Ontario Power Generation Inc.

PROPOSED CALABOGIE GENERATING STATION REDEVELOPMENT PROJECT

Aquatic Environment Technical Support Document
Final

March 2020

PROPOSED CALABOGIE GENERATING STATION REDEVELOPMENT PROJECT

Aquatic Environment
Technical Support Document – Final

Prepared for:
Gillian MacLeod
Ontario Power Generation Inc.
700 University Avenue
Toronto, ON M5G 1X6

Prepared by:
Arcadis Canada Inc.
121 Granton Drive, Suite 12
Richmond Hill, Ontario L4B 3N4
Tel 905 764 9380
and
C. Portt and Associates
56 Waterloo Avenue
Guelph, Ontario N1H 3H5

Our Ref.:
30000724-10 (351316-000-00003)

Date:
March 2020

George Coker
Cam Portt
C. Portt & Associates
Lead Author

Phil Shantz
Supporting Author

VERSION CONTROL, OPTIONAL

Issue	Revision No	Date Issued	Page No	Description	Reviewed by

CONTENTS

TABLES

FIGURES

APPENDICES

EXECUTIVE SUMMARY

Ontario Power Generation (OPG) is proposing to redevelop the existing Calabogie Generating Station (GS). Constructed in 1917, the original station had an installed capacity of 5 megawatts (MW). The existing Calabogie GS is over one hundred years old and was at the end of its life prior to the tornado that hit the GS in September 2018. The GS has not operated since that time. OPG intends to redevelop the site and increase the station's capacity to approximately 11 MW.

The proposed Project is located in the Village of Calabogie, Township of Greater Madawaska, Renfrew County, Ontario. The Project involves the demolition of the existing powerhouse and forebay inlet structure and the construction of a new powerhouse with integral intake structure and tailrace. Other ancillary facilities will also be constructed. The Project may also involve the construction of additional sluiceway capacity. This Technical Support Document (TSD) assesses the potential effects of the Project on the aquatic environment.

This TSD provides an aquatic environmental baseline, as well as an assessment of the potential environmental effects of the proposed Calabogie GS Redevelopment Project on the aquatic environment and the recommended mitigation measures to minimize these effects.

During Project construction, potential effects on the aquatic environment may occur due to dewatering, soil erosion causing turbidity and sedimentation in surface waters, waste generation, incidental spills, hazardous materials usage, blasting, in-water construction activities and fish habitat enhancement/creation. Based on assessment of the available baseline information and potential effects, as well as the implementation of the recommended mitigation measures, it is concluded that effects during construction will be minimal, localized and short-term with no adverse residual effects.

During the operation of the proposed Project, potential effects on the aquatic environment may occur due to incidental spills, increased flow through the generation station and commensurately less flow through the south channel spillway, fish habitat loss/gain, and fish entrainment. Based on assessment of the baseline information and potential effects, and implementation of recommended mitigation measured, it is concluded that the operation of the proposed Project will have no adverse residual effects on the aquatic environment.

OPG will provide a detailed assessment of habitat changes associated with the new project as part of the DFO review process. The assessment will account for both temporary and permanent changes and opportunities to balance habitat productivity will be investigated. The goal of the fish habitat design process is to balance the effects from the project so there is a no-net-loss of fish habitat.

The proposed Calabogie Project will not have a negative effect upon the fish communities of the Madawaska River. There will be no significant changes to river conditions upstream or downstream of the plant as a result of the Project with the exception of the South Channel Spillway and the GS forebay and tailrace. Net changes in the area of fish habitat will be minor. More of the total river flow will pass through the forebay, GS and tailrace, and less will pass through the South Channel Spillway. This transfer of flow is expected to result in less extreme flows in the spill channel in high flow years, potentially creating better conditions for spawning Walleye and other spring-spawning fishes (e.g. White Sucker) and will result in zero flow through the spill channel more frequently (i.e. in more years) during the spring spawning season, which will render the area unsuitable for spawning by those same species.. Flow through the South Channel Spillway will be zero for longer each year. This area experiences no flow for part of the year under the current conditions. Most of the area remains submerged due to the backwater effect from downstream and the area effected is primarily bedrock and very large boulders. No significant effect on the fish communities is expected.

OPG is committed to supporting the recovery of American Eel in consultation with Indigenous Peoples and in accordance with provincial recovery strategies and policy direction. On the Madawaska River, there are no known occurrences of American Eel, including at or in the immediate area of Arnprior GS, Stewartville GS and Calabogie GS. Therefore, these facilities are currently compliant with the *Endangered Species Act*. Over time, and as recovery strategies advance and succeed, American Eel may once again be present in the Madawaska River. This will signal that recovery strategies are working. OPG is using this redevelopment project to make the redeveloped Calabogie GS eel ready. Eel ready means that the redevelopment will be planned, designed and executed in anticipation of adaptive management strategies that can be applied to allow Eel passage. The proposed project represents an improvement over the existing situation of a GS that is not able to pass American Eel and therefore represents an overall net benefit.

Environmental protection during proposed Calabogie Project construction and operation will be ensured by adherence to the site-specific Environmental Management Plan, as well as compliance with regulatory standards and guidelines.

The Environment Management Plan ensures that environmental protection will be achieved during construction by describing government agency requirements, proposed Project commitments and recommended mitigation measures to be undertaken. The Environmental Management Plan will include the Erosion and Sediment Control Plan, Spills Emergency Preparedness and Response Plan, Hazardous Materials Management Plan and Waste Management Plan.

During operation, environmental protection will be achieved by adherence to the Spills Emergency Preparedness and Response Plan and the Calabogie River System WMP, deployment of public safety measures and environmental monitoring.

1 INTRODUCTION

1.1 Regulatory Framework

In Ontario, proposed waterpower facilities are subject to the *Environmental Assessment Act* (*EA Act*). The Ontario Waterpower Association (OWA, 2018) developed the Class Environmental Assessment for Waterpower Projects (OWA Class EA) process which was approved by the Ontario Minister of the Environment and the Lieutenant Governor in Council in 2008. The *EA Act* formally recognizes the OWA Class EA process which outlines the requirements for Environmental Assessment (EA) approval. The proposed Calabogie Station Re-Development Project (CSRP) is being carried out according to the eighth edition of the OWA Class EA.

Under the OWA Class EA, the proposed CSRP is classified as a "Project Associated with Existing Infrastructure". Provided the requirements of the OWA Class EA planning process are met and a Part II Order request for a "bump-up" to an Individual EA is not made (or denied), a project is considered approved under the *EA Act*.

1.2 Other Environmental Approvals

Other permits, approvals and clearances will be sought as the proposed Project moves into the construction stage. Section 7.2.4 and Table 7.2 of the Environmental Report (ER) identify a range of possible approvals required during construction and or operations; however, specific permits and approvals will likely be required under the provincial *Lakes and Rivers Improvement Act* (*LRIA*), *Environmental Protection Act* (*EPA*) and *Ontario Water Resources Act* (*OWRA*).

1.3 Overview of the Aquatic Technical Support Documents

This Aquatic Technical Support Document (TSD) is the product of several years extensive study and consultation C. Portt & Associates. The ER and the associated TSDs were prepared by Arcadis Canada Inc. with the assistance of Ontario Power Generation (OPG), KGS Group and SNC-Sullivan.

Data sources used to document the existing environment included published and unpublished literature, government files, personal interviews and field studies. Where possible, existing data sources were used; however, extensive field studies were required to complete the study.

This Aquatic TSD is organized into five chapters:

- Chapter 1.0 – introduces the proposed Project, outlines the EA process and other environmental approvals, and lays out the various chapters;
- Chapter 2.0 – provides a detailed project description;
- Chapter 3.0 – provides a description of the existing aquatic environment;
- Chapter 4.0 – provides an overview of aquatic effects and mitigation measures during construction and operations, and discusses the significance of effects;

- Chapter 5.0 – provides the summary and conclusions;
- Chapter 6.0 – provides references;
- Chapter 7.0 – provides the acronyms and abbreviations; and,
- Chapter 8.0 – provides the glossary.

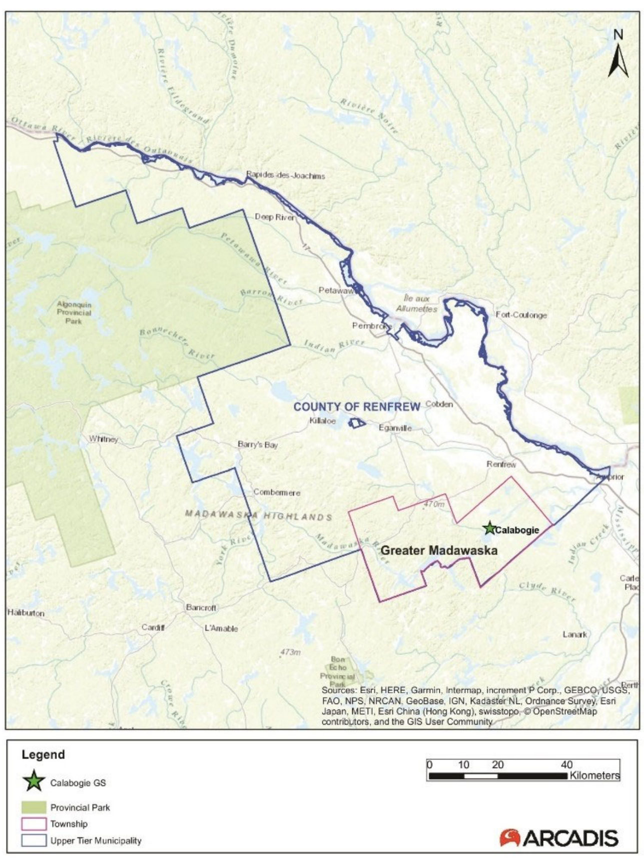
2 PROJECT DESCRIPTION

Ontario Power Generation (OPG) is proposing to redevelop the existing Calabogie Generating Station (GS). Constructed in 1917, the original station had an installed capacity of 5 megawatts (MW). The existing Calabogie GS is over one hundred years old and was at the end of its life prior to the tornado that hit the GS in September 2018. The GS has not operated since that time. OPG intends to redevelop the site and increase the station’s capacity to approximately 11 MW. The Project involves the demolition and removal of the existing powerhouse and its structures including the forebay retaining walls and the forebay inlet structure and the subsequent construction of a new powerhouse and forebay embankment, with integral intake structure and tailrace. The Project will be constructed by a joint venture consisting of SNC-Lavalin and M. Sullivan and Son (the Contractor). OPG is advised by KGS Consultants (the Owner’s Engineer) and Arcadis (the Environmental Consultant).

2.1 Project Location

The existing Calabogie GS is located within the Village of Calabogie, in the municipality of Greater Madawaska, Renfrew County, Ontario (Figure 2-1). It is located approximately 80 km northwest of Ottawa and 20 km southwest of Renfrew.

Figure 2-1. Location of the Calabogie Generating Station



The Calabogie GS, located on the Madawaska River is approximately 10 km downstream of Barrett Chute GS and 20 km upstream of Stewartville GS, both OPG-owned hydroelectric facilities. Calabogie GS is part of OPG's Eastern Operations Group. The location of Calabogie GS relative to OPG's hydroelectric facilities on the Madawaska, Ottawa and St. Lawrence Rivers is shown on Figure 2-2.

Figure 2-2. Calabogie Generating Station within OPG's Eastern Operations

Source: https://www.opg.com/building-strong-and-safe-communities/our-communities/eastern-ontario/

2.2 Existing Calabogie Generating Station

2.2.1 History and Operations

Calabogie Generating Station was constructed in 1917 with an installed capacity of 4 MW utilizing two quadruple-Francis horizontal turbines operating at a gross head of just under 9 metres. With a maximum total turbine outflow of 66 cubic metres per second (cms), and only limited storage available in Calabogie Lake, the plant is significantly undersized in comparison to either typical mean flows or to both the upstream and downstream hydroelectric stations on the river, which have daily peaking flows up to 458 cms. Over the last 50 years several studies have investigated redeveloping the site or increasing generation at the existing plant.

