brought to full capacity prior to the summer months and will be discharged as necessary to maintain flow within Cameron Flowage. The north settling pond will discharge to Cameron Flowage at a rate similar to the predicted loss of baseflow (303 m^3/day) in order to supplement the total flow for the months of July, August and September, the months which experience the least amount of predicted runoff as per the GHD Water Balance Assessment (GHD, 2021a). All water discharged from the north settling pond during this time will be regulatory water quality objectives outlined in the GHD Predictive Water Quality Assessment (GHD, 2021c).

3.2 Pit at Capacity Conditions

Once the pit has been filled Cameron Flowage is still expected to see a 20% to 24% decrease in baseflow from baseline conditions. This decrease in baseflow is expected to occur as the proposed pit lake elevation is below the baseline groundwater elevation within the proposed pit lake footprint. As such, the hydraulic gradient from the pit to Cameron Flowage is predicted to decrease from baseline conditions to PC conditions. The decreased hydraulic gradient will result in a reduction in groundwater discharge to Cameron Flowage. The decreased baseflow to Cameron Flowage under PC conditions is mitigated by the surface water discharge point of the pit lake and the predicted increase in runoff to the Killag River of 1.1% as per the Water Balance Analysis (GHD, 2021a), due to an increase in the drainage area contributing to the Killag River. The pit lake discharge point is located approximately 200 m from the furthest downstream point in the Cameron Flowage Groundwater Influence Zone, as show on Figure 2.1.

3.3 Baseflow Reduction Mitigation Options

Baseflow to Cameron Flowage is predicted to permanently decrease by 20 to 24% during PC conditions, once the pit lake has reached an elevation of 127m. A mitigation strategy to reduce the potential baseflow reduction would be to raise the water surface elevation of the pit lake to 130 masl and discharge the runoff via a discharge channel on the west side of the pit lake, through the pre-existing north settling pond discharge channel. The increase in water surface elevation would re-instate the existing positive groundwater gradient towards Cameron Flowage from the pit lake. Additionally, by discharging on the west side of the pit lake, surface water will be discharged upstream of where the majority of any remaining baseflow reduction would occur.

4. Conclusions

GHD has performed an assessment of the impacts of baseflow reduction on the total flow in Cameron Flowage for three (3) conditions: operating conditions, pit filling conditions and pit at capacity conditions. The predicted reduction in baseflow under operating conditions is mitigated by the flow path of the intercepted groundwater. Groundwater that discharges into the open pit will be pumped to the north settling pond before discharging back into Cameron Flowage. The impact that the baseflow reduction during operation conditions will have on the total flow in the Killag River is expected to be mitigated by this circular flow path.

The baseflow reduction under pit filling conditions is to be mitigated by continuing operation of the north settling pond while the pit is being filled with water. All Site surface water will be directed first towards the north settling pond with an overflow leading to the pit. The north settling pond will be maintained at full capacity with the purpose of providing surface water discharge to Cameron Flowage during the months of July, August and September. This flow augmentation will mitigate the impacts that a reduction in baseflow would have on the total flow in Cameron Flowage during July, August, and September.

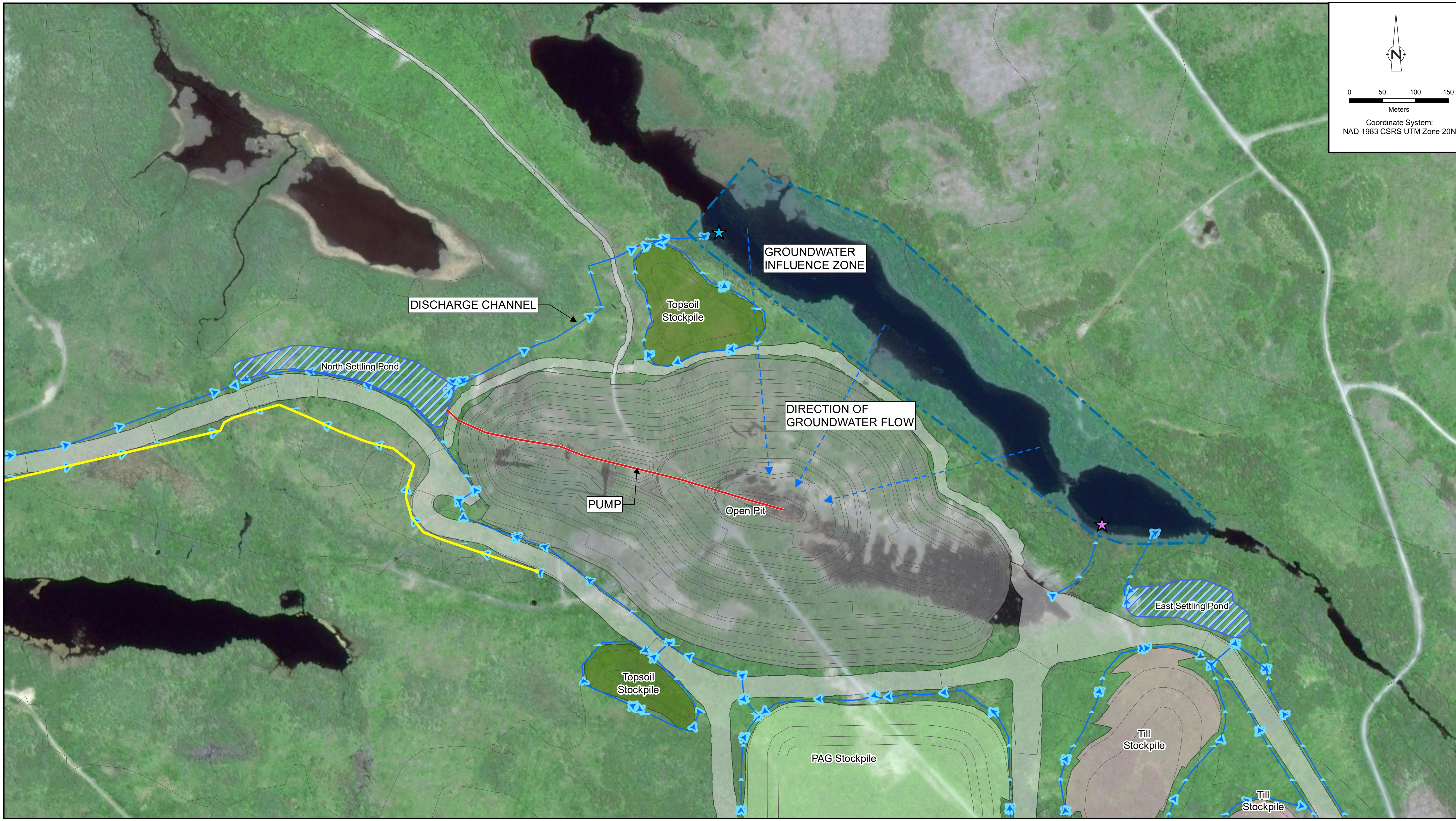
Once the pit has been filled Cameron Flowage is still anticipated to see a decrease in baseflow due to a reduction in hydraulic gradient. The reduced baseflow in Cameron Flowage will be mitigated by the discharge from the pit lake. While the discharge point of the pit lake occurs near the downstream end of Cameron Flowage, the overall runoff to the Killag River is expected to increase by 1.1% (GHD, 2021a), resulting in an increase in total flow in the Killag River, despite the reduction in baseflow. An additional mitigation strategy includes raising the pit lake elevation to 130 masl and discharging on the west side of the pit lake. This would reduce the potential baseflow reduction to Cameron Flowage while discharging surface water upstream of where the majority of any remaining baseflow reduction would occur.

5. References

GHD (2021a). Water Balance Analysis, Beaver Dam Mine Site, Marinette, Nova Scotia

GHD (2021b). Hydrogeologic Modelling Report, Beaver Dam Mine Site, Marinette, Nova Scotia

GHD (2021c). Predictive Water Quality Assessment, Beaver Dam Mine Site, Marinette, Nova Scotia



Source: CanVec Edition 1.1 © Department of Natural Resources Canada. All rights reserved;
Imagery: Image ©2021 DigitalGlobe, ©2021 Google, Imagery date: 18/6/2012

Legend

- SWM Ditches
- Clean Water Ditch
- Pumping Path
- Groundwater Influence Zone
- Direction of Groundwater Flow
- Elevation Contour
- EOM Discharge Point
- PC Discharge Point
- Settling Pond
- Open Pit
- PAG Stockpile
- Road
- Topsoil Stockpile
- Till Stockpile

ATLANTIC MINING NOVA SCOTIA
BEAVER DAM MINE
MINE WATER MANAGEMENT PLAN
BASEFLOW MITIGATION ASSESSMENT

088664-50
Feb 12, 2021

CAMERON FLOWAGE BASEFLOW MITIGATION

FIGURE 2.1

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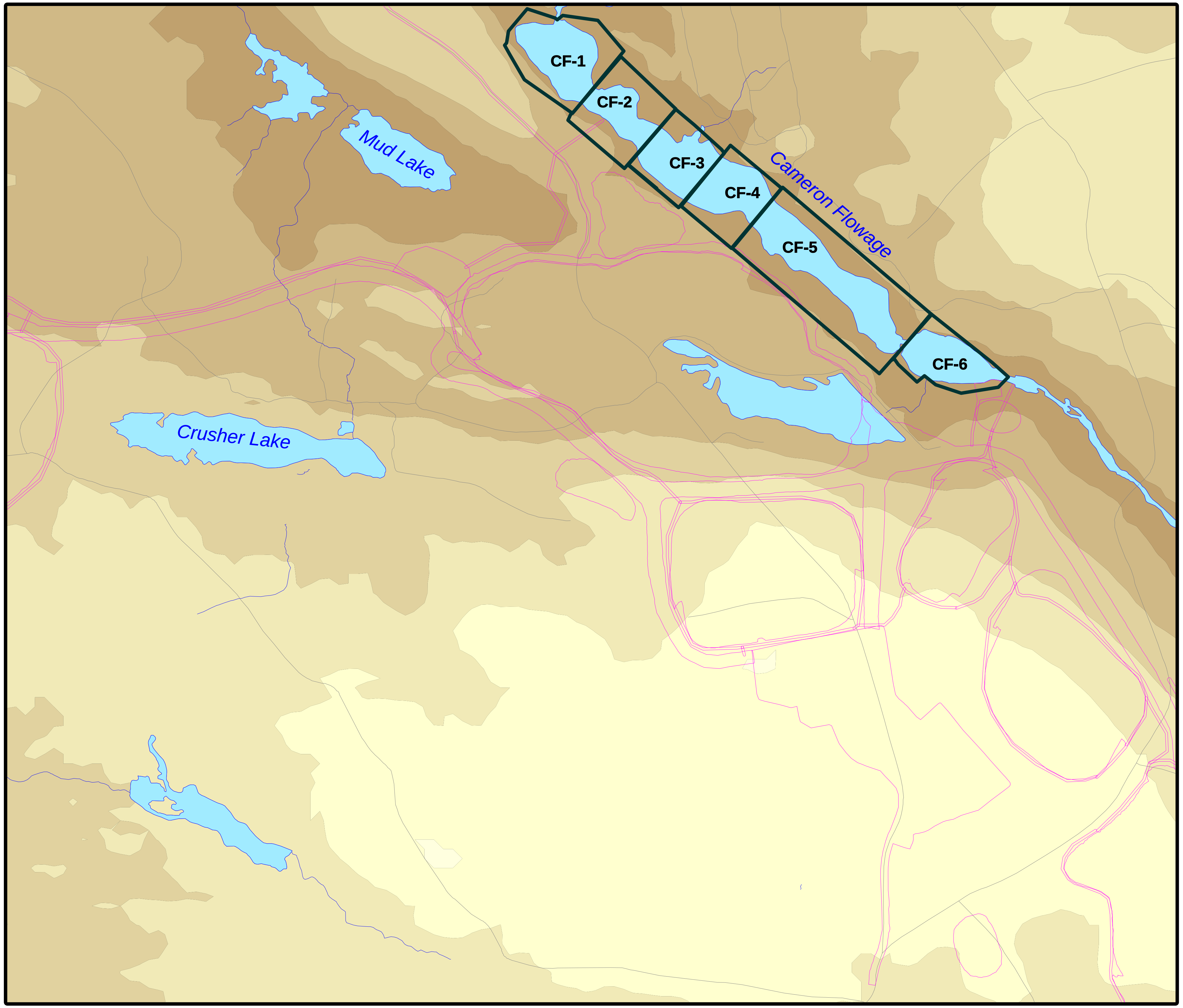