As noted in the 2009 Madawaska River Water Management Plan:

> *"The Calabogie GS operates as a peaking plant in conjunction with the four other OPG owned GS on the Madawaska River. Although the generating units at the station have limited flow capacity, the units and sluice gates are integrated with the rest of the peaking system on the Madawaska River. Calabogie is a generation bottleneck on the Madawaska River. The small turbine capacity results in frequent spill past the station.*
>
> *The operation of the GS is based on a daily/weekly cycle. The inflow is passed through the GS over a daily or weekly period. Operation of the GS takes into consideration energy demands, recreational opportunities as well as walleye spawning activities."*

The average historical inflow for the period between 1965 and 2017 at Calabogie is approximately 90 m^3/s with a median of 72 m^3/s. The flow duration curve and historic daily discharge record is presented below.

Figure 2-3. Calabogie Flow Duration Curve 1968 – 2018

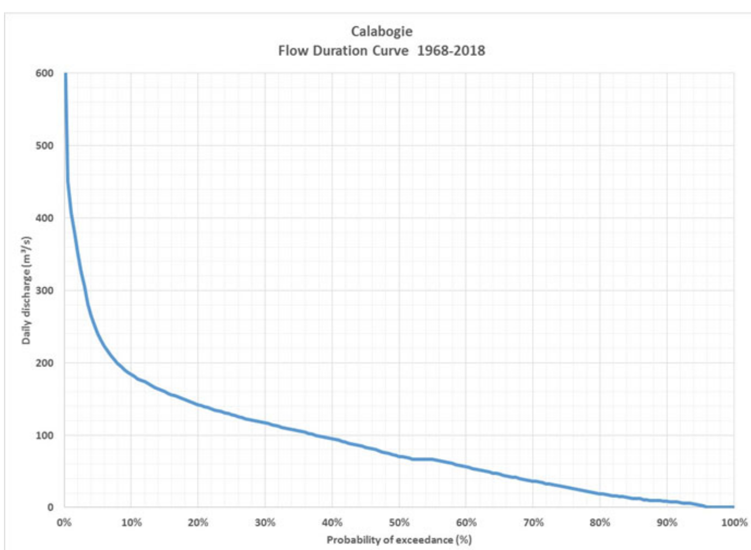
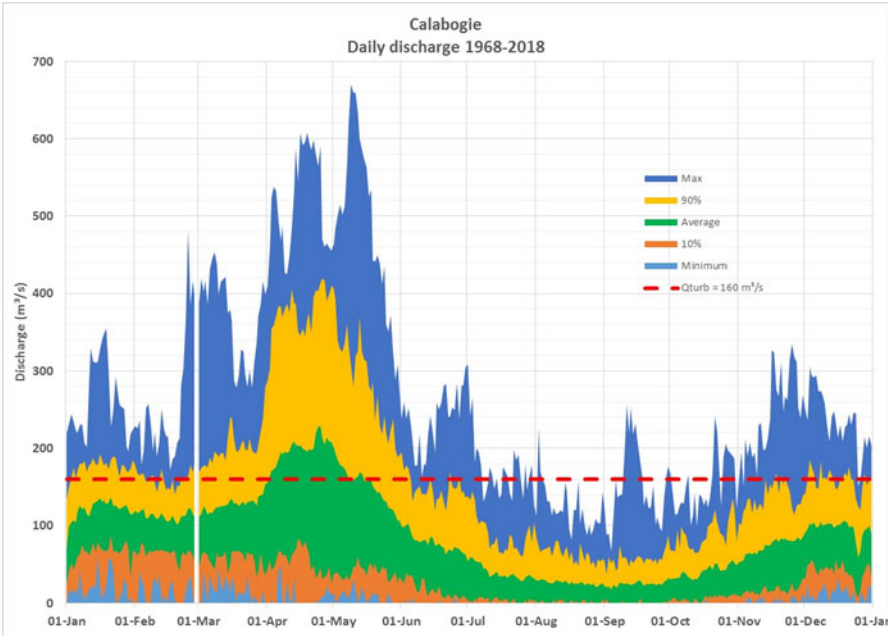


Figure 2-4. Calabogie Daily Discharge 1968 – 2018



The existing Calabogie GS is considered at end of life and OPG intends to redevelop the site with an increased capacity in order to take advantage of the existing water resources.

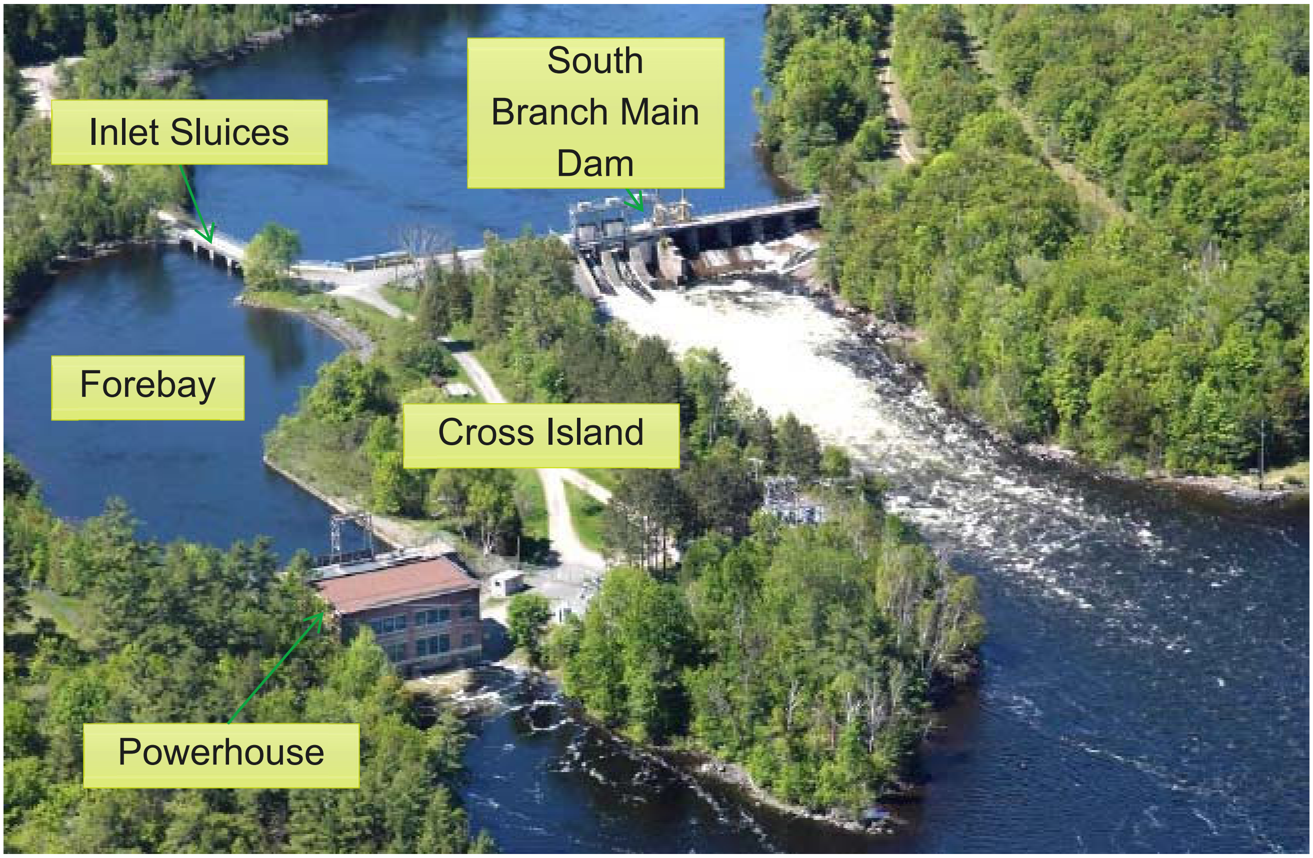
In September 2018, a tornado swept through the Calabogie area that resulted in significant damage to the GS. OPG began immediate repairs to the sluiceway to make it operable but the powerhouse roof was removed, rendering it unsafe. Calabogie GS has not operated since that time and will not be returning to services until completion of the redevelopment project.

2.2.2 Description of the Existing Calabogie Generating Station

While OPG intends to re-develop the power production component of the Calabogie GS, most of the other features and equipment at the site pertaining to water management will remain as is. Figure 2-5 below shows an aerial image of the Calabogie GS and key surrounding features. Figure 2-6 is a colour air photo focusing on the south branches of the River including the South Branch Main Dam.

Figure 2-5. Calabogie Generating Station Site Map

Figure 2-6. Calabogie Generating Station Colour Air Photo: Inlet, South Dam and PowerHouse



As shown in Figure 2-5, the Madawaska River immediately downstream of Calabogie Lake is characterized by three separate channels.

The northernmost channel is the North Channel that connects directly to Calabogie Lake. The North Channel is a natural river channel with flows controlled by the North Channel Sluiceway (owned and operated by OPG). The North Channel is not used for regular water management operations, however there is a compliance minimum flow of 0.8 cms. This flow has not been measured since the replacement of the wooden stop logs with steel stop logs. The 0.8 cms is an estimated flow. During the walleye spawn and incubation period the minimum flow is 5 cms subject to temperature conditions (described in more detail in Table 9.16 of the Madawaska River Water Management Plan).

The middle channel of the Madawaska River is the South Channel Sluiceway. This is the channel used to control the water management operations along with the Calabogie GS. There is no minimum flow requirement in the South Channel Sluiceway.

The southernmost channel of the Madawaska River is the forebay, powerhouse and tailrace of the existing and proposed GS. It is believed that this channel was excavated at the time of the original GS construction.

The Calabogie GS powerhouse is situated about 800 metres downstream of the outlet at Calabogie Lake.

As shown in Figure 2-5, two islands were formed by the three channels in this reach of the Madawaska River, the southern island (Cross Island) which is shown in greater detail and in full in Figure 2-6 and the larger northern island (Calabogie Island).

Cross Island is the hub of the Calabogie GS. It is accessed via Generating Station Lane, a private OPG owned gravel road that is accessible from Lanark Road, which is also known as Renfrew County Road 511 (formerly Highway 511). This road follows the southern channel of the River and then crosses over the entrance to the forebay. The OPG Bridge/Inlet Structure in this location serves two purposes: it first acts as a bridge to Cross Island; and second, it also integrates the inlet structure to the forebay with several sluices that control water flowing to the existing powerhouse. Cross Island also includes a trailer that serves as an office and washroom facilities. A Hydro One Networks Distribution Station (Calabogie DS) is also located on the island and connects to the powerhouse. Except for the eastern tip, Cross Island is largely cleared of trees. Along with all the infrastructures mentioned above, Cross Island included a cul-de-sac type road with parking areas and grassed areas for storage of equipment and materials. The tornado of September 2018 snapped a large percentage of the remaining trees on the island, which were subsequently cleared by OPG.

As shown in Figures 2-5 and 2-6 the South Branch Main Dam connects Calabogie and Cross Islands. The South Branch Main Dam provides the primary water management function at the GS and water in excess of the powerhouse discharge is passed through the dam.

Calabogie Island was also impacted by the September 2018 tornado, but the Island remains largely forest covered. The Island can be accessed by foot across the South Branch Main Dam or by vehicle on an OPG owned private gravel road that is also accessible from County Road 511. Near the South Branch Main Dam, and south of it, the Island has been disturbed by the dam construction and on-going operations. Calabogie Island is also bisected by HONI's connection line to the Calabogie GS. OPG maintains a boat launch with access to the Madawaska River downstream of the South Branch Main Dam sluiceway. The boat launch allows for operations and maintenance activities that need to occur by water on the downstream side of the facility.

Figure 2-5 also shows safety booms placed and maintained by OPG on both the upstream and downstream sides of the River.

2.3 Alternatives Analysis

Over the last 50 years several studies have investigated redeveloping the site or increasing generation at the existing plant. Studies from 1960 through to 2016 considered refurbishment and expansion of the existing plant or complete replacement with generating capacities that ranged from approximately 6 MW to 15 MW.

The latest plant redevelopment options were optimized through a multi-stage refinement process, with an initial optimization by KGS Group for OPG, followed by more detailed project refinement by the Contractor. While numerous alternatives were considered through the re-development process, three primary alternatives emerged for final consideration. These were:

- Alternative #1 – Refurbishment of the existing powerhouse with minimal civil work.
- Alternative #2 – Refurbishment, expansion and redesign of the existing powerhouse.
- Alternative #3 – Construction of a new powerhouse.

Based on the analysis completed, Alternative #3 was selected as the preferred alternative to complete the Calabogie GS redevelopment. Alternative #3 will make best use of the available water resource at site and will result in the highest estimated annual energy generation. It also better addresses qualitative risk factors than the other alternatives.

Some of the qualitative benefits of this alternative over the other two included the following:

- Alternative #3 allows for the largest addition of green, carbon free capacity and energy to OPG's portfolio. This aligns with OPG's Strategic Direction.
- Alternative #3 is better equipped to manage the possibility of higher water quantities that are expected with future climate change.
- Alternative #3 allows for the safe removal of hazardous materials in the existing powerhouse, including, but not limited to, lead paint and asbestos. The new powerhouse will be free of these designated substances.
- Alternative #3 utilizes traditional turbine equipment, of which OPG has extensive operating experience.
- Alternative #3 with its larger plant flow capacity makes better use of available water in the Madawaska River to use more efficiently the resource and generate more energy and hydroelectric power.
- Alternative #3 with a new powerhouse allows the constructors to optimize design for constructability.
- Alternative #3 allows for optimal design to ensure accessibility and modern equipment. Alternative #3 will also be entirely new, leading to higher degree of reliability of operation with potentially less forced outages due to failures in the immediate future. Following the tornado of September 2018, significant damage occurred to the powerhouse rendering it inoperable and unsafe. Given that Alternative 3 will demolish the existing station, only minimal safe state investment is required to ensure safety and mitigate the risk of environmental spills/releases.

As the above analysis indicates, the preferred option is to construct a new powerhouse together with associated ancillary features. The existing water control facilities for both the north and south channels has been recently upgraded and is not considered part of this project.

2.4 General Layout and Description

2.4.1 General Layout

A new powerhouse will be constructed, approximately 50 metres upstream of the existing powerhouse within the existing forebay. The existing powerhouse will be demolished. The new station will have two horizontal-axis Kaplan type turbines and be rated at approximately 10.7 megawatts while both units are running. Implementation of this alternative will involve the following:

- Construction of a new powerhouse with all new turbine generator equipment.
- Removal of all existing power equipment and demolition of the existing powerhouse.
- Removal of the inlet structure to the forebay and widening of the inlet section, along with excavation in the forebay and tailrace, to allow for increased flow conditions.
- Construction of a new substation and interconnection to the existing transmission line.

The new powerhouse location was selected to be upstream of the existing powerhouse in the forebay to optimize the increased station flow and hydraulic conditions.

The re-developed GS will have the following characteristics:

- Effective Capacity of 10.7 MW;
- Estimated Annual Energy Generation with 98 % of availability – (on the order of 44 GWh to 47 GWh depending on operation);
- Number of Units – 2 horizontal turbines capable of producing approximately 5.4 MW each;
- Station Flow – 160 m^3/s;
- Minimum Operating Flow – 20 m^3/s;
- Average Annual Flow – 90.5 m^3/s; and
- Average head of 8.6 m (range of 6.6 m to 9.9 m).

The proposed site plan for the new GS is shown below in Figure 2-7, while the powerhouse arrangement is presented in Figure 2-8. As already described, the proposed new powerhouse will be located in the forebay approximately 50 metres upstream of the existing one. The proposed undertaking will remove the current bridge and inlet structure over the forebay with access to the new powerhouse and existing sluiceway provided on the east side of the forebay.

Figure 2-7. Proposed Site Plan for the Calabogie GS

Figure 2-8. Proposed Powerhouse Arrangement for Calabogie

2.4.2 Construction Sequencing

The construction of the new GS will be undertaken sequentially in the following stages as shown below.

Stage #1

In Stage #1 of the demolition and construction, the construction facilities and laydown areas will be set up, site trailers mobilized, access roads upgraded where necessary and the rock and overburn stockpile areas cleared. As of the fall of 2019, the existing inlet structure (located at the bridge) has been closed and the existing forebay channel de-watered. The following summer, the forebay sediment, soil and rock will be excavated in the dry for construction of the new intake forebay channel and new powerhouse substructure. During this time the existing powerhouse will be used as a downstream cofferdam.

While the existing powerhouse overburden is excavated out, hazardous material abatement will be completed within the existing powerhouse. The existing equipment will be removed, preparing for the powerhouse superstructure to be demolished. Throughout all stages of demolition, hazardous and recyclable materials will be separated from general waste and any potential waste requiring specialized treatment.

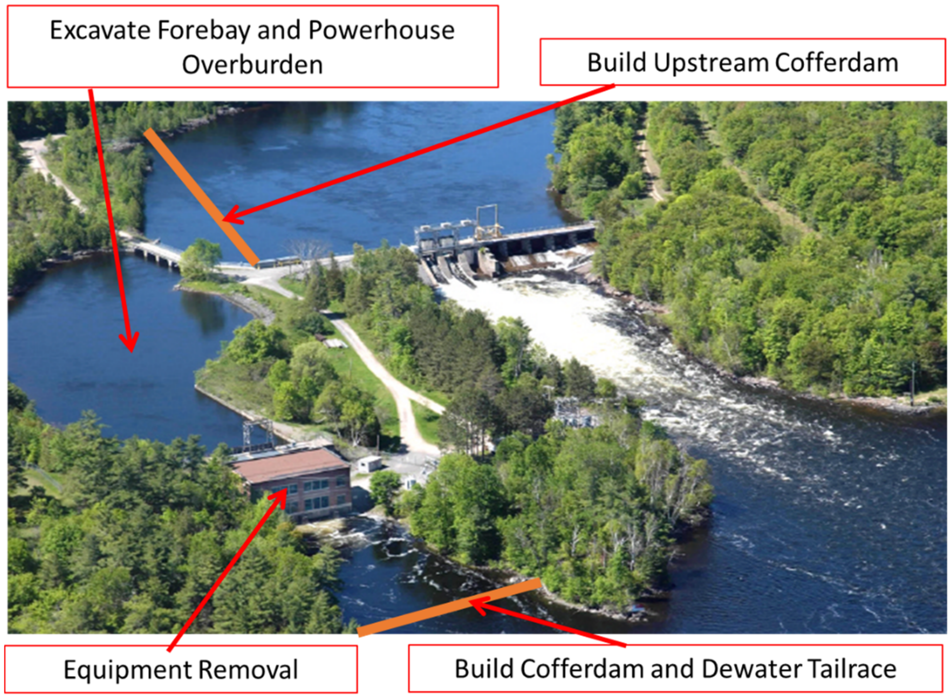
Prior to demolition of the existing Powerhouse, a cofferdam will be constructed downstream of the existing powerhouse and the existing tailrace de-watered. At the same time the downstream cofferdam is constructed, an upstream cofferdam will be constructed upstream of the inlet structure. The section between the upstream cofferdam and the inlet structure will be dewatered allowing overburden excavation to continue preparing for the rock excavation in Stage 2.

The existing inlet structure/sluices will allow the forebay to be isolated and excavation work to begin in the forebay at the start of construction. Following the July 15th fish window, the cofferdam will be constructed upstream of the inlet structure (as shown in Figure 2-9) to allow for removal of the existing inlet structure in the dry and rock excavation to continue. The upstream cofferdam will be constructed from blasted rock that has been excavated to accommodate the new powerhouse. Clean blast rock will be used to construct a 5.8 metres wide cofferdam, with a slope of 1.5H:1V up to elevation 155.17 masl. The upstream face of the cofferdam will be lined with a heavy-duty cofferdam membrane and sealed to the riverbed with a bentonite clay seal. Upon completion of the powerhouse, the liner, blasted rock and overburden will be removed, and the channel will be graded with rockfill.

The downstream cofferdam is required to isolate the downstream side of the construction and allow for the demolition of the existing powerhouse and construction of the new powerhouse and tailrace. The proposed cofferdam is a rockfill dam with an impervious geomembrane on the water side of the cofferdam. Seepage through the cofferdam will be collected and directed to a settling pond prior to discharge back into the river.

The bed material in the area where the downstream cofferdam will be constructed is primarily cobble/boulder/gravel across the main channel with some sand/gravel/cobble and bedrock/boulder/cobble distributed proximate to the river bank.

Figure 2-9. Work Sequence – Stage #1 – Excavation, Removals and Cofferdam Construction

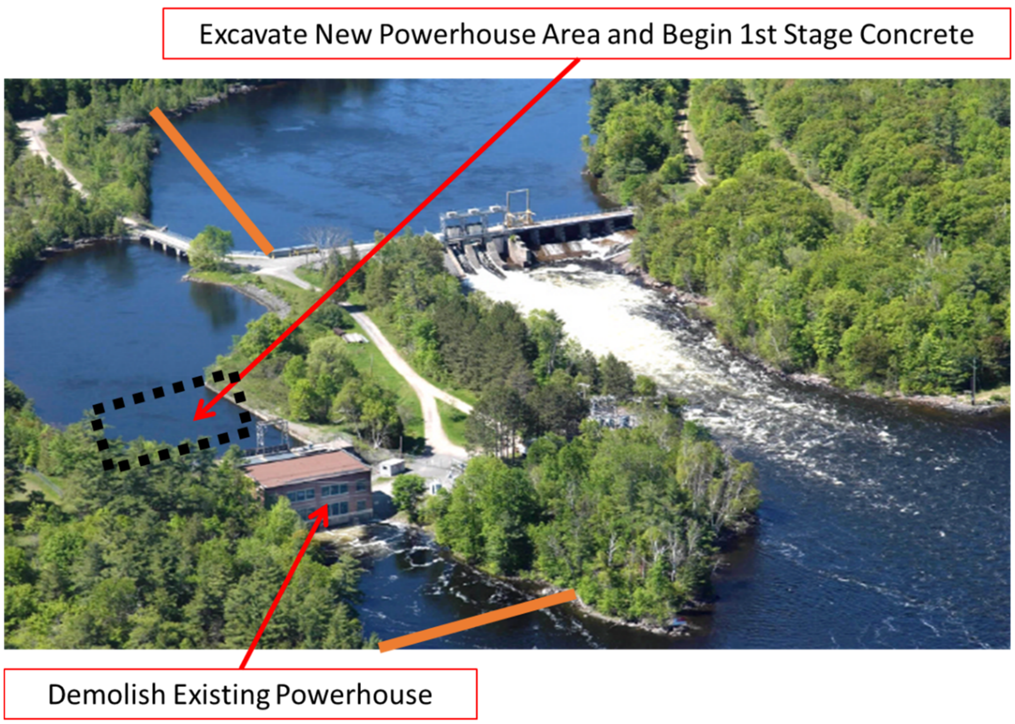


Stage #2

In Stage #2 the existing powerhouse superstructure will be demolished, followed by the existing powerhouse concrete substructure. Rock excavation for the foundation of the new powerhouse will be completed and the left embankment works will start.

Hazardous and recyclable materials will continue to be separated from general waste and any potential waste requiring specialized treatment. First stage concrete work will begin for the new powerhouse and the new embankments within the forebay and downstream of the existing forebay inlet structure will be constructed.