LEGEND

SURFACE WATER BODY

MINE FEATURES

ROAD

CAMERON FLOWAGE BASEFLOW ASSEMENT REACH

GROUND SURFACE ELEVATION (m AMSL)

0 20 40 60 80 100 120 140 160 180 200

0 80 160 240 m

N

ATLANTIC MINING NOVA SCOTIA
MARINETTE, NOVA SCOTIA
BEAVER DAM MINE

088664-50

February 12, 2021

CAMERON FLOWAGE BASEFLOW ASSESSMENT REACHES

FIGURE 2.2

HEG file: Z:\HEG\088664\MOD\F50\WC-CameronFlowage-MB\Figure 2.2 - CF-BF-Reaches.srf

Appendix D

Lacustrine Habitat Equivalent Unit Spreadsheet Outputs

Beaver Dam Quantification – April 9, 2021
Revised areas (as per MEL email dated April 9, 2021)

Step 1

Note: Only enter the values in the cells shaded blue, the subtotals, totals and ratios will be calculated a

Enter Lake name: WL59

Part 1 Entering Lake depth(s):

IF Lake Depth is less than or equal to 10 m:			IF Lake Depth is greater than 10 m:	
Path 1		OR	**Path 2**	
A Enter Depth of Littoral Zone:	1		A-1 Enter mean depth of Non-Littoral Zone	0
B Enter Mean Depth of Lake:	1		B-1 Enter depth of Benthic Zone:	0

Path 2 (Continued…)

IF Lake Depth is greater than 10 m:			
	Mean depth of Non-Littoral Zone:		*(Reduced Value)*
	Depth of the Benthic Zone:		*(Reduced Value)*
	Benthic Pelagic ratio:		

Part 2 Enter the values for the estimated bottom surface area:

Littoral Zone (No vegetation):

Substrate:	Coarse	m^2	Medium	m^2	Fine	m^2
	Bedrock:	0.00	Rubble:	507.00	Sand:	28.00
	Boulder:	0.00	Cobble:	282.00	Silt:	282.00
			Gravel:	84.00	Muck:	17,398.00
					Clay:	0.00
	SubTotals:	0		873		17,708

Littoral Zone (Vegetation)

Substrate:	Coarse	m^2	Medium	m^2	Fine	m^2
	Bedrock:	0.00	Rubble:	0.00	Sand:	0.00
	Boulder:	0.00	Cobble:	0.00	Silt:	0.00
			Gravel:	0.00	Muck:	18,581.00
					Clay:	0.00
	SubTotals:	0		0		18,581

Non-Littoral Zone

Substrate:	Coarse	m^2	Medium	m^2	Fine	m^2
	Bedrock:	0.00	Rubble:	0.00	Sand:	0.00
	Boulder:	0.00	Cobble:	0.00	Silt:	0.00
			Gravel:	0.00	Muck:	0.00
					Clay:	0.00
	SubTotals:	0		0		0

Part 3 Summary Table for Bottom Surface Area Totals:

Habitat Types	Bottom Surface area (m^2)
Littoral Coarse/No vegetation	0
Littoral Medium/No vegetation	873
Littoral Fine/No vegetation	17,708
subtotal Littoral/No vegetation	**18,581**
Littoral Coarse/Vegetation	0
Littoral Medium/Vegetation	0
Littoral Fine/Vegetation	18,581
Subtotal Littoral/Vegetation	**18,581**
Subtotal Littoral	**37,162**
Non-littoral Coarse/Pelagic	0
Non-littoral Medium/Pelagic	0
Non-littoral Fine/Pelagic	0
Subtotal nonlittoral	**0**
Total Available Habitat	**37,162**

Note:
Pearl dace used as surrogate for Golden Shiner and Northern Red Belly Dace
Longnose sucker used as surrogate for White Sucker

Beaver Dam Quantification – April 9, 2021
Revised areas (as per MEL email dated April 9, 2021)

STEP 4 Lake name: WL59

Part 1

Tal Habitat Suitability Indices for all Fish species, including their respective life stages, which are present within the lake

	Species	Life Stage	Littoral Zone						Non-Littoral Zone		
			Coarse/No Vegetation	Medium/No Vegetation	Fine/No Vegetation	Coarse/Vegetation	Medium/Vegetation	Fine/Vegetation	Coarse/Pelagic	Medium/Pelagic	Fine/Pelagic
1	American eel	Spawning	NA	0.00	0.00	NA	0.00	0.00	NA	NA	0.00
		YOY	NA	0.00	0.00	NA	0.00	0.00	NA	NA	0.00
		Juvenile	NA	0.33	0.33	NA	0.26	0.26	NA	NA	0.00
		Adult	NA	0.33	0.33	NA	0.33	0.33	NA	NA	0.00
2	Banded killfish	Spawning	NA	0.00	1.00	NA	0.00	1.00	NA	NA	0.00
		YOY	NA	0.22	1.00	NA	0.26	1.00	NA	NA	0.00
		Juvenile	NA	0.50	1.00	NA	0.56	1.00	NA	NA	0.00
		Adult	NA	0.50	1.00	NA	0.56	1.00	NA	NA	0.00
3	Pearl dace	Spawning	NA	0.17	0.50	NA	0.17	0.50	NA	NA	0.00
		YOY	NA	0.00	0.67	NA	0.00	0.67	NA	NA	0.00
		Juvenile	NA	0.00	0.33	NA	0.00	0.33	NA	NA	0.00
		Adult	NA	0.00	0.00	NA	0.00	0.00	NA	NA	0.00
4	Ninespine stickleback	Spawning	NA	0.72	0.72	NA	0.82	0.82	NA	NA	0.00
		YOY	NA	0.00	0.89	NA	0.00	0.93	NA	NA	0.00
		Juvenile	NA	0.00	0.00	NA	0.00	0.00	NA	NA	0.00
		Adult	NA	0.89	0.22	NA	0.93	0.26	NA	NA	0.00

STEP 5 Lake name: WL59

Table 1: **Habitat Equivalent Units for each individual fish species present within the lake.**

	Species	Littoral Zone						Non-Littoral Zone			
		Coarse/No Vegetation	Medium/No Vegetation	Fine/No Vegetation	Coarse/Vegetation	Medium/Vegetation	Fine/Vegetation	Coarse/Pelagic	Medium/Pelagic	Fine/Pelagic	Total Available Habitat
1	American eel	0	297	6021	0	0	6318	0	0	0	12635.8
2	Banded killfish	0	445	17708	0	0	18581	0	0	0	36734.2
3	Pearl dace	0	148	11864	0	0	12449	0	0	0	24461.4
4	Ninespine stickleback	0	777	15760	0	0	17280	0	0	0	33817.0

Note:
Pearl dace used as surrogate for Golden Shiner and Northern Red Belly Dace
Longnose sucker used as surrogate for White Sucker

Beaver Dam Quantification – April 9, 2021
Revised areas (as per MEL email dated April 9, 2021)

Step 1

Note: Only enter the values in the cells shaded blue, the subtotals, totals and ratios will be calculated a

Enter Lake name:	WL56

Part 1 Entering Lake depth(s):

IF Lake Depth is less than or equal to 10 m:			**IF Lake Depth is greater than 10 m:**	
Path 1		**OR**	**Path 2**	
A Enter Depth of Littoral Zone:	1		**A-1 Enter mean depth of Non-Littoral Zone**	0
B Enter Mean Depth of Lake:	1		**B-1 Enter depth of Benthic Zone:**	0

Path 2 (Continued…)

IF Lake Depth is greater than 10 m:			
	Mean depth of Non-Littoral Zone:		*(Reduced Value)*
	Depth of the Benthic Zone:		*(Reduced Value)*
	Benthic Pelagic ratio:		

Part 2 Enter the values for the estimated bottom surface area:

Littoral Zone (No vegetation):

Substrate:	**Coarse**	m^2	**Medium**	m^2	**Fine**	m^2
	Bedrock:	**0.00**	Rubble:	**0.00**	Sand:	**0.00**
	Boulder:	**0.00**	Cobble:	**0.00**	Silt:	**0.00**
			Gravel:	**0.00**	Muck:	**1,163.00**
					Clay:	**0.00**
	SubTotals:	0		0		1,163

Littoral Zone (Vegetation)

Substrate:	**Coarse**	m^2	**Medium**	m^2	**Fine**	m^2
	Bedrock:	**0.00**	Rubble:	**0.00**	Sand:	**0.00**
	Boulder:	**0.00**	Cobble:	**0.00**	Silt:	**0.00**
			Gravel:	**0.00**	Muck:	**291.00**
					Clay:	**0.00**
	SubTotals:	0		0		291

Non-Littoral Zone

Substrate:	**Coarse**	m^2	**Medium**	m^2	**Fine**	m^2
	Bedrock:	**0.00**	Rubble:	**0.00**	Sand:	**0.00**
	Boulder:	**0.00**	Cobble:	**0.00**	Silt:	**0.00**
			Gravel:	**0.00**	Muck:	**0.00**
					Clay:	**0.00**
	SubTotals:	0		0		0

Part 3 Summary Table for Bottom Surface Area Totals:

Habitat Types	**Bottom Surface area (m^2)**
Littoral Coarse/No vegetation	0
Littoral Medium/No vegetation	0
Littoral Fine/No vegetation	1,163
subtotal Littoral/No vegetation	**1,163**
Littoral Coarse/Vegetation	0
Littoral Medium/Vegetation	0
Littoral Fine/Vegetation	291
Subtotal Littoral/Vegetation	**291**
Subtotal Littoral	**1,454**
Non-littoral Coarse/Pelagic	0
Non-littoral Medium/Pelagic	0
Non-littoral Fine/Pelagic	0
Subtotal nonlittoral	**0**
Total Available Habitat	1,454

Note:
Pearl dace used as surrogate for Golden Shiner and Northern Red Belly Dace
Longnose sucker used as surrogate for White Sucker

Beaver Dam Quantification – April 9, 2021
Revised areas (as per MEL email dated April 9, 2021)

STEP 4 **Lake name:** WL56

Part 1

Tal **Habitat Suitability Indices for all Fish species, including their respective life stages, which are present within the lake**

	Species	Life Stage	Littoral Zone						Non-Littoral Zone		
			Coarse/No Vegetation	Medium/No Vegetation	Fine/No Vegetation	Coarse/Vegetation	Medium/Vegetation	Fine/Vegetation	Coarse/Pelagic	Medium/Pelagic	Fine/Pelagic
		Spawning	NA	NA	0.00	NA	NA	0.00	NA	NA	0.00
		YOY	NA	NA	0.00	NA	NA	0.00	NA	NA	0.00
		Juvenile	NA	NA	0.00	NA	NA	0.00	NA	NA	0.00
1	American eel	Adult	NA	NA	0.00	NA	NA	0.00	NA	NA	0.00
		Spawning	NA	NA	1.00	NA	NA	1.00	NA	NA	0.00
		YOY	NA	NA	1.00	NA	NA	1.00	NA	NA	0.00
		Juvenile	NA	NA	1.00	NA	NA	1.00	NA	NA	0.00
2	Banded killfish	Adult	NA	NA	1.00	NA	NA	1.00	NA	NA	0.00
		Spawning	NA	NA	0.50	NA	NA	0.50	NA	NA	0.00
		YOY	NA	NA	1.00	NA	NA	1.00	NA	NA	0.00
		Juvenile	NA	NA	0.50	NA	NA	0.50	NA	NA	0.00
3	Pearl dace	Adult	NA	NA	0.00	NA	NA	0.00	NA	NA	0.00
		Spawning	NA	NA	0.67	NA	NA	0.67	NA	NA	0.00
		YOY	NA	NA	0.00	NA	NA	0.00	NA	NA	0.00
		Juvenile	NA	NA	0.00	NA	NA	0.00	NA	NA	0.00
4	Brook Trout (freshwater resident)	Adult	NA	NA	0.00	NA	NA	0.00	NA	NA	0.00

STEP 5 **Lake name:** WL56

Table 1: **Habitat Equivalent Units for each individual fish species present within the lake.**

	Species	Littoral Zone						Non-Littoral Zone			
		Coarse/No Vegetation	Medium/No Vegetation	Fine/No Vegetation	Coarse/Vegetation	Medium/Vegetation	Fine/Vegetation	Coarse/Pelagic	Medium/Pelagic	Fine/Pelagic	Total Available Habitat
1	American eel	0	0	0	0	0	0	0	0	0	0.0
2	Banded killfish	0	0	1163	0	0	291	0	0	0	1454.0
3	Pearl dace	0	0	1163	0	0	291	0	0	0	1454.0
4	Brook Trout (freshwater resident)	0	0	779	0	0	195	0	0	0	974.0

Note:
Pearl dace used as surrogate for Golden Shiner and Northern Red Belly Dace
Longnose sucker used as surrogate for White Sucker

Beaver Dam Quantification – April 9, 2021
Revised areas (as per MEL email dated April 9, 2021)

Step 1

Note: Only enter the values in the cells shaded blue, the subtotals, totals and ratios will be calculated a

Enter Lake name: WL61

Part 1 Entering Lake depth(s):

IF Lake Depth is less than or equal to 10 m:		OR	IF Lake Depth is greater than 10 m:	
Path 1			**Path 2**	
A Enter Depth of Littoral Zone:	1		A-1 Enter mean depth of Non-Littoral Zone	0
B Enter Mean Depth of Lake:	1		B-1 Enter depth of Benthic Zone:	0

Path 2 (Continued…)

IF Lake Depth is greater than 10 m:			
	Mean depth of Non-Littoral Zone:		*(Reduced Value)*
	Depth of the Benthic Zone:		*(Reduced Value)*
	Benthic Pelagic ratio:		

Part 2 Enter the values for the estimated bottom surface area:

Littoral Zone (No vegetation):

Substrate:	Coarse	m²	Medium	m²	Fine	m²
	Bedrock:	0.00	Rubble:	0.00	Sand:	0.00
	Boulder:	0.00	Cobble:	0.00	Silt:	0.00
			Gravel:	174.00	Muck:	0.00
					Clay:	0.00
	SubTotals:	0		174		0

Littoral Zone (Vegetation)

Substrate:	Coarse	m²	Medium	m²	Fine	m²
	Bedrock:	0.00	Rubble:	0.00	Sand:	0.00
	Boulder:	0.00	Cobble:	0.00	Silt:	0.00
			Gravel:	0.00	Muck:	0.00
					Clay:	0.00
	SubTotals:	0		0		0

Non-Littoral Zone

Substrate:	Coarse	m²	Medium	m²	Fine	m²
	Bedrock:	0.00	Rubble:	0.00	Sand:	0.00
	Boulder:	0.00	Cobble:	0.00	Silt:	0.00
			Gravel:	0.00	Muck:	0.00
					Clay:	0.00
	SubTotals:	0		0		0

Part 3 Summary Table for Bottom Surface Area Totals:

Habitat Types	Bottom Surface area (m²)
Littoral Coarse/No vegetation	0
Littoral Medium/No vegetation	174
Littoral Fine/No vegetation	0
subtotal Littoral/No vegetation	**174**
Littoral Coarse/Vegetation	0
Littoral Medium/Vegetation	0
Littoral Fine/Vegetation	0
Subtotal Littoral/Vegetation	**0**
Subtotal Littoral	**174**
Non-littoral Coarse/Pelagic	0
Non-littoral Medium/Pelagic	0
Non-littoral Fine/Pelagic	0
Subtotal nonlittoral	**0**
Total Available Habitat	**174**

Note:
Pearl dace used as surrogate for Golden Shiner and Northern Red Belly Dace
Longnose sucker used as surrogate for White Sucker

Beaver Dam Quantification – April 9, 2021
Revised areas (as per MEL email dated April 9, 2021)

STEP 4 Lake name: WL61

Part 1

Table: **Habitat Suitability Indices for all Fish species, including their respective life stages, which are present within the lake**

	Species	Life Stage	Littoral Zone: Coarse/No Vegetation	Littoral Zone: Medium/No Vegetation	Littoral Zone: Fine/No Vegetation	Littoral Zone: Coarse/Vegetation	Littoral Zone: Medium/Vegetation	Littoral Zone: Fine/Vegetation	Non-Littoral Zone: Coarse/Pelagic	Non-Littoral Zone: Medium/Pelagic	Non-Littoral Zone: Fine/Pelagic
1	American eel	Spawning	NA	NA	NA	NA	NA	NA	NA	NA	0.00
		YOY	NA	NA	NA	NA	NA	NA	NA	NA	0.00
		Juvenile	NA	NA	NA	NA	NA	NA	NA	NA	0.00
		Adult	NA	NA	NA	NA	NA	NA	NA	NA	0.00
2	Banded killfish	Spawning	NA	NA	NA	NA	NA	NA	NA	NA	0.00
		YOY	NA	NA	NA	NA	NA	NA	NA	NA	0.00
		Juvenile	NA	NA	NA	NA	NA	NA	NA	NA	0.00
		Adult	NA	NA	NA	NA	NA	NA	NA	NA	0.00
3	Pearl dace	Spawning	NA	NA	NA	NA	NA	NA	NA	NA	0.00
		YOY	NA	NA	NA	NA	NA	NA	NA	NA	0.00
		Juvenile	NA	NA	NA	NA	NA	NA	NA	NA	0.00
		Adult	NA	NA	NA	NA	NA	NA	NA	NA	0.00
4	Longnose sucker	Spawning	NA	0.50	NA	NA	0.50	NA	NA	NA	0.00
		YOY	NA	0.00	NA	NA	0.00	NA	NA	NA	0.00
		Juvenile	NA	0.00	NA	NA	0.00	NA	NA	NA	0.00
		Adult	NA	0.00	NA	NA	0.00	NA	NA	NA	0.00

STEP 5 Lake name: WL61

Table 1: **Habitat Equivalent Units for each individual fish species present within the lake.**

	Species	Littoral Zone: Coarse/No Vegetation	Littoral Zone: Medium/No Vegetation	Littoral Zone: Fine/No Vegetation	Littoral Zone: Coarse/Vegetation	Littoral Zone: Medium/Vegetation	Littoral Zone: Fine/Vegetation	Non-Littoral Zone: Coarse/Pelagic	Non-Littoral Zone: Medium/Pelagic	Non-Littoral Zone: Fine/Pelagic	Total Available Habitat
1	American eel	0	0	0	0	0	0	0	0	0	0.0
2	Banded killfish	0	0	0	0	0	0	0	0	0	0.0
3	Pearl dace	0	0	0	0	0	0	0	0	0	0.0
4	Longnose sucker	0	87	0	0	0	0	0	0	0	87.0

Note:
Pearl dace used as surrogate for Golden Shiner and Northern Red Belly Dace
Longnose sucker used as surrogate for White Sucker

Appendix E

2020 Musquodoboit River Water Quality Results

Bureau Veritas Laboratories
200 Bluewater Road, Bedford, Nova Scotia Canada B4B 1G9 Tel:(902) 420-0203 Toll-free:800-563-6266 Fax:(902) 420-8612 www.bvlabs.com

Page of

Chain Of Custody Record

INVOICE TO:		Report Information		Project Information	
Company Name	#16589 Atlantic Mining NS Corp	Company Name	#22600 McCallum Environmental	Quotation #	C02927
Contact Name	Accounts Payable	Contact Name	Melanie MacDonald	P.O. #	
Address	6749 Moose River Rd	Address	2 Bluewater Rd., Suite 135	Project #	
	Middle Musquodoboit NS B0N 1X0		Bedford NS B4B 1G7	Project Name	
Phone	(902) 384-2772 Fax: (902) 384-2772	Phone	(902) 880-6375 Fax:	Site #	
Email	accounts@atlanticgoldcorporation.com	Email	Melanie@mccallumenvironmental.com	Sampled By	

Laboratory Use Only

BV Labs Job #	Bottle Order #:
C0Y2001	806626
Chain Of Custody Record	Project Manager
C#806626-01-01	Maryann Comeau

Regulatory Criteria:

Special Instructions

** Specify Matrix: Surface/Ground/Tapwater/Sewage/Effluent/Seawater Potable/Nonpotable/Tissue/Soil/Sludge/Metal

SAMPLES MUST BE KEPT COOL (< 10°C) FROM TIME OF SAMPLING UNTIL DELIVERY TO BV LABS

ANALYSIS REQUESTED (PLEASE BE SPECIFIC)

Turnaround Time (TAT) Required:

Please provide advance notice for rush projects

Regular (Standard) TAT:
(will be applied if Rush TAT is not specified):
Standard TAT = 5-7 Working days for most tests..
Please note: Standard TAT for certain tests such as BOD and Dioxins/Furans are > 5 days - contact your Project Manager for details.

Job Specific Rush TAT (if applies to entire submission)
Date Required: Time Required:

	Sample Barcode Label	Sample (Location) Identification	Date Sampled	Time Sampled	Matrix	Field Filtered & Preserved	Lab Filtration Required	Atlantic RCAp-MS Total Metals in Water	Metals Water Diss. MS (as rec'd)	Ammonia	TOC							# of Bottles	Comments / Hazards / Other Required Analysis
1		CUL-2	20/12/22	9:50	H2O			X	X	X	X							5	Dissolved metals filtered,
2		POND	"	10:00	"			X	X	X	X							5	all others not filtered
3		OFF-A	"	10:30	"			X	X	X	X							5	
4		CUL-6	"	10:40	"			X	X	X	X							5	
5																			
6																			
7																			
8																			
9																			
10																			

2020 DEC 22 15:52

* RELINQUISHED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	RECEIVED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	# jars used and not submitted
<Original signed by> Meghan Quinn	20/12/22	1330	<Original signed by>			

Lab Use Only

Time Sensitive	Temperature (°C) on Receipt	Custody Seal Intact on Cooler?
☐	4, 0, 2	☐ Yes ☐ No

White: BV Labs Yellow: Client

Bureau Veritas Canada (2019) Inc.

Your P.O. #: PENDING
Your C.O.C. #: 806626-01-01

Attention: Melanie MacDonald

McCallum Environmental
2 Bluewater Rd., Suite 135
Bedford, NS
CANADA B4B 1G7

Report Date: 2020/12/31
Report #: R6467431
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BV LABS JOB #: C0Y2001
Received: 2020/12/22, 15:52

Sample Matrix: Water
Samples Received: 4

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Carbonate, Bicarbonate and Hydroxide	4	N/A	2020/12/29	N/A	SM 23 4500-CO2 D
Alkalinity	4	N/A	2020/12/29	ATL SOP 00013	EPA 310.2 R1974 m
Chloride	4	N/A	2020/12/30	ATL SOP 00014	SM 23 4500-Cl- E m
Colour	4	N/A	2020/12/30	ATL SOP 00020	SM 23 2120C m
Conductance - water	4	N/A	2020/12/29	ATL SOP 00004	SM 23 2510B m
Hardness (calculated as CaCO3)	2	N/A	2020/12/28	ATL SOP 00048	Auto Calc
Hardness (calculated as CaCO3)	2	N/A	2020/12/29	ATL SOP 00048	Auto Calc
Metals Water Diss. MS (as rec'd)	4	N/A	2020/12/28	ATL SOP 00058	EPA 6020B R2 m
Metals Water Total MS	2	2020/12/24	2020/12/24	ATL SOP 00058	EPA 6020B R2 m
Metals Water Total MS	2	2020/12/24	2020/12/28	ATL SOP 00058	EPA 6020B R2 m
Ion Balance (% Difference)	4	N/A	2020/12/31	N/A	Auto Calc.
Anion and Cation Sum	3	N/A	2020/12/29	N/A	Auto Calc.
Anion and Cation Sum	1	N/A	2020/12/31	N/A	Auto Calc.
Nitrogen Ammonia - water	3	N/A	2020/12/29	ATL SOP 00015	EPA 350.1 R2 m
Nitrogen Ammonia - water	1	N/A	2020/12/30	ATL SOP 00015	EPA 350.1 R2 m
Nitrogen - Nitrate + Nitrite	4	N/A	2020/12/30	ATL SOP 00016	USGS I-2547-11m
Nitrogen - Nitrite	4	N/A	2020/12/30	ATL SOP 00017	SM 23 4500-NO2- B m
Nitrogen - Nitrate (as N)	4	N/A	2020/12/30	ATL SOP 00018	ASTM D3867-16
pH (1)	4	N/A	2020/12/29	ATL SOP 00003	SM 23 4500-H+ B m
Phosphorus - ortho	4	N/A	2020/12/29	ATL SOP 00021	SM 23 4500-P E m
Sat. pH and Langelier Index (@ 20C)	4	N/A	2020/12/31	ATL SOP 00049	Auto Calc.
Sat. pH and Langelier Index (@ 4C)	4	N/A	2020/12/31	ATL SOP 00049	Auto Calc.
Reactive Silica	4	N/A	2020/12/29	ATL SOP 00022	EPA 366.0 m
Sulphate	4	N/A	2020/12/30	ATL SOP 00023	ASTM D516-16 m
Total Dissolved Solids (TDS calc)	4	N/A	2020/12/31	N/A	Auto Calc.
Organic carbon - Total (TOC) (2)	4	N/A	2020/12/29	ATL SOP 00203	SM 23 5310B m
Turbidity	4	N/A	2020/12/29	ATL SOP 00011	EPA 180.1 R2 m

Remarks:

Bureau Veritas Laboratories are accredited to ISO/IEC 17025 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by BV Labs are based upon recognized Provincial, Federal or US method compendia such as CCME, MELCC, EPA, APHA.