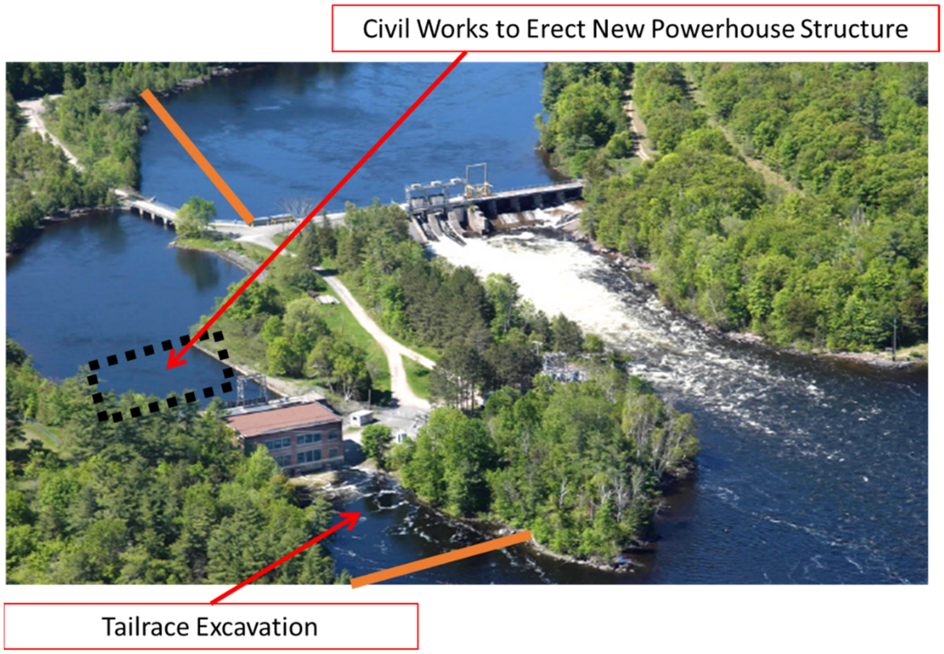
Figure 2-10. Work Sequence – Stage #2 – Powerhouse Demolition and Excavation of New Powerhouse



Stage #3

In Stage #3, the new powerhouse construction will include the remainder of 1st stage concrete works for the new powerhouse, installation of the embedded parts for hydro-mechanical equipment including gates and stoplogs, secondary concrete works, construction of the powerhouse superstructure, installation of the powerhouse crane and enclosure of the powerhouse. On the downstream side, the tailrace will be excavated down to the new elevation. The new substation equipment installation will commence, and the existing substation will be removed.

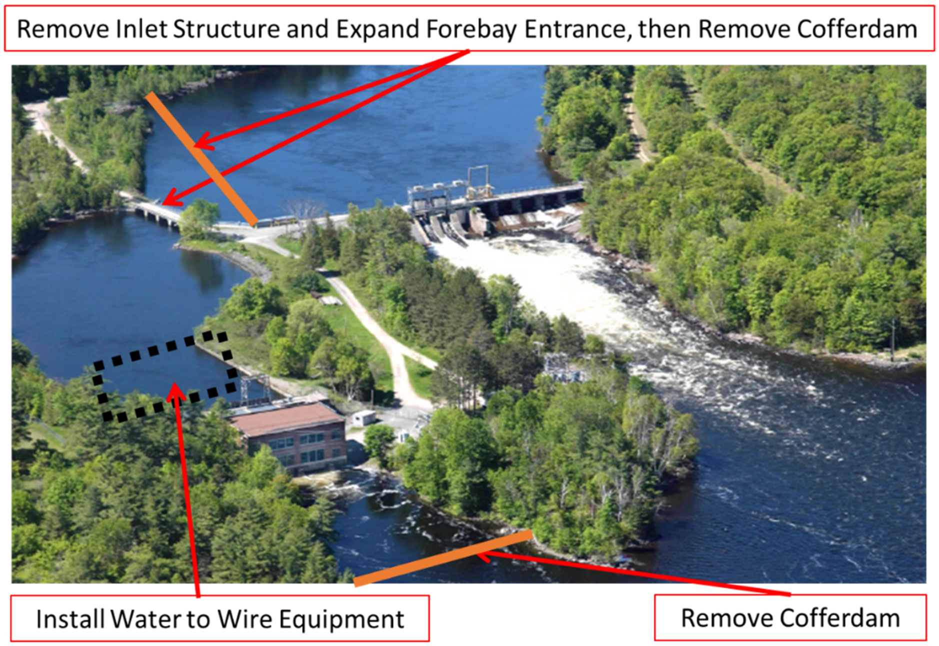
Figure 2-11. Work Sequence – Stage #3 – Construct Powerhouse and Excavate Tailrace



Stage #4

In Stage #4 the associated mechanical and electrical components for the Water to Wire turbines and generators will be installed as well as the balance of plant equipment. Sufficient work will have been completed in the new forebay and new tailrace. The entrance to the new forebay channel will have been widened to improve flow conditions to the new powerhouse and the tailrace will have been excavated as such to produce the required flow conditions specified. Once the existing forebay inlet structure is demolished and removed, the upstream and downstream cofferdams will be removed, and the systems commissioned.

Figure 2-12. Work Sequence – Stage #4 – Remove Inlet Structure and Cofferdams, Finish Powerhouse Installation



Stage #5

In Stage #5 the new units for the GS will be tested, commissioned and finally, put into commercial operation and transferred to OPG for operation.

Figure 2-13. Work Sequence – Stage #5 – Commission New Generating Station

2.4.3 Major Components

2.4.3.1 Forebay and Intake

Once the existing forebay inlet structure is removed, the forebay inlet will be slightly widened (by approximately 20 to 25 m) in order to improve the hydraulic conditions of the flow to the GS. The anticipated change to the forebay inlet is shown in Figure 2-8.

The existing forebay is shallow and contains simple fish habitat (this was defined as 'simple' due to the absence of shoreline features, bathymetric complexity, absence of aquatic macrophytes or coarse woody debris, and the absence of any unique or limiting habitat) and is shown in Figure 2-14 below.

Figure 2-14. Existing Forebay Substrate

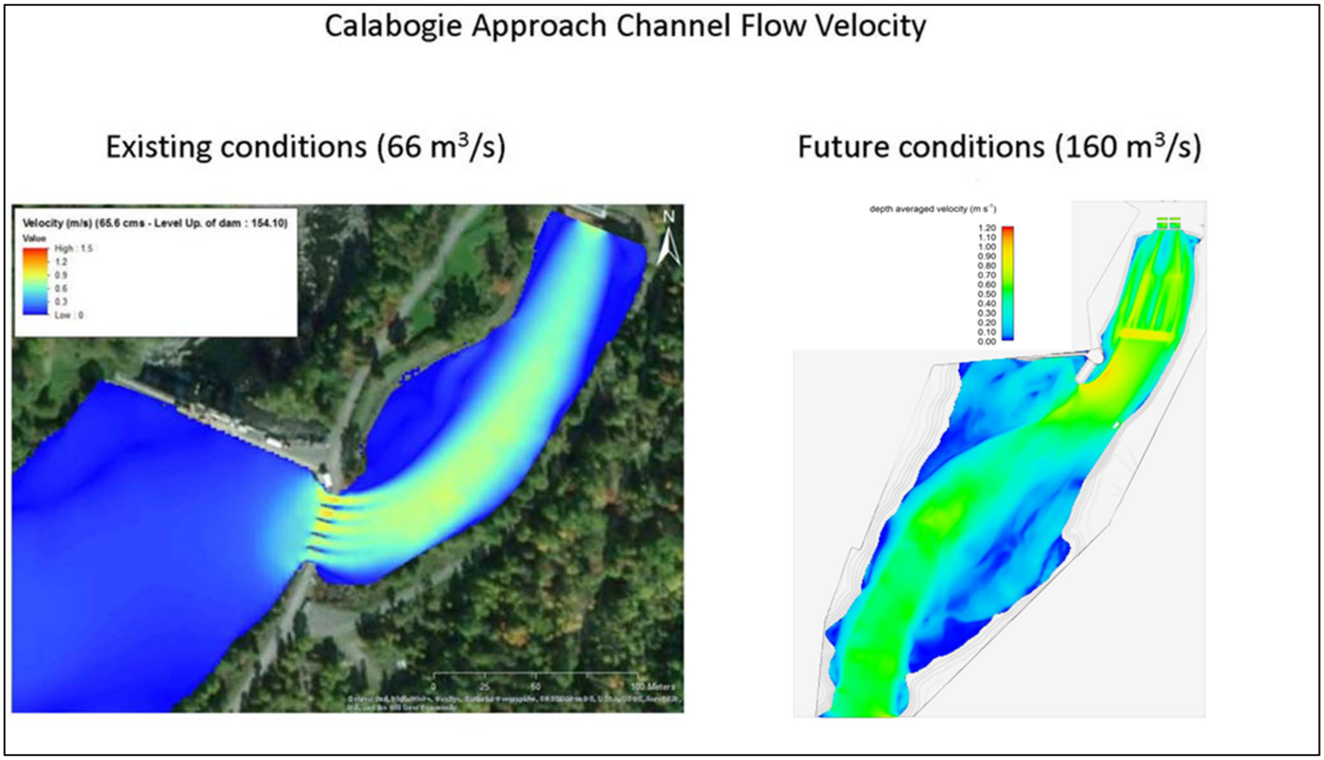
Sediment, soil and excavated rock will be removed from the existing forebay to also improve flow and to allow for construction of the new GS. Forebay hydraulic optimization has dictated the extent of excavation upstream of the new powerhouse. Bedrock will be excavated in vertical cuts and overburden will be sloped and protected against erosion and sloughing. The new intake will have training walls on either side of it to contain the new embankments away from the intake structure. Upon completion of the forebay channel, the embankments will be provided with suitably sized rock protection to ensure bank stability against the forces of erosion and ice action.

The new powerhouse intake will be integrated with the new powerhouse and will be constructed of reinforced concrete. The intake will be equipped with trashracks, suitably sized and with bar spacing to mitigate in as much as possible, fish entrainment. The trashracks will cover the complete area of the turbine water passage intakes. The new trashrack bar spacing will remain consistent with the trashrack spacing at the existing Calabogie GS, with 50 mm clear space between the trashrack bars.

The new trashracks will be periodically cleaned with rakes as well as using mobile crane, with space provided on the intake deck for a future trash rack cleaning machine, however, a trash rack cleaning machine will not be provided at this time. The trashrack slots will also be used interchangably for stoplogs, to provide a means to perform periodic inspections and eventual repairs and servicing of the downstream emergency closure gates in the future. The intake will also include emergency close vertical lift intake gates operated from the intake deck.

The intake and the trashrack of the new powerhouse have been designed to minimize potential entrainment of fish with a trashrack velocity of less than 0.9 m/s (at a distance of 75 mm in front of screen). While the future conditions will increase the plant flows through the new powerhouse from 66 m^3/s to 160 m^3/s, the velocities in the approach channel will be similar with velocities under 1 m/s as demonstrated by numerical flow modelling and as shown in Figure 2-15.

Figure 2-15. Comparison of Velocities – Existing and Proposed GSs



As shown above the proposed velocities in the approach channel at full flow are generally under 1 m/s and will vary along and across the channel between 0.25 and 1.0 m/s.

2.4.3.2 Powerhouse

The proposed new powerhouse will be situated approximately 50 metres upstream of the existing one. The powerhouse will be approximately 25 metres by 45 meters structure and will be 28 metres tall from the invert of the excavation to the top of the superstructure roof. The powerhouse will be excavated to a depth of approximately 12 metres to allow for proper submergence settings of the turbines. Hydraulic passages, both upstream and downstream of the units, will be appropriately sized to maintain machine performance.

It is currently anticipated that the powerhouse structure will be comprised of a cast-in-place concrete substructure and a metal clad steel superstructure. The switchyard will be constructed in close proximity to the new powerhouse on the left side of the new structure. Parking and a laydown area will also be provided in the same general vicinity.

2.4.3.3 Turbines

As previously indicated, the powerhouse will include the installation of two horizontal-axis Kaplan type turbines. Specifically, the turbines will be installed in an open pit, direct drive configuration. Each turbine will be capable of producing approximately 5.4 MW for a combined total capacity of 10.7 MW. The station will be capable of passing a flow of 160 cms with a minimum operating flow of 20 cms. Each turbine runner will have four blades and will operate at 156.5 rpm.

2.4.3.4 Tailrace

The existing channel downstream of the new powerhouse will be excavated to form the new tailrace. This new tailrace will be similar in width to the existing one as shown in Figure 2-8. A series of Figures below portray the existing and proposed tailrace hydraulic conditions (i.e. velocities) under various flow conditions.

The new tailrace channel is anticipated to be in the order of 25 m wide and will connect the powerhouse within the downstream river reach. The upstream portion of the tailrace channel (between the new powerhouse and the existing powerhouse) will be excavated in overburden for the first 5 to 7 m and in bedrock below. The downstream portion of the channel (downstream of the new powerhouse) will be excavated mostly in rock. Limited overburden excavations are expected in this portion of the channel. Bedrock will be excavated in vertical cuts and overburden will be sloped and protected against erosion and sloughing. For the purpose, the area will be dewatered using a downstream cofferdam.