Your P.O. #: PENDING
Your C.O.C. #: 806626-01-01

Attention: Melanie MacDonald

McCallum Environmental
2 Bluewater Rd., Suite 135
Bedford, NS
CANADA B4B 1G7

Report Date: 2020/12/31
Report #: R6467431
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BV LABS JOB #: C0Y2001
Received: 2020/12/22, 15:52

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in BV Labs profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and BV Labs in writing). All data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported; unless indicated otherwise, associated sample data are not blank corrected. Where applicable, unless otherwise noted, Measurement Uncertainty has not been accounted for when stating conformity to the referenced standard.

BV Labs liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. BV Labs 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 BV Labs, unless otherwise agreed in writing. BV Labs is not responsible for the accuracy or any data impacts, that result from the information provided by the customer or their agent.

Solid sample results, except biota, are based on dry weight unless otherwise indicated. Organic analyses are not recovery corrected except for isotope dilution methods.
Results relate to samples tested. When sampling is not conducted by BV Labs, results relate to the supplied samples tested.
This Certificate shall not be reproduced except in full, without the written approval of the laboratory.
Reference Method suffix "m" indicates test methods incorporate validated modifications from specific reference methods to improve performance.
* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.
(1) The APHA Standard Method require pH to be analyzed within 15 minutes of sampling and therefore field analysis is required for compliance. All Laboratory pH analyses in this report are reported past the APHA Standard Method holding time.
(2) TOC / DOC present in the sample should be considered as non-purgeable TOC / DOC.

Encryption Key

AUTHORIZED REPORT
RAPPORT AUTORISÉ

Bureau Veritas Laboratories
31 Dec 2020 09:33:38

Please direct all questions regarding this Certificate of Analysis to your Project Manager.
Maryann Comeau, Project Manager
Email: <email address removed>
Phone# <personal information removed>
==
This report has been generated and distributed using a secure automated process.
BV Labs has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per ISO/IEC 17025, signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Bureau Veritas Laboratories 200 Bluewater Rd, Suite 105, Bedford, Nova Scotia Canada B4B 1G9 Tel: 902-420-0203 Toll-free: 800-565-7227 Fax: 902-420-8612 www.bvlabs.com

RESULTS OF ANALYSES OF WATER

BV Labs ID		OME824			OME824			OME825		
Sampling Date		2020/12/22 09:50			2020/12/22 09:50			2020/12/22 10:00		
COC Number		806626-01-01			806626-01-01			806626-01-01		
	UNITS	**CUL-2**	**RDL**	**QC Batch**	**CUL-2 Lab-Dup**	**RDL**	**QC Batch**	**POND**	**RDL**	**QC Batch**
Calculated Parameters										
Anion Sum	me/L	0.750	N/A	7124560				0.600	N/A	7124560
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	11	1.0	7124556				5.4	1.0	7124556
Calculated TDS	mg/L	44	1.0	7124565				39	1.0	7124565
Carb. Alkalinity (calc. as CaCO3)	mg/L	<1.0	1.0	7124556				<1.0	1.0	7124556
Cation Sum	me/L	0.690	N/A	7124560				0.530	N/A	7124560
Hardness (CaCO3)	mg/L	16	1.0	7124557				18	1.0	7124557
Ion Balance (% Difference)	%	4.17	N/A	7124558				6.19	N/A	7124558
Langelier Index (@ 20C)	N/A	-2.94		7124563				-3.90		7124563
Langelier Index (@ 4C)	N/A	-3.19		7124564				-4.15		7124564
Nitrate (N)	mg/L	0.43	0.050	7124561				0.14	0.050	7124561
Saturation pH (@ 20C)	N/A	9.64		7124563				9.83		7124563
Saturation pH (@ 4C)	N/A	9.89		7124564				10.1		7124564
Inorganics										
Total Alkalinity (Total as CaCO3)	mg/L	11	5.0	7128816				5.4	5.0	7128816
Dissolved Chloride (Cl-)	mg/L	15	1.0	7128818				6.9	1.0	7128818
Colour	TCU	18	5.0	7128823				42	5.0	7128823
Nitrate + Nitrite (N)	mg/L	0.43	0.050	7128825				0.14	0.050	7128825
Nitrite (N)	mg/L	<0.010	0.010	7128826				<0.010	0.010	7128826
Nitrogen (Ammonia Nitrogen)	mg/L	<0.050	0.050	7130514	<0.050	0.050	7130514	<0.050	0.050	7128357
Total Organic Carbon (C)	mg/L	3.1	0.50	7129016				6.3	0.50	7129020
Orthophosphate (P)	mg/L	0.016	0.010	7128824				<0.010	0.010	7128824
pH	pH	6.71		7128863				5.94		7128863
Reactive Silica (SiO2)	mg/L	2.6	0.50	7128822				3.7	0.50	7128822
Dissolved Sulphate (SO4)	mg/L	2.7	2.0	7128820				14	2.0	7128820
Turbidity	NTU	6.3	0.10	7129043				4.8	0.10	7129043
Conductivity	uS/cm	78	1.0	7128860				61	1.0	7128860

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate
N/A = Not Applicable

BV Labs Job #: C0Y2001
Report Date: 2020/12/31

McCallum Environmental
Your P.O. #: PENDING

RESULTS OF ANALYSES OF WATER

BV Labs ID		OME826		OME827		
Sampling Date		2020/12/22 10:30		2020/12/22 10:40		
COC Number		806626-01-01		806626-01-01		
	UNITS	OFF-A	QC Batch	CUL-6	RDL	QC Batch
Calculated Parameters						
Anion Sum	me/L	0.870	7124560	0.780	N/A	7124560
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	18	7124556	11	1.0	7124556
Calculated TDS	mg/L	46	7124565	47	1.0	7124565
Carb. Alkalinity (calc. as CaCO3)	mg/L	<1.0	7124556	<1.0	1.0	7124556
Cation Sum	me/L	0.590	7124560	0.700	N/A	7124560
Hardness (CaCO3)	mg/L	18	7124557	20	1.0	7124557
Ion Balance (% Difference)	%	19.2	7124558	5.41	N/A	7124558
Langelier Index (@ 20C)	N/A	-2.80	7124563	-2.73		7124563
Langelier Index (@ 4C)	N/A	-3.06	7124564	-2.99		7124564
Nitrate (N)	mg/L	0.67	7124561	0.96	0.050	7124561
Saturation pH (@ 20C)	N/A	9.33	7124563	9.52		7124563
Saturation pH (@ 4C)	N/A	9.58	7124564	9.77		7124564
Inorganics						
Total Alkalinity (Total as CaCO3)	mg/L	18	7128816	11	5.0	7128816
Dissolved Chloride (Cl-)	mg/L	12	7128818	12	1.0	7128818
Colour	TCU	43	7128823	38	5.0	7128823
Nitrate + Nitrite (N)	mg/L	0.67	7128825	0.96	0.050	7128825
Nitrite (N)	mg/L	<0.010	7128826	<0.010	0.010	7128826
Nitrogen (Ammonia Nitrogen)	mg/L	<0.050	7128357	0.060	0.050	7128357
Total Organic Carbon (C)	mg/L	7.1	7129020	6.9	0.50	7129020
Orthophosphate (P)	mg/L	0.022	7128824	0.014	0.010	7128824
pH	pH	6.52	7128863	6.78		7128863
Reactive Silica (SiO2)	mg/L	2.5	7128822	2.6	0.50	7128822
Dissolved Sulphate (SO4)	mg/L	5.3	7128820	6.7	2.0	7128820
Turbidity	NTU	7.9	7129043	9.6	0.10	7129046
Conductivity	uS/cm	73	7128860	79	1.0	7128860

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
N/A = Not Applicable

Bureau Veritas Laboratories 200 Bluewater Rd, Suite 105, Bedford, Nova Scotia Canada B4B 1G9 Tel: 902-420-0203 Toll-free: 800-565-7227 Fax: 902-420-8612 www.bvlabs.com

ELEMENTS BY ICP/MS (WATER)

BV Labs ID		OME824	OME825			OME825			OME826		
Sampling Date		2020/12/22 09:50	2020/12/22 10:00			2020/12/22 10:00			2020/12/22 10:30		
COC Number		806626-01-01	806626-01-01			806626-01-01			806626-01-01		
	UNITS	**CUL-2**	**POND**	**RDL**	**QC Batch**	**POND Lab-Dup**	**RDL**	**QC Batch**	**OFF-A**	**RDL**	**QC Batch**
Metals											
Dissolved Aluminum (Al)	ug/L	57	100	5.0	7128449	110	5.0	7128449	97	5.0	7128449
Total Aluminum (Al)	ug/L	220	220	5.0	7126459				250	5.0	7126459
Dissolved Antimony (Sb)	ug/L	<1.0	<1.0	1.0	7128449	<1.0	1.0	7128449	<1.0	1.0	7128449
Total Antimony (Sb)	ug/L	<1.0	<1.0	1.0	7126459				<1.0	1.0	7126459
Dissolved Arsenic (As)	ug/L	<1.0	<1.0	1.0	7128449	<1.0	1.0	7128449	<1.0	1.0	7128449
Total Arsenic (As)	ug/L	<1.0	<1.0	1.0	7126459				<1.0	1.0	7126459
Dissolved Barium (Ba)	ug/L	9.0	16	1.0	7128449	16	1.0	7128449	11	1.0	7128449
Total Barium (Ba)	ug/L	10	18	1.0	7126459				14	1.0	7126459
Dissolved Beryllium (Be)	ug/L	<1.0	<1.0	1.0	7128449	<1.0	1.0	7128449	<1.0	1.0	7128449
Total Beryllium (Be)	ug/L	<1.0	<1.0	1.0	7126459				<1.0	1.0	7126459
Dissolved Bismuth (Bi)	ug/L	<2.0	<2.0	2.0	7128449	<2.0	2.0	7128449	<2.0	2.0	7128449
Total Bismuth (Bi)	ug/L	<2.0	<2.0	2.0	7126459				<2.0	2.0	7126459
Dissolved Boron (B)	ug/L	<50	<50	50	7128449	<50	50	7128449	<50	50	7128449
Total Boron (B)	ug/L	<50	<50	50	7126459				<50	50	7126459
Dissolved Cadmium (Cd)	ug/L	<0.010	0.042	0.010	7128449	0.045	0.010	7128449	0.024	0.010	7128449
Total Cadmium (Cd)	ug/L	0.011	0.049	0.010	7126459				0.047	0.010	7126459
Dissolved Calcium (Ca)	ug/L	4100	5400	100	7128449	5400	100	7128449	5200	100	7128449
Total Calcium (Ca)	ug/L	3900	5300	100	7126459				5200	100	7126459
Dissolved Chromium (Cr)	ug/L	<1.0	<1.0	1.0	7128449	<1.0	1.0	7128449	<1.0	1.0	7128449
Total Chromium (Cr)	ug/L	<1.0	<1.0	1.0	7126459				<1.0	1.0	7126459
Dissolved Cobalt (Co)	ug/L	<0.40	0.41	0.40	7128449	<0.40	0.40	7128449	<0.40	0.40	7128449
Total Cobalt (Co)	ug/L	<0.40	0.50	0.40	7126459				<0.40	0.40	7126459
Dissolved Copper (Cu)	ug/L	0.71	0.55	0.50	7128449	0.55	0.50	7128449	0.88	0.50	7128449
Total Copper (Cu)	ug/L	0.98	0.73	0.50	7126459				1.6	0.50	7126459
Dissolved Iron (Fe)	ug/L	65	310	50	7128449	310	50	7128449	110	50	7128449
Total Iron (Fe)	ug/L	220	520	50	7126459				280	50	7126459
Dissolved Lead (Pb)	ug/L	<0.50	<0.50	0.50	7128449	<0.50	0.50	7128449	<0.50	0.50	7128449
Total Lead (Pb)	ug/L	<0.50	<0.50	0.50	7126459				<0.50	0.50	7126459
Dissolved Magnesium (Mg)	ug/L	1300	980	100	7128449	1000	100	7128449	1100	100	7128449
Total Magnesium (Mg)	ug/L	1100	870	100	7126459				1200	100	7126459
Dissolved Manganese (Mn)	ug/L	35	200	2.0	7128449	190	2.0	7128449	48	2.0	7128449
Total Manganese (Mn)	ug/L	41	190	2.0	7126459				55	2.0	7126459
Dissolved Molybdenum (Mo)	ug/L	<2.0	<2.0	2.0	7128449	<2.0	2.0	7128449	<2.0	2.0	7128449
Total Molybdenum (Mo)	ug/L	<2.0	<2.0	2.0	7126459				<2.0	2.0	7126459