Figures 2-16 and 2-17 depict the existing and proposed Calabogie GS Tailrace hydraulic conditions with no flow (velocity scale (meters per second) is shown in the bottom right of each figure).

Figures 2-18 and 2-19 depict the existing and proposed Calabogie GS Tailrace hydraulic conditions at flows of 66 cms, which is the capacity of the existing powerhouse. These two figures demonstrate that at this flow rate the proposed new powerhouse will eliminate the areas of high velocity that occur under the existing situation and instead disperse more moderate velocities over a wider area.

A tailrace water level survey program will be completed during the detailed design phase of the project to further define the hydraulic conditions downstream of the Calabogie site.

Figure 2-16. Existing Calabogie GS Tailrace Hydraulic Conditions. No Flow

Figure 2-17. Future Calabogie GS Tailrace Hydraulic Conditions. No Flow

Figure 2-18. Existing Calabogie GS Tailrace Hydraulic Conditions. 66 cms Flow (no spill)

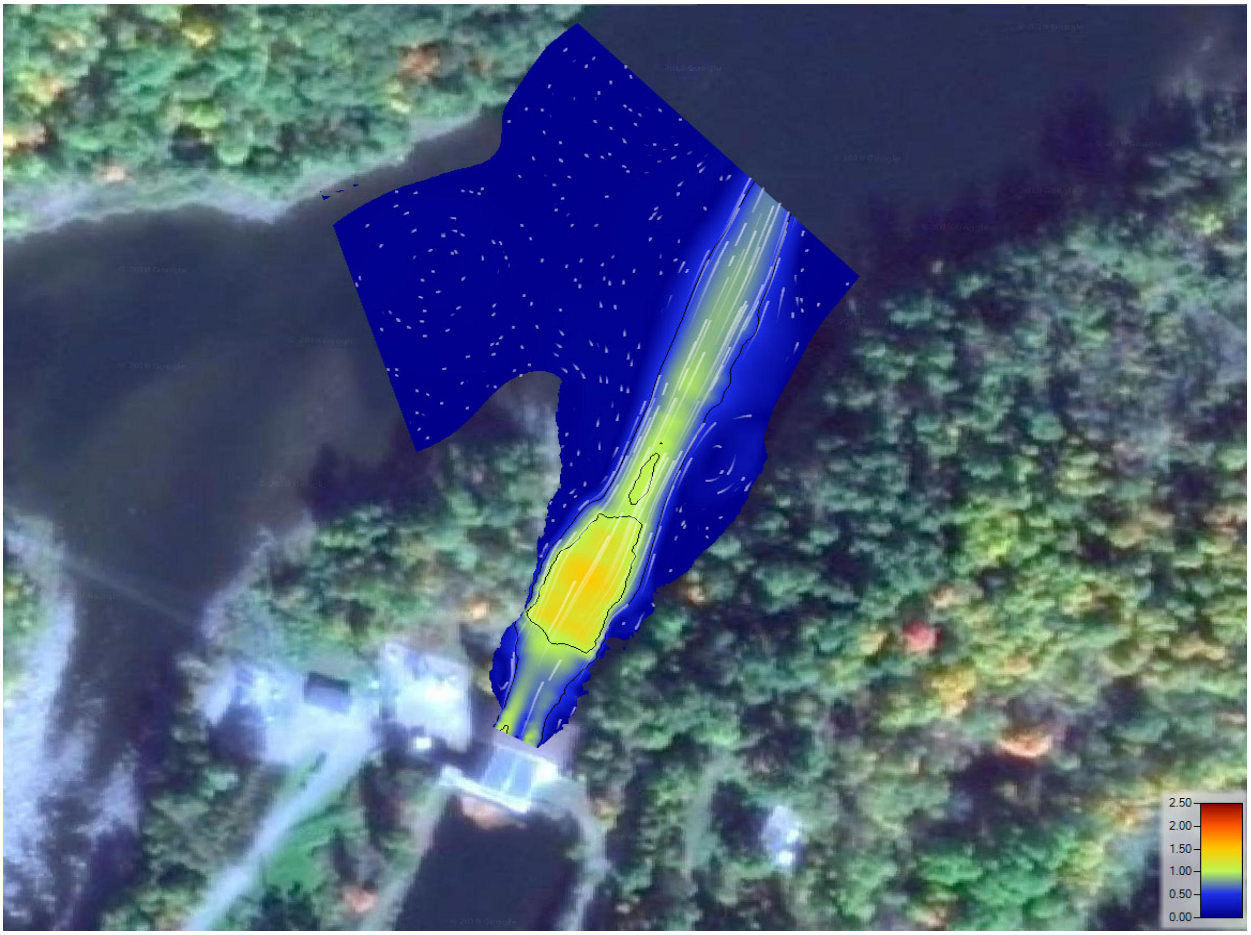


Figure 2-19. Future Calabogie GS Tailrace Hydraulic Conditions. 66 cms Flow (no spill)

Figures 2-20 and 2-21 depict the existing and proposed Calabogie GS Tailrace hydraulic conditions at flows of 160 cms, which is the capacity of the proposed powerhouse. Figure 2-20 representing the existing conditions shows moderate flows at both the tailrace and to a lesser extent through the South Branch Main Dam. Figure 2-21 shows higher velocities through the central portion of the tailrace.

Figure 2-20. Existing Calabogie GS Tailrace Hydraulic Conditions. 160 cms Total Flow: 66 cms Flow through Powerhouse and 94 cms through the South Branch Main Dam

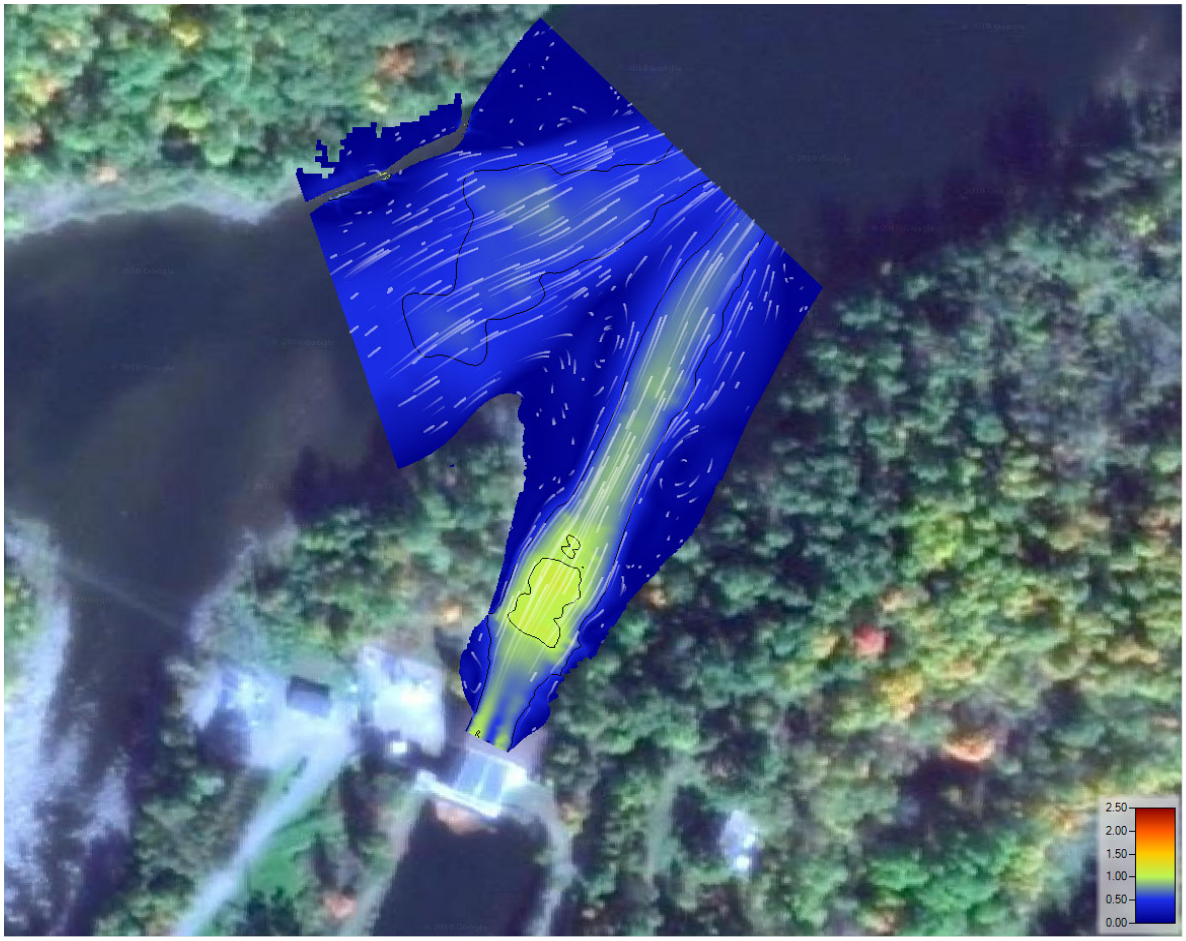
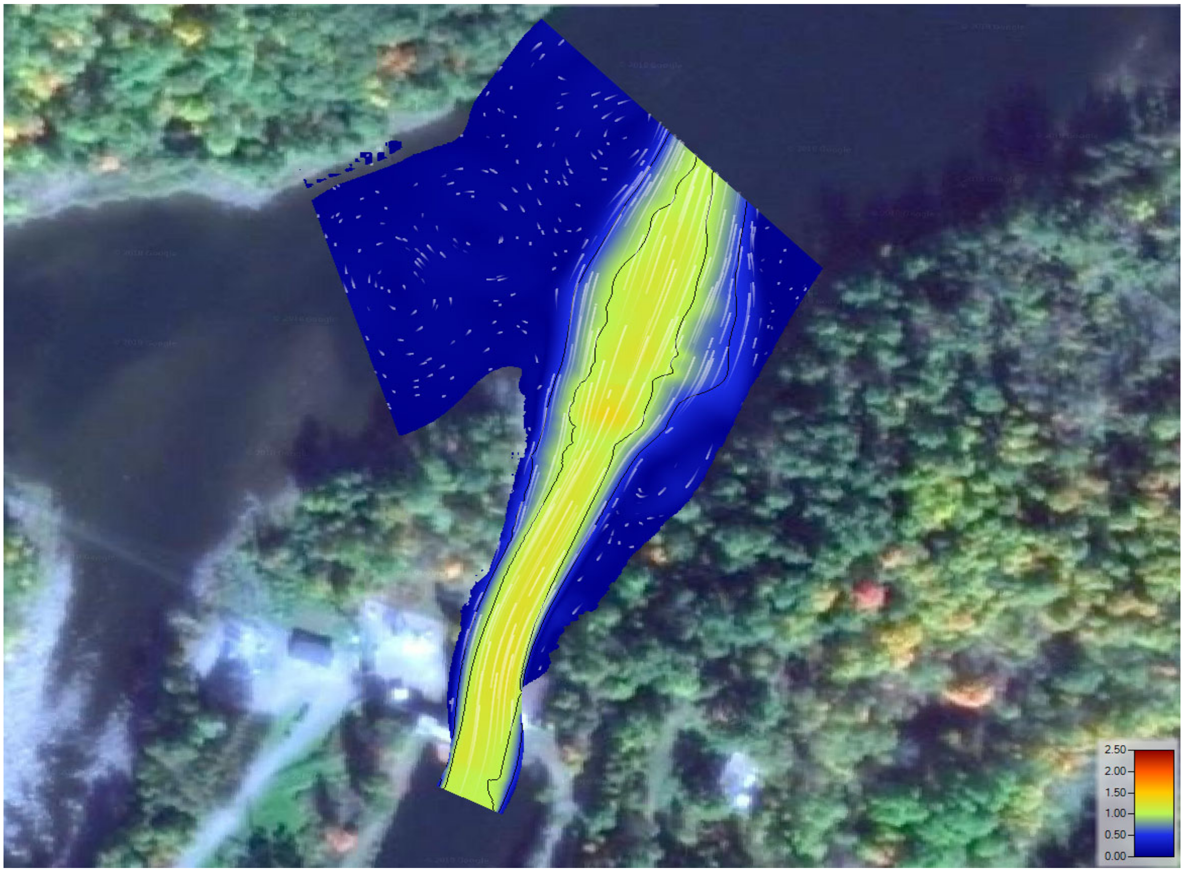


Figure 2-21. Future Calabogie GS Tailrace Hydraulic Conditions. 160 cms Total Flow, All Through the Powerhouse



The construction of much of the new tailrace will be undertaken in the “dry” by using a cofferdam. The tailrace area may require riprap to locally protect against erosion and sloughing of the overburden encountered, however, it is currently envisaged that the bulk of the tailrace excavation will be rock. Portions of the Madawaska River riverbank in the immediate vicinity of the tailrace area may also require erosion protection.

The shift of moving the powerhouse 50 meters upstream will increase the amount of tailrace habitat while reducing the amount of forebay habitat.

OPG will pursue more in-depth discussions with DFO as part of the request for review process and provide all information DFO requires to determine whether an Authorization is required and if so, what off-setting measures would be considered.

2.4.3.5 Structures for the American Eel

OPG is committed to supporting the recovery of American eel in consultation with Indigenous People and in accordance with provincial recovery strategies and policy direction. On the Madawaska River, there are no known occurrences of American Eel, including at or in the immediate area of Arnprior GS, Stewartville GS and Calabogie GS. As such, these facilities are currently compliant with the ESA.

Over time and as recovery strategies advance and succeed, the Madawaska River may become a focus of interest. This will signal that recovery strategies are working. OPG is using this redevelopment project to make the redeveloped Calabogie GS “eel ready”.

Eel ready means that the redevelopment will be planned, designed and executed in anticipation of adaptive management strategies that can be applied as circumstances change around the presence of American eel in the vicinity of the station.

Specific measures have been scoped into the design of the station to accommodate potential future needs for upstream and downstream passage, including:

- designing attractive flow at an eel trap/ladder at the plant tailrace;
- including a temporary trap and transport system at the plant tailrace to help monitor for early signs of eels showing up below the station;
- leaving room for permanent upstream and downstream passage infrastructure to be retrofitted on a long-term basis (OPG’s research suggests that upstream passage should likely occur in the plant tailrace and that is the proposed location for the temporary trap and transport system. Should eels return to the Madawaska River in this reach of the River, consideration could be given for another location);
- intake velocities and bar exclusion screen layouts designed to facilitate implementation of future effective safe passage of eels downstream through the GS;
- provision for future inclined screen and downstream flow bypass for downstream passage with bar spacing in the screen at a maximum of 19 mm during periods of downstream movement; and,
- early consideration of the pros and cons of operational variations that may support eel passage.

An adaptive management approach will be applied during operations to determine the best course of action to implement or install specific measures to support recovery as circumstances change.

2.4.3.6 Transmission Line

The existing GS is connected to Hydro One’s transmission network via a 44 kV transmission line that is connected to the Calabogie GS to the north. The existing transformer yard was extensively damaged during the 2018 tornado.

A new switchyard for the main step-up transformer will be constructed in close vicinity to the new powerhouse and will connect to the HONI transmission line at a pre-determined location.

2.4.3.7 Off-Site Communication

The new Calabogie GS will require a communication link with Stewartville TS for tele-protection signals and with Eastern Operation Control Center [EOCC] for remote SCADA.

To achieve this, a new microwave link between Calabogie GS and Stewartville GS will be constructed. The link will consist of two 150ft Microwave towers, one at each end. The location of the two towers will require the construction of new access roads. Wood poles to carry the power cables and Fiber Optic cables will be constructed to connect the MW towers to their respective Generating stations.

2.4.3.8 Water Control Features

The Ontario Ministry of Natural Resources and Forestry (MNRF) has in place Lakes and Rivers Improvement Act Technical Bulletins that detail the Ministry requirements for the safe operations of dams. The Technical Bulletins were initially issued in 2011. Based on the “Classification and Inflow Design Flood Criteria” Technical Bulletin, Ontario Power Generation (OPG) is evaluating whether additional spill capacity is required at Calabogie GS. While no decision has yet been made on whether any spill capacity alterations will be required for the site, OPG anticipates additional spill capacity will be required and achieved through a combination of channel improvements and constructing additional sluices.

OPG is only at the early stages of assessing the potential additional spill capacity requirements and options. As such, the review of environmental effects associated with the construction of additional spill capacity has not yet been initiated and are not discussed in this Report.

Environmental approval for the work could be considered per Section 8.8 of the OWA Class EA Process, “Addendum Provisions for Environmental Reports.” That assessment work could be carried out as modification to the project or Addendum provision. Alternatively, the approval could be undertaken through a separate process.

2.4.3.9 Other Features

Other features of the Calabogie GS that will remain unchanged from the current situation. Safety devices such as buoys, signage and booms will remain unchanged from the current situation. The existing office and washroom in the trailer are expected to remain but may be re-located closer to the new powerhouse.

2.5 Construction

Figure 2-7 shows the Calabogie site with a variety of construction stage features. These are each described below.

2.5.1 Site Access, Roads and Parking Areas

The primary access road to the site will remain as Generating Station Lane, a gravel road that is sufficiently wide to accommodate passing passenger vehicles. The Lane provides access to Lanark Road/County Road 511.

At this point no modifications are anticipated to the site entrance at County Road 511 (Lanark Road). However, should modifications be required these would be subject to review and approval by the County's Public Works Department. The Department has indicated that a traffic management plan will be required to describe the proposed traffic and how any impacts can be mitigated. The plan will likely need to ensure that signs are erected on the County Road to advise the other road users of turning traffic and a traffic control person may be needed during periods of high turning movements to/from the site.

A secondary access road currently exists from County Road 511 to Calabogie Island that is labelled as "Calabogie Island Road" on Figure 2-7. This is an existing single lane gravel road that provides access to the north side of OPG's South Branch Main Dam and to an OPG boat launch that is situated slightly further downstream. This road will be used for two purposes during construction. First, it is anticipated that some or most of the workers will park their vehicles on the island and access the main construction site by walking across the South Branch Main Dam. A parking lot is proposed in close proximity to the South Branch Main Dam to allow for this. This parking lot would be capable of accommodating approximately 50 vehicles. Second, excess rock and sediment are proposed to be placed on Calabogie Island so dump (or tipper) trucks will utilize the road. Imported engineered aggregates will be used to improve the roads should they be considered acceptable.

OPG, SNC-Sullivan and the Township of Greater Madawaska have entered into a Memorandum of Understanding to provide excavated rock from the project and deposit this on adjacent Township lands. This is described in more detail in 2.5.4 and 2.5.5. That arrangement will require SNC-Sullivan to construct a 200 to 300 meter length road on to the adjacent Township lands and also temporarily use the Township access to County Road 511 for the project (see Section 2.5.5).

2.5.2 Laydown and Storage Areas

During construction laydown and storage areas are required in order to facilitate demolition, excavation and construction. Most of Cross Island will be available at various times for temporary laydown and storage areas. Cross Island has historically had large cleared and flat areas that are suitable for such work. With the 2018 tornado the cleared area has expanded. Figure 2-7 shows one laydown area slightly west of the proposed powerhouse, however another large cleared area south of the powerhouse will be used to: allow equipment to work and turn around; park vehicles; store materials and equipment in an environmentally safe fashion; place trailers for worker use; etc.

2.5.3 Cofferdams and In-Water Works

The existing inlet structure/sluices will allow the forebay to be isolated and excavation work to begin in the forebay at the start of construction. Following the July 15th fish window, a cofferdam will be constructed upstream of the inlet structure to allow for removal of the existing inlet structure in the dry and rock excavation to continue. The upstream cofferdam will be constructed from blasted rock that has been excavated to accommodate the new powerhouse. Blast rock will be used to construct a 5.8 metres wide cofferdam, with a slope of 1.5H:1V up to elevation 155.17 masl. The upstream face of the cofferdam will be lined with a heavy-duty cofferdam membrane and sealed to the riverbed with a bentonite clay seal. Upon completion of the powerhouse, the liner, blasted rock and overburden will be removed, and the channel will be graded with rockfill.

A downstream cofferdam is required to isolate the downstream side of the construction and allow for the demolition of the existing powerhouse and construction of the new powerhouse and tailrace. The proposed cofferdam is a rockfill dam with an impervious geomembrane on the water side of the cofferdam. Seepage through the cofferdam will be collected and directed to a settling pond prior to discharge back into the river.

A small amount of tree and vegetation clearing is required on the east end of Cross Island to allow for access to construct this cofferdam. Similar to the upstream cofferdam, the downstream cofferdam will be constructed from blasted rock that has been excavated to accommodate the new powerhouse. Blast rock will be used to construct a 5.8 metres wide cofferdam across the width of the tailrace, with a slope of 1.5H:1V up to elevation 148.00 masl. The downstream face of the cofferdam will be lined with a heavy-duty cofferdam membrane and sealed to the riverbed with a bentonite clay seal. Upon completion of the powerhouse, the liner and blasted rock will be removed, and the area will be graded to align with the tailrace channel profile.

Should any in-water construction activities be required, they will be timed to avoid the spawning and egg incubation period of spring spawning fishes, such as Walleye. The exclusion period is from March 15 to July 15.

2.5.4 Excavation

The construction of the new powerhouse will require a significant amount of sediment and rock to be removed from the construction area. It is estimated that approximately 60,000 cubic meters of sediment/overburden and 66,800 cubic meters of rock would need to be removed. The sediment and rock have been tested. The rock can be re-used and the sediment/overburden will be disposed of on OPG property.

Blasting will be required to remove the rock for the new powerhouse, in the forebay and in the tailrace. A third-party firm will be hired to implement a vibration monitoring program, provide engineered blast designs, and consult in all blasting operations as required.

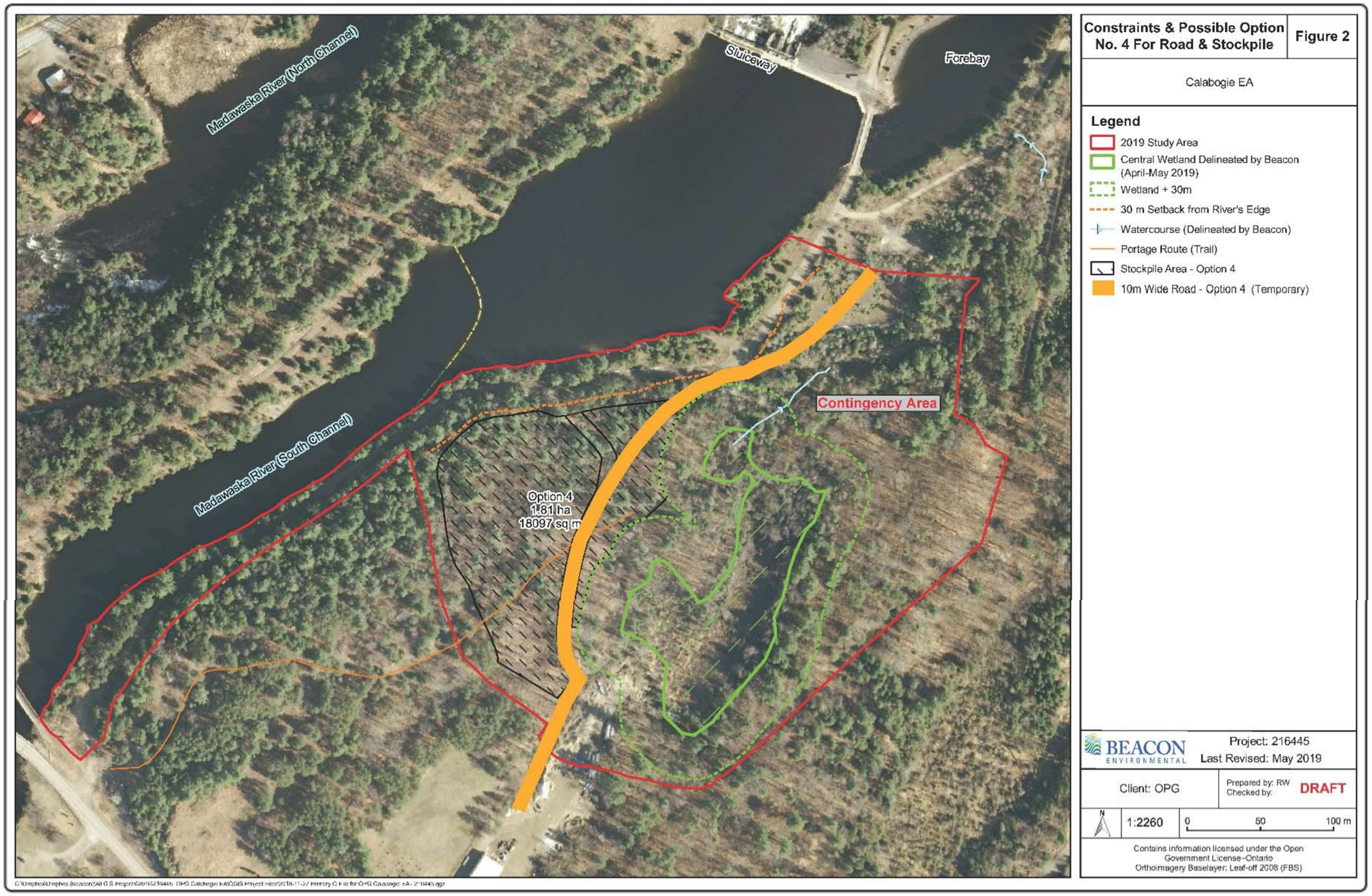
Prior to any blasting or rock excavation, the sediment in the forebay will be excavated down to either rock or the required hydraulic elevations and disposed of on OPG Property. Once the sediment has been removed and blasting is underway, excavation of the rock will begin. The rock will either be used as cofferdam material, stockpiled for later use as embankment treatment, or disposed of on Township Property (see section 2.5.5 Rock and Soil Deposition Areas where this is further discussed).