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate

ELEMENTS BY ICP/MS (WATER)

BV Labs ID		OME824	OME825			OME825			OME826		
Sampling Date		2020/12/22 09:50	2020/12/22 10:00			2020/12/22 10:00			2020/12/22 10:30		
COC Number		806626-01-01	806626-01-01			806626-01-01			806626-01-01		
	UNITS	CUL-2	POND	RDL	QC Batch	POND Lab-Dup	RDL	QC Batch	OFF-A	RDL	QC Batch
Dissolved Nickel (Ni)	ug/L	<2.0	<2.0	2.0	7128449	<2.0	2.0	7128449	<2.0	2.0	7128449
Total Nickel (Ni)	ug/L	<2.0	<2.0	2.0	7126459				<2.0	2.0	7126459
Dissolved Phosphorus (P)	ug/L	<100	<100	100	7128449	<100	100	7128449	<100	100	7128449
Total Phosphorus (P)	ug/L	<100	<100	100	7126459				<100	100	7126459
Dissolved Potassium (K)	ug/L	1000	340	100	7128449	350	100	7128449	740	100	7128449
Total Potassium (K)	ug/L	1100	370	100	7126459				1100	100	7126459
Dissolved Selenium (Se)	ug/L	<0.50	<0.50	0.50	7128449	<0.50	0.50	7128449	<0.50	0.50	7128449
Total Selenium (Se)	ug/L	<0.50	<0.50	0.50	7126459				<0.50	0.50	7126459
Dissolved Silver (Ag)	ug/L	<0.10	<0.10	0.10	7128449	<0.10	0.10	7128449	<0.10	0.10	7128449
Total Silver (Ag)	ug/L	<0.10	<0.10	0.10	7126459				<0.10	0.10	7126459
Dissolved Sodium (Na)	ug/L	8000	3600	100	7128449	3500	100	7128449	4900	100	7128449
Total Sodium (Na)	ug/L	6700	3000	100	7126459				5900	100	7126459
Dissolved Strontium (Sr)	ug/L	9.9	22	2.0	7128449	21	2.0	7128449	18	2.0	7128449
Total Strontium (Sr)	ug/L	8.5	21	2.0	7126459				16	2.0	7126459
Dissolved Thallium (Tl)	ug/L	<0.10	<0.10	0.10	7128449	<0.10	0.10	7128449	<0.10	0.10	7128449
Total Thallium (Tl)	ug/L	<0.10	<0.10	0.10	7126459				<0.10	0.10	7126459
Dissolved Tin (Sn)	ug/L	<2.0	<2.0	2.0	7128449	<2.0	2.0	7128449	<2.0	2.0	7128449
Total Tin (Sn)	ug/L	<2.0	<2.0	2.0	7126459				<2.0	2.0	7126459
Dissolved Titanium (Ti)	ug/L	<2.0	<2.0	2.0	7128449	<2.0	2.0	7128449	<2.0	2.0	7128449
Total Titanium (Ti)	ug/L	7.7	4.6	2.0	7126459				3.4	2.0	7126459
Dissolved Uranium (U)	ug/L	<0.10	<0.10	0.10	7128449	<0.10	0.10	7128449	<0.10	0.10	7128449
Total Uranium (U)	ug/L	<0.10	<0.10	0.10	7126459				<0.10	0.10	7126459
Dissolved Vanadium (V)	ug/L	<2.0	<2.0	2.0	7128449	<2.0	2.0	7128449	<2.0	2.0	7128449
Total Vanadium (V)	ug/L	<2.0	<2.0	2.0	7126459				<2.0	2.0	7126459
Dissolved Zinc (Zn)	ug/L	<5.0	7.5	5.0	7128449	7.0	5.0	7128449	<5.0	5.0	7128449
Total Zinc (Zn)	ug/L	<5.0	7.2	5.0	7126459				5.7	5.0	7126459

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate

ELEMENTS BY ICP/MS (WATER)

BV Labs ID		OME827		
Sampling Date		2020/12/22 10:40		
COC Number		806626-01-01		
	UNITS	CUL-6	RDL	QC Batch
Metals				
Dissolved Aluminum (Al)	ug/L	130	5.0	7128449
Total Aluminum (Al)	ug/L	330	5.0	7126459
Dissolved Antimony (Sb)	ug/L	<1.0	1.0	7128449
Total Antimony (Sb)	ug/L	<1.0	1.0	7126459
Dissolved Arsenic (As)	ug/L	<1.0	1.0	7128449
Total Arsenic (As)	ug/L	<1.0	1.0	7126459
Dissolved Barium (Ba)	ug/L	18	1.0	7128449
Total Barium (Ba)	ug/L	20	1.0	7126459
Dissolved Beryllium (Be)	ug/L	<1.0	1.0	7128449
Total Beryllium (Be)	ug/L	<1.0	1.0	7126459
Dissolved Bismuth (Bi)	ug/L	<2.0	2.0	7128449
Total Bismuth (Bi)	ug/L	<2.0	2.0	7126459
Dissolved Boron (B)	ug/L	<50	50	7128449
Total Boron (B)	ug/L	<50	50	7126459
Dissolved Cadmium (Cd)	ug/L	0.050	0.010	7128449
Total Cadmium (Cd)	ug/L	0.062	0.010	7126459
Dissolved Calcium (Ca)	ug/L	5700	100	7128449
Total Calcium (Ca)	ug/L	5800	100	7126459
Dissolved Chromium (Cr)	ug/L	<1.0	1.0	7128449
Total Chromium (Cr)	ug/L	<1.0	1.0	7126459
Dissolved Cobalt (Co)	ug/L	<0.40	0.40	7128449
Total Cobalt (Co)	ug/L	<0.40	0.40	7126459
Dissolved Copper (Cu)	ug/L	1.3	0.50	7128449
Total Copper (Cu)	ug/L	1.7	0.50	7126459
Dissolved Iron (Fe)	ug/L	160	50	7128449
Total Iron (Fe)	ug/L	390	50	7126459
Dissolved Lead (Pb)	ug/L	<0.50	0.50	7128449
Total Lead (Pb)	ug/L	<0.50	0.50	7126459
Dissolved Magnesium (Mg)	ug/L	1300	100	7128449
Total Magnesium (Mg)	ug/L	1400	100	7126459
Dissolved Manganese (Mn)	ug/L	210	2.0	7128449
Total Manganese (Mn)	ug/L	250	2.0	7126459
Dissolved Molybdenum (Mo)	ug/L	<2.0	2.0	7128449
Total Molybdenum (Mo)	ug/L	<2.0	2.0	7126459
Dissolved Nickel (Ni)	ug/L	<2.0	2.0	7128449

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

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ELEMENTS BY ICP/MS (WATER)

BV Labs ID		OME827		
Sampling Date		2020/12/22 10:40		
COC Number		806626-01-01		
	UNITS	CUL-6	RDL	QC Batch
Total Nickel (Ni)	ug/L	<2.0	2.0	7126459
Dissolved Phosphorus (P)	ug/L	<100	100	7128449
Total Phosphorus (P)	ug/L	<100	100	7126459
Dissolved Potassium (K)	ug/L	1100	100	7128449
Total Potassium (K)	ug/L	1100	100	7126459
Dissolved Selenium (Se)	ug/L	<0.50	0.50	7128449
Total Selenium (Se)	ug/L	<0.50	0.50	7126459
Dissolved Silver (Ag)	ug/L	<0.10	0.10	7128449
Total Silver (Ag)	ug/L	<0.10	0.10	7126459
Dissolved Sodium (Na)	ug/L	6200	100	7128449
Total Sodium (Na)	ug/L	6200	100	7126459
Dissolved Strontium (Sr)	ug/L	16	2.0	7128449
Total Strontium (Sr)	ug/L	15	2.0	7126459
Dissolved Thallium (Tl)	ug/L	<0.10	0.10	7128449
Total Thallium (Tl)	ug/L	<0.10	0.10	7126459
Dissolved Tin (Sn)	ug/L	<2.0	2.0	7128449
Total Tin (Sn)	ug/L	<2.0	2.0	7126459
Dissolved Titanium (Ti)	ug/L	2.4	2.0	7128449
Total Titanium (Ti)	ug/L	4.5	2.0	7126459
Dissolved Uranium (U)	ug/L	<0.10	0.10	7128449
Total Uranium (U)	ug/L	<0.10	0.10	7126459
Dissolved Vanadium (V)	ug/L	<2.0	2.0	7128449
Total Vanadium (V)	ug/L	<2.0	2.0	7126459
Dissolved Zinc (Zn)	ug/L	6.0	5.0	7128449
Total Zinc (Zn)	ug/L	6.5	5.0	7126459

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

GENERAL COMMENTS

Each temperature is the average of up to three cooler temperatures taken at receipt

Package 1	2.0°C

Sample OME824 [CUL-2] : ortho-Phosphate > Phosphorus: Both values fall within the method uncertainty for duplicates and are likely equivalent.

Sample OME825 [POND] : RCAp Ion Balance acceptable. Anion/cation agreement within 0.2 meq/L.

Sample OME826 [OFF-A] : ortho-Phosphate > Phosphorus: Both values fall within the method uncertainty for duplicates and are likely equivalent.

RCAp Ion Balance acceptable. Low ionic strength sample.

Sample OME827 [CUL-6] : ortho-Phosphate > Phosphorus: Both values fall within the method uncertainty for duplicates and are likely equivalent.
RCAp Ion Balance acceptable. Anion/cation agreement within 0.2 meq/L.

Results relate only to the items tested.