It is expected that groundwater infiltration or surface water runoff (including cofferdam leakage) could require pre-treatment prior to discharge. To collect water infiltration, sumps will be excavated at key locations of the excavation and pumps will be installed to dewater the area. If necessary, the water will be pumped into settling pond(s), silt treatment bags, and vegetated areas to mitigate any environmental issues that may arise from the dewatering. Should the water require secondary treatment for dissolved metals, proper measures will be taken including necessary permits and approvals.

2.5.5 Rock and Soil Deposition Areas

As previously indicated, an Agreement has been entered into among the Township of Greater Madawaska, OPG and SNC-Sullivan for the latter two to provide the Township with excavated rock for its future use. Excavated rock would be delivered to the rear of the Township's Works Yard which is situated approximately 200 metres away from the excavated area (see Figure 2-22 below). The Township has also indicated that it can take the demolished powerhouse (save for the exterior structure that has lead paint on it) as well. This Project will require Sullivan to construct an approximately 200-meter long temporary road spanning from OPG to Township property creating a direct access to a storage area at the back of the Township's lands. The Project would also involve decommissioning of this road following completion of the transfer of the rock. Figure 2-22 shows the likely area of rock placement based on archaeological, biological and engineering investigations and consultation with the Township. This area may be slightly further refined. This area is also shown as Area #3 on Figure 2-7.

Figure 2-22. Proposed Road and Possible Rock Placement Areas



As previously indicated, the Township has agreed to take most of the rock associated with the structure along with the demolished powerhouse. However, the Township is only interested in the rock and is not interested in the soil, sediment or co-mingled rock and soil. As such, OPG will still have extra material it will need to deposit on site.

As such, two different areas have been proposed on site to place the remaining excavated rock and soil. The two proposed areas are shown in Figure 2-7. These areas were selected based on their location and physical and environmental conditions. In general, the emphasis has been made to place the material close to the original excavation and/or use and in sites that have been historically disturbed.

Area #1 is located on the northeastern tip of Cross Island. This Area would be used to place the material left over from the downstream cofferdam. This will eliminate most of the need for truck traffic for this material. It is possible that some of the cofferdam material might be used for fish habitat pending further discussions with the DFO. Area #2 is located on Calabogie Island immediately adjacent and northeast of the South Branch Main Dam. This area was previously disturbed by the original construction of the Calabogie GS and is a lower lying area. Given that this is a lower area, excavated material can be placed here with fewer potential concerns with respect to visual effects from residents located on the north side of the North Channel. A section of this area may also be potentially used for parking or other purposes during construction. Both of these areas are considered to be of lower ecological value. The placement of the rock and sediment will occur above the high-water mark to ensure there is no loss of riparian habitat.

OPG has been in recent discussions with the AOO and AOP about minor adjustments to the sediment and rock pile stockpile areas (Areas #2 and #3 in Figure 2-7) to address AOO and AOP questions and concerns. This may include placing the sediment pile beyond 30 meters from the high-water mark.

Following construction, the areas will be revegetated to suit the surrounding environment. This may involve seeding, planting or natural re-generation by placement of topsoil and with an appropriate seeding or planting. Discussions could be held with the AOO and AOP as to possible plantings.

2.5.6 Construction Schedule and Strategy

Construction will be initiated in early 2020 with the intention of the GS being operational in 2023. Vegetation clearing at the site is anticipated to occur in the early months of 2020 ahead of the spring breeding bird season. The placement of cofferdams will adhere to any fisheries windows.

2.6 Proposed Calabogie GS Operations

As outlined in the 2009 Madawaska River Water Management Plan, Calabogie GS operated (prior to the September 2018 tornado) to support the peaking operations of the four other OPG owned GSs on the Madawaska River. The generating units at the station had limited flow capacity (66 m^3/s), but the operation of the units and sluice gates are integrated with the rest of the system on the Madawaska River. Calabogie was a generation bottleneck on the Madawaska River, and the small turbine capacity results in frequent spill past the station.

The operation of the existing plant is based on a daily/weekly cycle, with the inflow passed through the plant over a daily or weekly period. The 2009 WMP notes that operation of the plant takes into consideration energy demands, recreational opportunities as well as walleye spawning activities.

OPG does not propose to alter the existing water management compliance requirements associated with this facility. The redevelopment of Calabogie GS will continue to be operated in full accordance with all of the flow and water level targets and compliance conditions identified in the WMP. Daily flows will remain unchanged, but additional portion of river flow will pass through the plant to generate electricity rather than just passing through the spillway gates.

In terms of mandatory and conditional water level targets, for Calabogie G.S. Table 9.15 of the 2009 WMP defines the following:

Table 2-1. Water Management Plan – Calabogie GS Mandatory and Condition Level Limits

Table 9.15: Calabogie GS Mandatory and Conditional Level Limits

Parameter	Limit Type, Conditions and Notes
Absolute Maximum 154.17 m	Type: Mandatory Maximum level
Absolute Minimum 153.56 m	Type: Mandatory Minimum level
Summer Minimum 153.80 m	Type: Conditional Requirement The specified minimum level is the applicable limit provided the following condition outlined below is fulfilled. 1.The date is within the summer period. The summer period starts on Saturday 00:00 EST of the Victoria Day weekend and ends on the Monday at 24:00 EST of the Thanksgiving Weekend. The summer minimum can be suspended when the following conditions are fulfilled. 1. Declaration of an “Emergency Operating State” by the IESO. 2. IESO requests market participants to seek approval for environmental variances. 3. Implementation of a “3% Voltage Reduction” by the IESO. 4. Within 24 hours after the end of an Emergency Operating State, the level will be returned to the summer minimum level. 5. Walleye spawn/incubation flow limits at Calabogie are not active. 6. OPG will notify MNR once there is a reasonable probability that energy emergency flexibility will be used.
Walleye Spawn & Incubation Maximum 154.05 m	Type: Conditional Requirement The maximum level is applicable provided all the four conditions outlined below are fulfilled. The maximum level is to protect spawning grounds in Constant Creek. 1.The water temperature measured in the Barrett Chute tailrace or an agreed-upon location has reached 6 ^{0}C. 2.MNR has confirmed significant walleye activity at the Barrett Chute spawning shoal. 3.MNR has provided 24 hours notice of the start of the walleye spawning period. 4.The water temperature degree days since the start of the incubation period is less than 205 ^{0}C.
Walleye Spawn & Incubation Minimum 153.80 m	Type: Conditional Requirement The minimum level is applicable provided all the four conditions outlined below have been met. 1. The water temperature measured in the Barrett Chute tailrace or an agreed-upon location has reached 6 ^{0}C. 2. MNR has confirmed significant walleye activity at the Barrett Chute spawning shoal. 3. MNR has provided 24 hours notice of the start of the walleye spawning period. 4. The water temperature degree days since the start of the incubation period is less than 205 ^{0}C.

In terms of mandatory and conditional water flow targets, for Calabogie G.S. Table 9.16 of the 2009 WMP defines the following:

Table 2-2. Water Management Plan – Calabogie GS Mandatory and Condition Flow Limits

Table 9.16: Calabogie GS Mandatory and Conditional Flow Limits

Parameter	Limit Type, Conditions and Notes
Minimum Flow 0.8 m^3/s	Type: Mandatory Minimum Level Note:This flow has not been measured since the replacement of the wooden stop logs with steel stop logs. The 0.8 m^3/s is an estimated flow.
Walleye Spawn & Incubation 5 m^3/s.	Type: Conditional Requirement The minimum walleye spawn flow is applicable provided all the three conditions outlined below are fulfilled. 1. The water temperature measured in the North Channel at Calabogie or an agreed-upon location has reached 6 °C. 2. MNR has provided 24 hours notice of the start of the walleye spawning period. 3. The water temperature degree days since the start of the incubation period is less than 205 °C.This flow limit is an instantaneous flow that must be maintained throughout the walleye spawning period.

The annual variation of the mandatory and conditional limits are shown in Figure 9.08.

OPG will continue to operate the Calabogie GS and the other plants on the Madawaska River in full accordance with all flow and water level targets and compliance conditions in the Madawaska River Water Management Plan.

The Calabogie GS is a generating station on the Madawaska River, located between Barrett Chute GS and Stewartville GS. The existing turbine capacity of Calabogie is lower than the other stations on the Madawaska River, which becomes a constraint in the operation of the system. The present discharge capacity at Calabogie GS is 66 m^3/s, but the upstream and downstream capacity at Barrett Chute GS and Stewartville GS is exceeding 450 m^3/s. Under these conditions, Calabogie Lake is used as a daily reservoir to regulate the discharge and to maximize the energy production.

The average historical inflow for the period between 1965 and 2017 at Calabogie is approximately 90 m^3/s with a median of 72 m^3/s. The Barrett Chute and Stewartville GS are peaking plants whereas the existing Calabogie GS was used to support these operations with combinations of continuous turbine flow and gate operations. These operations modes can cause daily fluctuations of the water elevation at Calabogie Lake and Stewartville headpond. This form of operations for Calabogie GS has existed since peaking plants with larger discharge capacity than Calabogie were commissioned on the river.