QUALITY ASSURANCE REPORT

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	UNITS	QC Limits
7126459	BAN	Matrix Spike	Total Aluminum (Al)	2020/12/24		89	%	80 - 120
			Total Antimony (Sb)	2020/12/24		107	%	80 - 120
			Total Arsenic (As)	2020/12/24		92	%	80 - 120
			Total Barium (Ba)	2020/12/24		98	%	80 - 120
			Total Beryllium (Be)	2020/12/24		102	%	80 - 120
			Total Bismuth (Bi)	2020/12/24		100	%	80 - 120
			Total Boron (B)	2020/12/24		98	%	80 - 120
			Total Cadmium (Cd)	2020/12/24		98	%	80 - 120
			Total Calcium (Ca)	2020/12/24		97	%	80 - 120
			Total Chromium (Cr)	2020/12/24		90	%	80 - 120
			Total Cobalt (Co)	2020/12/24		93	%	80 - 120
			Total Copper (Cu)	2020/12/24		91	%	80 - 120
			Total Iron (Fe)	2020/12/24		96	%	80 - 120
			Total Lead (Pb)	2020/12/24		98	%	80 - 120
			Total Magnesium (Mg)	2020/12/24		92	%	80 - 120
			Total Manganese (Mn)	2020/12/24		92	%	80 - 120
			Total Molybdenum (Mo)	2020/12/24		102	%	80 - 120
			Total Nickel (Ni)	2020/12/24		93	%	80 - 120
			Total Phosphorus (P)	2020/12/24		97	%	80 - 120
			Total Potassium (K)	2020/12/24		96	%	80 - 120
			Total Selenium (Se)	2020/12/24		94	%	80 - 120
			Total Silver (Ag)	2020/12/24		95	%	80 - 120
			Total Sodium (Na)	2020/12/24		88	%	80 - 120
			Total Strontium (Sr)	2020/12/24		100	%	80 - 120
			Total Thallium (Tl)	2020/12/24		99	%	80 - 120
			Total Tin (Sn)	2020/12/24		105	%	80 - 120
			Total Titanium (Ti)	2020/12/24		94	%	80 - 120
			Total Uranium (U)	2020/12/24		106	%	80 - 120
			Total Vanadium (V)	2020/12/24		93	%	80 - 120
			Total Zinc (Zn)	2020/12/24		NC	%	80 - 120
7126459	BAN	Spiked Blank	Total Aluminum (Al)	2020/12/24		88	%	80 - 120
			Total Antimony (Sb)	2020/12/24		105	%	80 - 120
			Total Arsenic (As)	2020/12/24		94	%	80 - 120
			Total Barium (Ba)	2020/12/24		97	%	80 - 120
			Total Beryllium (Be)	2020/12/24		101	%	80 - 120
			Total Bismuth (Bi)	2020/12/24		99	%	80 - 120
			Total Boron (B)	2020/12/24		96	%	80 - 120
			Total Cadmium (Cd)	2020/12/24		96	%	80 - 120
			Total Calcium (Ca)	2020/12/24		96	%	80 - 120
			Total Chromium (Cr)	2020/12/24		92	%	80 - 120
			Total Cobalt (Co)	2020/12/24		95	%	80 - 120
			Total Copper (Cu)	2020/12/24		93	%	80 - 120
			Total Iron (Fe)	2020/12/24		98	%	80 - 120
			Total Lead (Pb)	2020/12/24		98	%	80 - 120
			Total Magnesium (Mg)	2020/12/24		94	%	80 - 120
			Total Manganese (Mn)	2020/12/24		94	%	80 - 120
			Total Molybdenum (Mo)	2020/12/24		100	%	80 - 120
			Total Nickel (Ni)	2020/12/24		94	%	80 - 120
			Total Phosphorus (P)	2020/12/24		96	%	80 - 120
			Total Potassium (K)	2020/12/24		98	%	80 - 120
			Total Selenium (Se)	2020/12/24		95	%	80 - 120
			Total Silver (Ag)	2020/12/24		97	%	80 - 120
			Total Sodium (Na)	2020/12/24		91	%	80 - 120
			Total Strontium (Sr)	2020/12/24		97	%	80 - 120
			Total Thallium (Tl)	2020/12/24		99	%	80 - 120

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QUALITY ASSURANCE REPORT(CONT'D)

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	UNITS	QC Limits
			Total Tin (Sn)	2020/12/24		104	%	80 - 120
			Total Titanium (Ti)	2020/12/24		96	%	80 - 120
			Total Uranium (U)	2020/12/24		106	%	80 - 120
			Total Vanadium (V)	2020/12/24		93	%	80 - 120
			Total Zinc (Zn)	2020/12/24		98	%	80 - 120
7126459	BAN	Method Blank	Total Aluminum (Al)	2020/12/28	<5.0		ug/L	
			Total Antimony (Sb)	2020/12/28	<1.0		ug/L	
			Total Arsenic (As)	2020/12/28	<1.0		ug/L	
			Total Barium (Ba)	2020/12/28	<1.0		ug/L	
			Total Beryllium (Be)	2020/12/28	<1.0		ug/L	
			Total Bismuth (Bi)	2020/12/28	<2.0		ug/L	
			Total Boron (B)	2020/12/28	<50		ug/L	
			Total Cadmium (Cd)	2020/12/28	<0.010		ug/L	
			Total Calcium (Ca)	2020/12/28	<100		ug/L	
			Total Chromium (Cr)	2020/12/28	<1.0		ug/L	
			Total Cobalt (Co)	2020/12/28	<0.40		ug/L	
			Total Copper (Cu)	2020/12/28	<0.50		ug/L	
			Total Iron (Fe)	2020/12/28	<50		ug/L	
			Total Lead (Pb)	2020/12/28	<0.50		ug/L	
			Total Magnesium (Mg)	2020/12/28	<100		ug/L	
			Total Manganese (Mn)	2020/12/28	<2.0		ug/L	
			Total Molybdenum (Mo)	2020/12/28	<2.0		ug/L	
			Total Nickel (Ni)	2020/12/28	<2.0		ug/L	
			Total Phosphorus (P)	2020/12/28	<100		ug/L	
			Total Potassium (K)	2020/12/28	<100		ug/L	
			Total Selenium (Se)	2020/12/28	<0.50		ug/L	
			Total Silver (Ag)	2020/12/28	<0.10		ug/L	
			Total Sodium (Na)	2020/12/28	<100		ug/L	
			Total Strontium (Sr)	2020/12/28	<2.0		ug/L	
			Total Thallium (Tl)	2020/12/28	<0.10		ug/L	
			Total Tin (Sn)	2020/12/28	<2.0		ug/L	
			Total Titanium (Ti)	2020/12/28	<2.0		ug/L	
			Total Uranium (U)	2020/12/28	<0.10		ug/L	
			Total Vanadium (V)	2020/12/28	<2.0		ug/L	
			Total Zinc (Zn)	2020/12/28	<5.0		ug/L	
7126459	BAN	RPD	Total Aluminum (Al)	2020/12/24	0.74		%	20
7128357	EMT	Matrix Spike	Nitrogen (Ammonia Nitrogen)	2020/12/29		NC	%	80 - 120
7128357	EMT	Spiked Blank	Nitrogen (Ammonia Nitrogen)	2020/12/29		98	%	80 - 120
7128357	EMT	Method Blank	Nitrogen (Ammonia Nitrogen)	2020/12/29	<0.050		mg/L	
7128357	EMT	RPD	Nitrogen (Ammonia Nitrogen)	2020/12/29	0.044		%	20
7128449	MLB	Matrix Spike [OME825-05]	Dissolved Aluminum (Al)	2020/12/28		98	%	80 - 120
			Dissolved Antimony (Sb)	2020/12/28		95	%	80 - 120
			Dissolved Arsenic (As)	2020/12/28		93	%	80 - 120
			Dissolved Barium (Ba)	2020/12/28		96	%	80 - 120
			Dissolved Beryllium (Be)	2020/12/28		99	%	80 - 120
			Dissolved Bismuth (Bi)	2020/12/28		97	%	80 - 120
			Dissolved Boron (B)	2020/12/28		96	%	80 - 120
			Dissolved Cadmium (Cd)	2020/12/28		96	%	80 - 120
			Dissolved Calcium (Ca)	2020/12/28		100	%	80 - 120
			Dissolved Chromium (Cr)	2020/12/28		96	%	80 - 120
			Dissolved Cobalt (Co)	2020/12/28		94	%	80 - 120
			Dissolved Copper (Cu)	2020/12/28		94	%	80 - 120
			Dissolved Iron (Fe)	2020/12/28		102	%	80 - 120
			Dissolved Lead (Pb)	2020/12/28		98	%	80 - 120

QUALITY ASSURANCE REPORT(CONT'D)

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	UNITS	QC Limits
			Dissolved Magnesium (Mg)	2020/12/28		104	%	80 - 120
			Dissolved Manganese (Mn)	2020/12/28		NC	%	80 - 120
			Dissolved Molybdenum (Mo)	2020/12/28		99	%	80 - 120
			Dissolved Nickel (Ni)	2020/12/28		99	%	80 - 120
			Dissolved Phosphorus (P)	2020/12/28		102	%	80 - 120
			Dissolved Potassium (K)	2020/12/28		96	%	80 - 120
			Dissolved Selenium (Se)	2020/12/28		96	%	80 - 120
			Dissolved Silver (Ag)	2020/12/28		97	%	80 - 120
			Dissolved Sodium (Na)	2020/12/28		96	%	80 - 120
			Dissolved Strontium (Sr)	2020/12/28		98	%	80 - 120
			Dissolved Thallium (Tl)	2020/12/28		99	%	80 - 120
			Dissolved Tin (Sn)	2020/12/28		98	%	80 - 120
			Dissolved Titanium (Ti)	2020/12/28		101	%	80 - 120
			Dissolved Uranium (U)	2020/12/28		106	%	80 - 120
			Dissolved Vanadium (V)	2020/12/28		100	%	80 - 120
			Dissolved Zinc (Zn)	2020/12/28		97	%	80 - 120
7128449	MLB	Spiked Blank	Dissolved Aluminum (Al)	2020/12/28		100	%	80 - 120
			Dissolved Antimony (Sb)	2020/12/28		94	%	80 - 120
			Dissolved Arsenic (As)	2020/12/28		92	%	80 - 120
			Dissolved Barium (Ba)	2020/12/28		94	%	80 - 120
			Dissolved Beryllium (Be)	2020/12/28		95	%	80 - 120
			Dissolved Bismuth (Bi)	2020/12/28		99	%	80 - 120
			Dissolved Boron (B)	2020/12/28		97	%	80 - 120
			Dissolved Cadmium (Cd)	2020/12/28		94	%	80 - 120
			Dissolved Calcium (Ca)	2020/12/28		101	%	80 - 120
			Dissolved Chromium (Cr)	2020/12/28		93	%	80 - 120
			Dissolved Cobalt (Co)	2020/12/28		94	%	80 - 120
			Dissolved Copper (Cu)	2020/12/28		92	%	80 - 120
			Dissolved Iron (Fe)	2020/12/28		101	%	80 - 120
			Dissolved Lead (Pb)	2020/12/28		96	%	80 - 120
			Dissolved Magnesium (Mg)	2020/12/28		102	%	80 - 120
			Dissolved Manganese (Mn)	2020/12/28		96	%	80 - 120
			Dissolved Molybdenum (Mo)	2020/12/28		102	%	80 - 120
			Dissolved Nickel (Ni)	2020/12/28		95	%	80 - 120
			Dissolved Phosphorus (P)	2020/12/28		102	%	80 - 120
			Dissolved Potassium (K)	2020/12/28		96	%	80 - 120
			Dissolved Selenium (Se)	2020/12/28		95	%	80 - 120
			Dissolved Silver (Ag)	2020/12/28		94	%	80 - 120
			Dissolved Sodium (Na)	2020/12/28		96	%	80 - 120
			Dissolved Strontium (Sr)	2020/12/28		98	%	80 - 120
			Dissolved Thallium (Tl)	2020/12/28		100	%	80 - 120
			Dissolved Tin (Sn)	2020/12/28		98	%	80 - 120
			Dissolved Titanium (Ti)	2020/12/28		100	%	80 - 120
			Dissolved Uranium (U)	2020/12/28		103	%	80 - 120
			Dissolved Vanadium (V)	2020/12/28		99	%	80 - 120
			Dissolved Zinc (Zn)	2020/12/28		98	%	80 - 120
7128449	MLB	Method Blank	Dissolved Aluminum (Al)	2020/12/28	<5.0		ug/L	
			Dissolved Antimony (Sb)	2020/12/28	<1.0		ug/L	
			Dissolved Arsenic (As)	2020/12/28	<1.0		ug/L	
			Dissolved Barium (Ba)	2020/12/28	<1.0		ug/L	
			Dissolved Beryllium (Be)	2020/12/28	<1.0		ug/L	
			Dissolved Bismuth (Bi)	2020/12/28	<2.0		ug/L	
			Dissolved Boron (B)	2020/12/28	<50		ug/L	
			Dissolved Cadmium (Cd)	2020/12/28	<0.010		ug/L	
			Dissolved Calcium (Ca)	2020/12/28	<100		ug/L	

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QUALITY ASSURANCE REPORT(CONT'D)

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	UNITS	QC Limits
			Dissolved Chromium (Cr)	2020/12/28	<1.0		ug/L	
			Dissolved Cobalt (Co)	2020/12/28	<0.40		ug/L	
			Dissolved Copper (Cu)	2020/12/28	<0.50		ug/L	
			Dissolved Iron (Fe)	2020/12/28	<50		ug/L	
			Dissolved Lead (Pb)	2020/12/28	<0.50		ug/L	
			Dissolved Magnesium (Mg)	2020/12/28	<100		ug/L	
			Dissolved Manganese (Mn)	2020/12/28	<2.0		ug/L	
			Dissolved Molybdenum (Mo)	2020/12/28	<2.0		ug/L	
			Dissolved Nickel (Ni)	2020/12/28	<2.0		ug/L	
			Dissolved Phosphorus (P)	2020/12/28	<100		ug/L	
			Dissolved Potassium (K)	2020/12/28	<100		ug/L	
			Dissolved Selenium (Se)	2020/12/28	<0.50		ug/L	
			Dissolved Silver (Ag)	2020/12/28	<0.10		ug/L	
			Dissolved Sodium (Na)	2020/12/28	<100		ug/L	
			Dissolved Strontium (Sr)	2020/12/28	<2.0		ug/L	
			Dissolved Thallium (Tl)	2020/12/28	<0.10		ug/L	
			Dissolved Tin (Sn)	2020/12/28	<2.0		ug/L	
			Dissolved Titanium (Ti)	2020/12/28	<2.0		ug/L	
			Dissolved Uranium (U)	2020/12/28	<0.10		ug/L	
			Dissolved Vanadium (V)	2020/12/28	<2.0		ug/L	
			Dissolved Zinc (Zn)	2020/12/28	<5.0		ug/L	
7128449	MLB	RPD [OME825-05]	Dissolved Aluminum (Al)	2020/12/28	5.3		%	20
			Dissolved Antimony (Sb)	2020/12/28	NC		%	20
			Dissolved Arsenic (As)	2020/12/28	NC		%	20
			Dissolved Barium (Ba)	2020/12/28	3.3		%	20
			Dissolved Beryllium (Be)	2020/12/28	NC		%	20
			Dissolved Bismuth (Bi)	2020/12/28	NC		%	20
			Dissolved Boron (B)	2020/12/28	NC		%	20
			Dissolved Cadmium (Cd)	2020/12/28	7.2		%	20
			Dissolved Calcium (Ca)	2020/12/28	0.40		%	20
			Dissolved Chromium (Cr)	2020/12/28	NC		%	20
			Dissolved Cobalt (Co)	2020/12/28	2.8		%	20
			Dissolved Copper (Cu)	2020/12/28	0.19		%	20
			Dissolved Iron (Fe)	2020/12/28	0.74		%	20
			Dissolved Lead (Pb)	2020/12/28	NC		%	20
			Dissolved Magnesium (Mg)	2020/12/28	2.2		%	20
			Dissolved Manganese (Mn)	2020/12/28	1.2		%	20
			Dissolved Molybdenum (Mo)	2020/12/28	NC		%	20
			Dissolved Nickel (Ni)	2020/12/28	NC		%	20
			Dissolved Phosphorus (P)	2020/12/28	NC		%	20
			Dissolved Potassium (K)	2020/12/28	4.8		%	20
			Dissolved Selenium (Se)	2020/12/28	NC		%	20
			Dissolved Silver (Ag)	2020/12/28	NC		%	20
			Dissolved Sodium (Na)	2020/12/28	1.7		%	20
			Dissolved Strontium (Sr)	2020/12/28	2.3		%	20
			Dissolved Thallium (Tl)	2020/12/28	NC		%	20
			Dissolved Tin (Sn)	2020/12/28	NC		%	20
			Dissolved Titanium (Ti)	2020/12/28	NC		%	20
			Dissolved Uranium (U)	2020/12/28	NC		%	20
			Dissolved Vanadium (V)	2020/12/28	NC		%	20
			Dissolved Zinc (Zn)	2020/12/28	7.8		%	20
7128816	EMT	Matrix Spike	Total Alkalinity (Total as CaCO3)	2020/12/29		NC	%	80 - 120
7128816	EMT	Spiked Blank	Total Alkalinity (Total as CaCO3)	2020/12/29		102	%	80 - 120
7128816	EMT	Method Blank	Total Alkalinity (Total as CaCO3)	2020/12/29	<5.0		mg/L	
7128816	EMT	RPD	Total Alkalinity (Total as CaCO3)	2020/12/29	0.28		%	20

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QUALITY ASSURANCE REPORT(CONT'D)

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	UNITS	QC Limits
7128818	EMT	Matrix Spike	Dissolved Chloride (Cl-)	2020/12/31		NC	%	80 - 120
7128818	EMT	Spiked Blank	Dissolved Chloride (Cl-)	2020/12/30		101	%	80 - 120
7128818	EMT	Method Blank	Dissolved Chloride (Cl-)	2020/12/30	<1.0		mg/L	
7128818	EMT	RPD	Dissolved Chloride (Cl-)	2020/12/31	1.4		%	20
7128820	EMT	Matrix Spike	Dissolved Sulphate (SO4)	2020/12/30		NC	%	80 - 120
7128820	EMT	Spiked Blank	Dissolved Sulphate (SO4)	2020/12/30		104	%	80 - 120
7128820	EMT	Method Blank	Dissolved Sulphate (SO4)	2020/12/30	<2.0		mg/L	
7128820	EMT	RPD	Dissolved Sulphate (SO4)	2020/12/30	0.058		%	20
7128822	EMT	Matrix Spike	Reactive Silica (SiO2)	2020/12/29		94	%	80 - 120
7128822	EMT	Spiked Blank	Reactive Silica (SiO2)	2020/12/29		99	%	80 - 120
7128822	EMT	Method Blank	Reactive Silica (SiO2)	2020/12/29	<0.50		mg/L	
7128822	EMT	RPD	Reactive Silica (SiO2)	2020/12/29	4.1		%	20
7128823	EMT	Spiked Blank	Colour	2020/12/30		91	%	80 - 120
7128823	EMT	Method Blank	Colour	2020/12/30	<5.0		TCU	
7128823	EMT	RPD	Colour	2020/12/30	NC		%	20
7128824	EMT	Matrix Spike	Orthophosphate (P)	2020/12/29		94	%	80 - 120
7128824	EMT	Spiked Blank	Orthophosphate (P)	2020/12/29		99	%	80 - 120
7128824	EMT	Method Blank	Orthophosphate (P)	2020/12/29	<0.010		mg/L	
7128824	EMT	RPD	Orthophosphate (P)	2020/12/29	NC		%	20
7128825	EMT	Matrix Spike	Nitrate + Nitrite (N)	2020/12/30		NC	%	80 - 120
7128825	EMT	Spiked Blank	Nitrate + Nitrite (N)	2020/12/30		105	%	80 - 120
7128825	EMT	Method Blank	Nitrate + Nitrite (N)	2020/12/30	<0.050		mg/L	
7128825	EMT	RPD	Nitrate + Nitrite (N)	2020/12/30	1.6		%	20
7128826	EMT	Matrix Spike	Nitrite (N)	2020/12/30		98	%	80 - 120
7128826	EMT	Spiked Blank	Nitrite (N)	2020/12/30		90	%	80 - 120
7128826	EMT	Method Blank	Nitrite (N)	2020/12/30	<0.010		mg/L	
7128826	EMT	RPD	Nitrite (N)	2020/12/30	0.30		%	20
7128860	SHW	Spiked Blank	Conductivity	2020/12/29		98	%	80 - 120
7128860	SHW	Method Blank	Conductivity	2020/12/29	1.3, RDL=1.0		uS/cm	
7128860	SHW	RPD	Conductivity	2020/12/29	0.63		%	10
7128863	SHW	Spiked Blank	pH	2020/12/29		100	%	97 - 103
7128863	SHW	RPD	pH	2020/12/29	1.7		%	N/A
7129016	YLG	Matrix Spike	Total Organic Carbon (C)	2020/12/29		97	%	85 - 115
7129016	YLG	Spiked Blank	Total Organic Carbon (C)	2020/12/29		103	%	80 - 120
7129016	YLG	Method Blank	Total Organic Carbon (C)	2020/12/29	<0.50		mg/L	
7129016	YLG	RPD	Total Organic Carbon (C)	2020/12/29	NC		%	15
7129020	YLG	Matrix Spike	Total Organic Carbon (C)	2020/12/29		99	%	85 - 115
7129020	YLG	Spiked Blank	Total Organic Carbon (C)	2020/12/29		99	%	80 - 120
7129020	YLG	Method Blank	Total Organic Carbon (C)	2020/12/29	<0.50		mg/L	
7129020	YLG	RPD	Total Organic Carbon (C)	2020/12/29	NC		%	15
7129043	SHW	QC Standard	Turbidity	2020/12/29		106	%	80 - 120
7129043	SHW	Spiked Blank	Turbidity	2020/12/29		101	%	80 - 120
7129043	SHW	Method Blank	Turbidity	2020/12/29	<0.10		NTU	
7129043	SHW	RPD	Turbidity	2020/12/29	NC		%	20
7129046	SHW	QC Standard	Turbidity	2020/12/29		105	%	80 - 120
7129046	SHW	Spiked Blank	Turbidity	2020/12/29		98	%	80 - 120
7129046	SHW	Method Blank	Turbidity	2020/12/29	<0.10		NTU	
7129046	SHW	RPD	Turbidity	2020/12/29	2.5		%	20
7130514	EMT	Matrix Spike [OME824-03]	Nitrogen (Ammonia Nitrogen)	2020/12/30		98	%	80 - 120
7130514	EMT	Spiked Blank	Nitrogen (Ammonia Nitrogen)	2020/12/30		100	%	80 - 120
7130514	EMT	Method Blank	Nitrogen (Ammonia Nitrogen)	2020/12/30	<0.050		mg/L	

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QUALITY ASSURANCE REPORT(CONT'D)

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	UNITS	QC Limits
7130514	EMT	RPD [OME824-03]	Nitrogen (Ammonia Nitrogen)	2020/12/30	NC		%	20

N/A = Not Applicable

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

QC Standard: A sample of known concentration prepared by an external agency under stringent conditions. Used as an independent check of method accuracy.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spike amount was too small to permit a reliable recovery calculation (matrix spike concentration was less than the native sample concentration)

NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (absolute difference <= 2x RDL).

VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

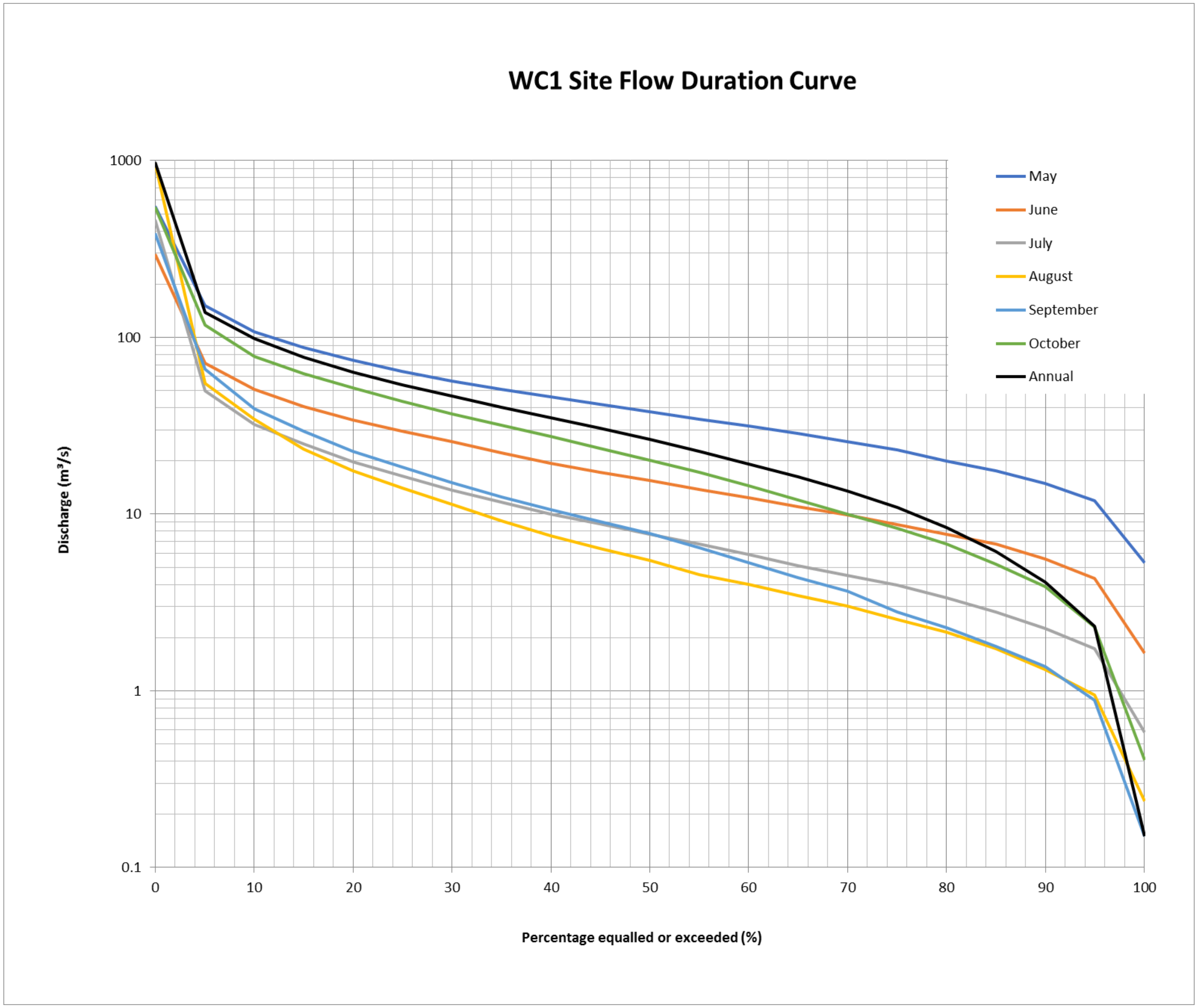
<Original signed by>

Mike MacGillivray, Scientific Specialist (Inorganics)

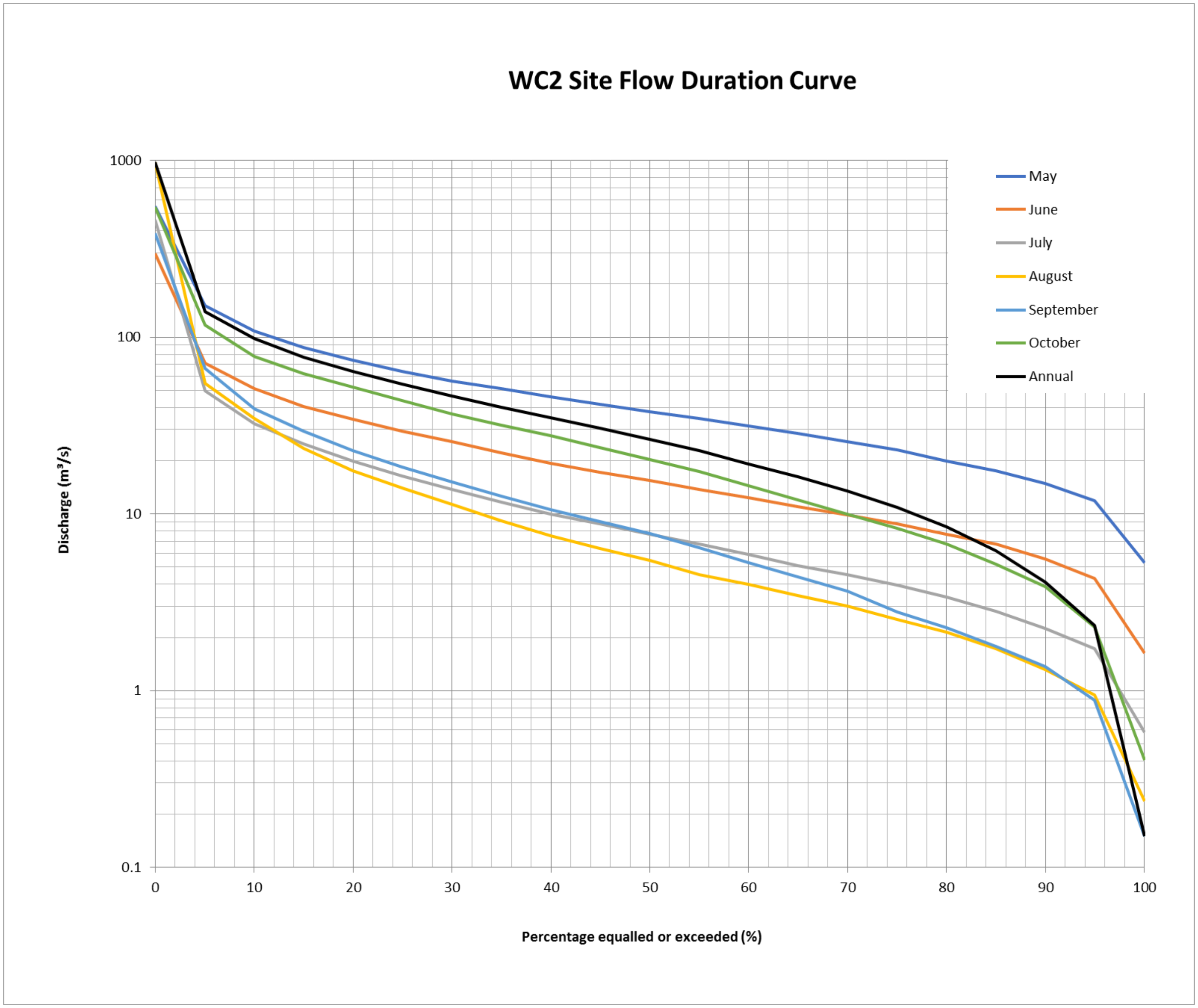
BV Labs has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per ISO/IEC 17025, signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Appendix F

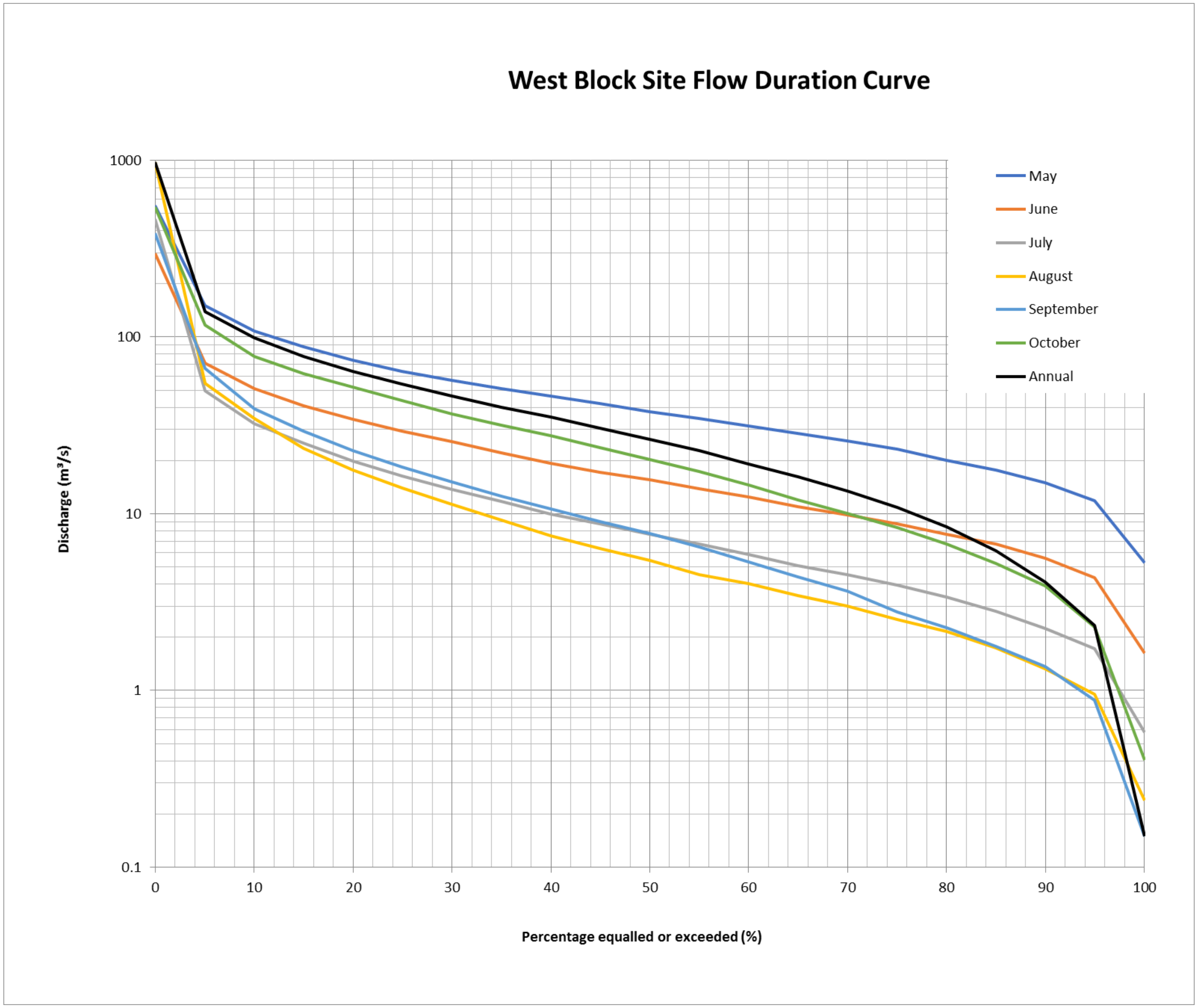
Musquodoboit River Flow Duration Curve Outputs



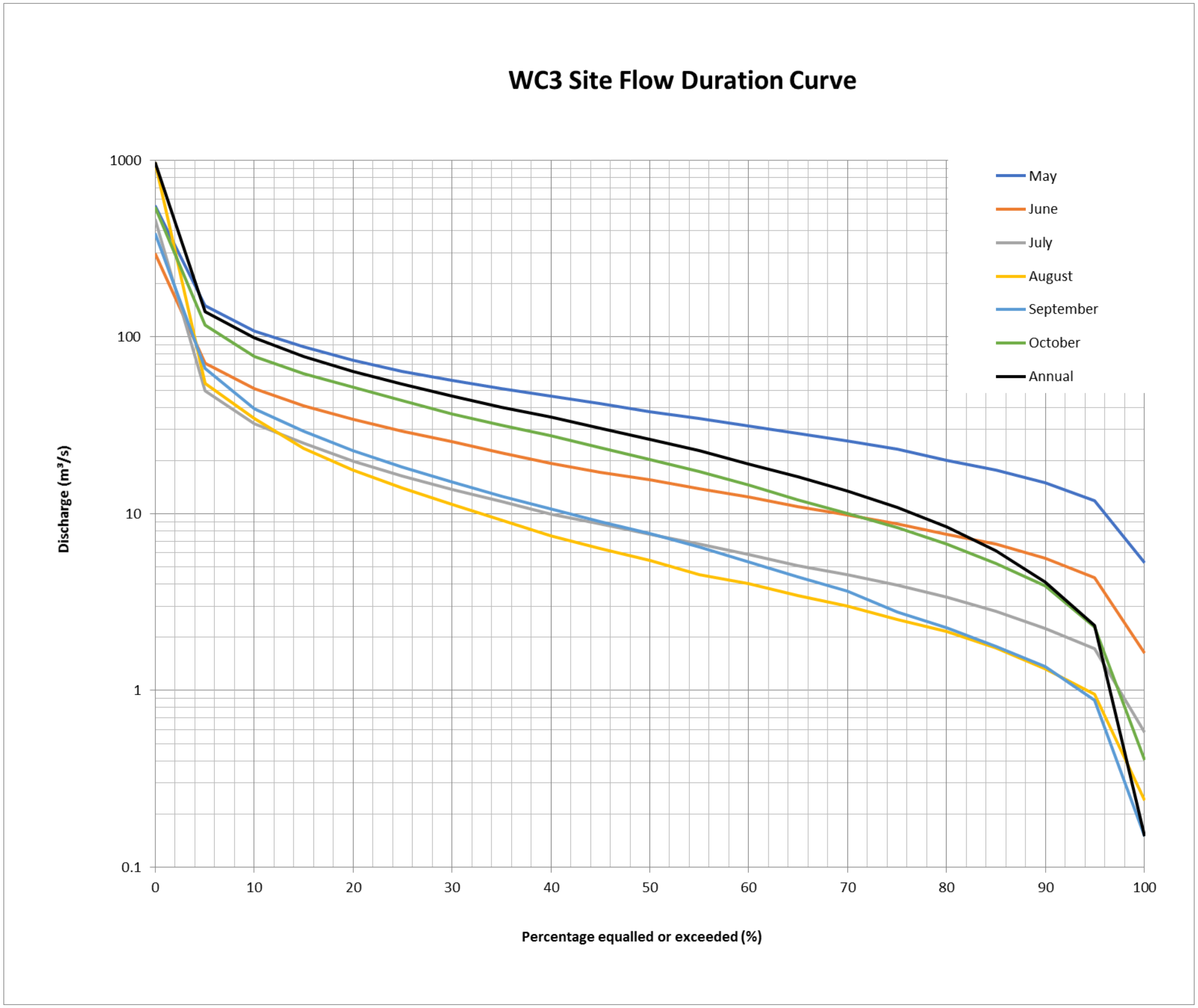
Watercourse WC1 Flow Duration Curve, Musquodoboit River



Watercourse WC2 Flow Duration Curve, Musquodoboit River



Watercourse West Block total Flow Duration Curve, Musquodoboit River



Watercourse WC3 Flow Duration Curve, Musquodoboit River