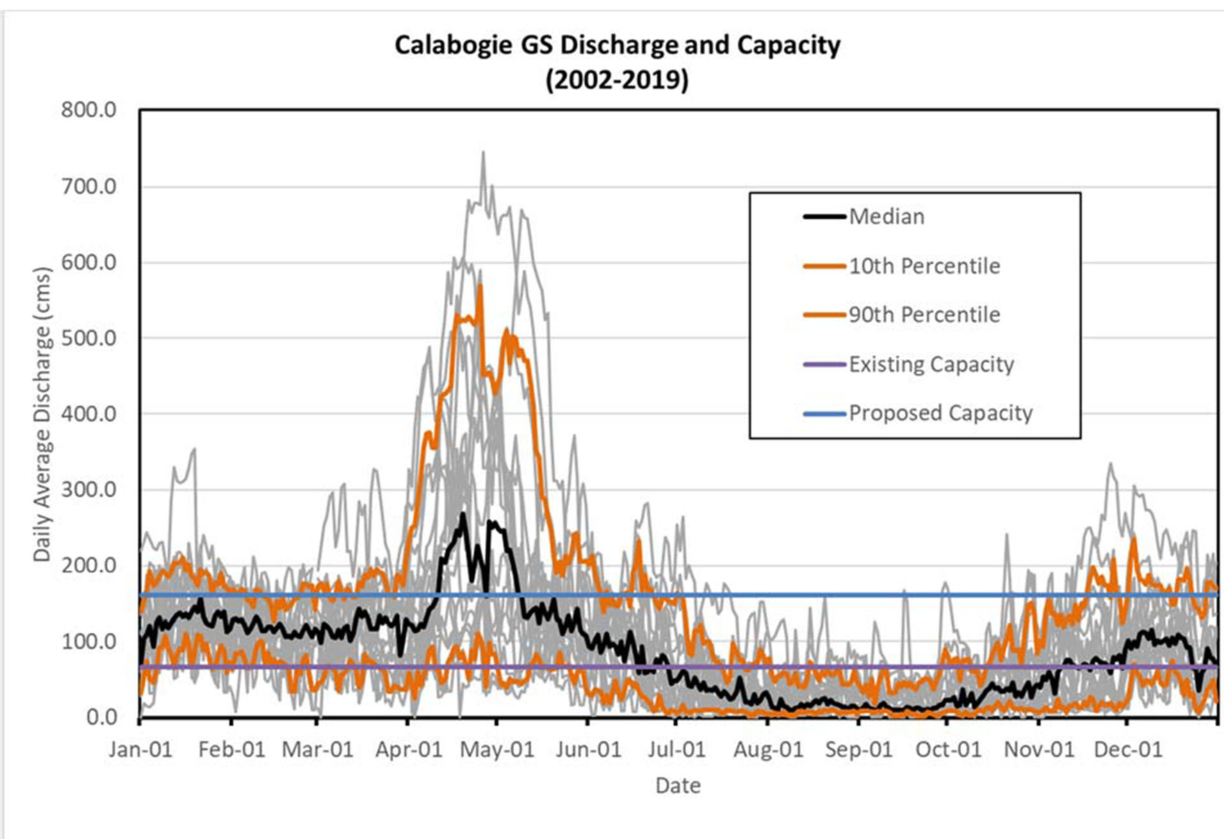
With the redevelopment of the Calabogie GS site and the increase of the generating and discharge capacity, there is the opportunity to more accurately shape the daily discharge from the facility. Regardless of the mode of operation, the turbine discharge capacity at Calabogie GS will remain lower than the discharge capacity at the other adjacent stations on the Madawaska River. Therefore, the priority in the operation of the hydro system will be for the Calabogie GS to continue to support the peaking operation of the downstream power plant at Stewartville with the possibility to minimize the fluctuations in the headpond to the extent practicable.

Figure 2-23 shows the historic total daily discharge (turbine flow & main control dam sluice flow) since the opening of the energy market, where each grey line is one year of data. The discharge past the Calabogie facility often exceeded the existing stations turbine capacity in the November to July period and was passed through sluiceways. The redevelopment will allow a greater amount of water to be passed through the turbines, which will allow OPG to produce more renewable energy from the existing water. The North Channel Control Dam sluiceway conditions will be maintained in accordance with the existing water management plan.

There will still be conditions and situations where a greater range at Stewartville GS is needed to meet Ontario grid requirements and maintain compliance with the other aspects of the Water Management Plan (WMP). However, there may be some conditions where the redeveloped Calabogie GS could match flow patterns at Barrett Chute GS and Stewartville GS to reduce water level fluctuations. If this occurs it will be done in compliance with the WMP. As a result, the redeveloped generating station will allow OPG to reduce the fluctuations in water level in Calabogie Lake and Stewartville more often than the current situation, but the impact will not be substantial.

Given the above, OPG does not plan to propose any formal changes to the compliance requirements in the WMP, however a Minor Amendment will be required to make administrative updates.

Figure 2-23. Calabogie GS Discharge and Capacity 2002 – 2019



There will be no permanent operating staff at the new station. Normal operation of the station and sluiceways will be carried out remotely by OPG. Normal maintenance activities at Calabogie GS will be carried out by OPG staff on an "as-required" basis. They will visit the station regularly.

Annual maintenance and overhauls for the redeveloped plant may require shut down of the units and will normally be scheduled when the flows are lowest and the loss of generation can be minimized. Minor overhauls require the units to be out of service for a minimum of 1 to 2 months and would likely only be required every 10 to 15 years. Major overhauls every 25 to 30 years could require a unit to be out of service for approximately 8 to 12 months. Unlike with the existing station, dewatering of the forebay will not be required to conduct maintenance on the new powerhouse.

2.7 Proposed Decommissioning

Decommissioning involves the permanent removal of the hydroelectric facilities, with the resultant loss of the site as a renewable source of electricity generation. Rather than decommissioning, redevelopment of a facility that is at the end of its designed service life could be a viable option. A number of OPG owned hydroelectric facilities that were built in the early 1900s have been redeveloped in the last 10 years, e.g., Wawaitin GS, Sandy Falls GS and Lower Sturgeon GS on the Upper Mattagami River, and Hound Chute GS on the Montreal River.

Once the Calabogie GS Redevelopment Project has reached the end of its service life in 90 years or more, additional redevelopment, rather than decommissioning, would be an option that should be considered again to further extend the life of this plant.

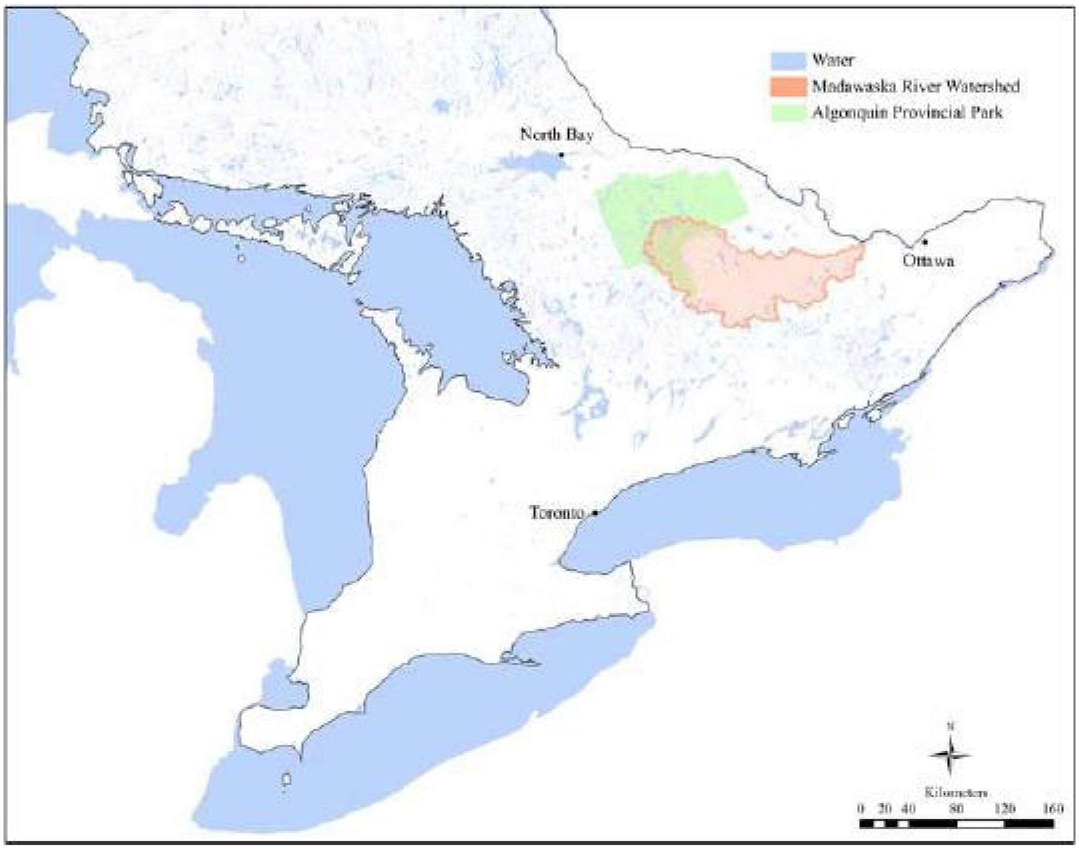
3 BASELINE AQUATIC ENVIRONMENT CONDITIONS

3.1 Water Resources

3.1.1 Madawaska River

The Madawaska River flows 270 km from its headwaters in Algonquin Provincial Park (see Figure 3-1 below) to the Ottawa River at Arnprior. Its drainage area covers over 8,500 square kilometres (OPG, 2009).

Figure 3-1. Madawaska River Watershed

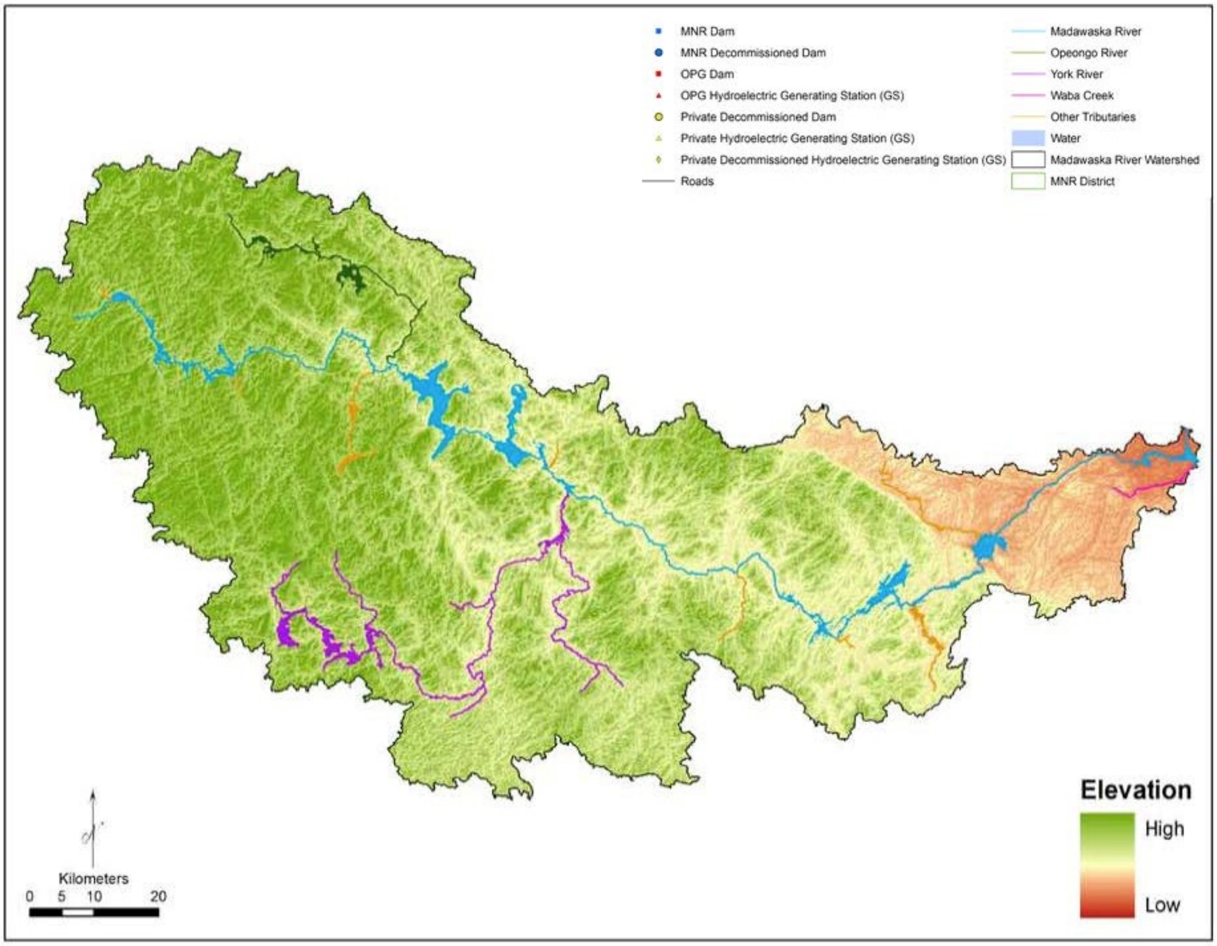


Source: OPG, 2009

The headwaters of the Madawaska River originate from a network of streams and lakes in the southeast corner of Algonquin Provincial Park (OPG, 2009). Most of the River occurs in the Laurentian Sub-Region of the Canadian Shield.

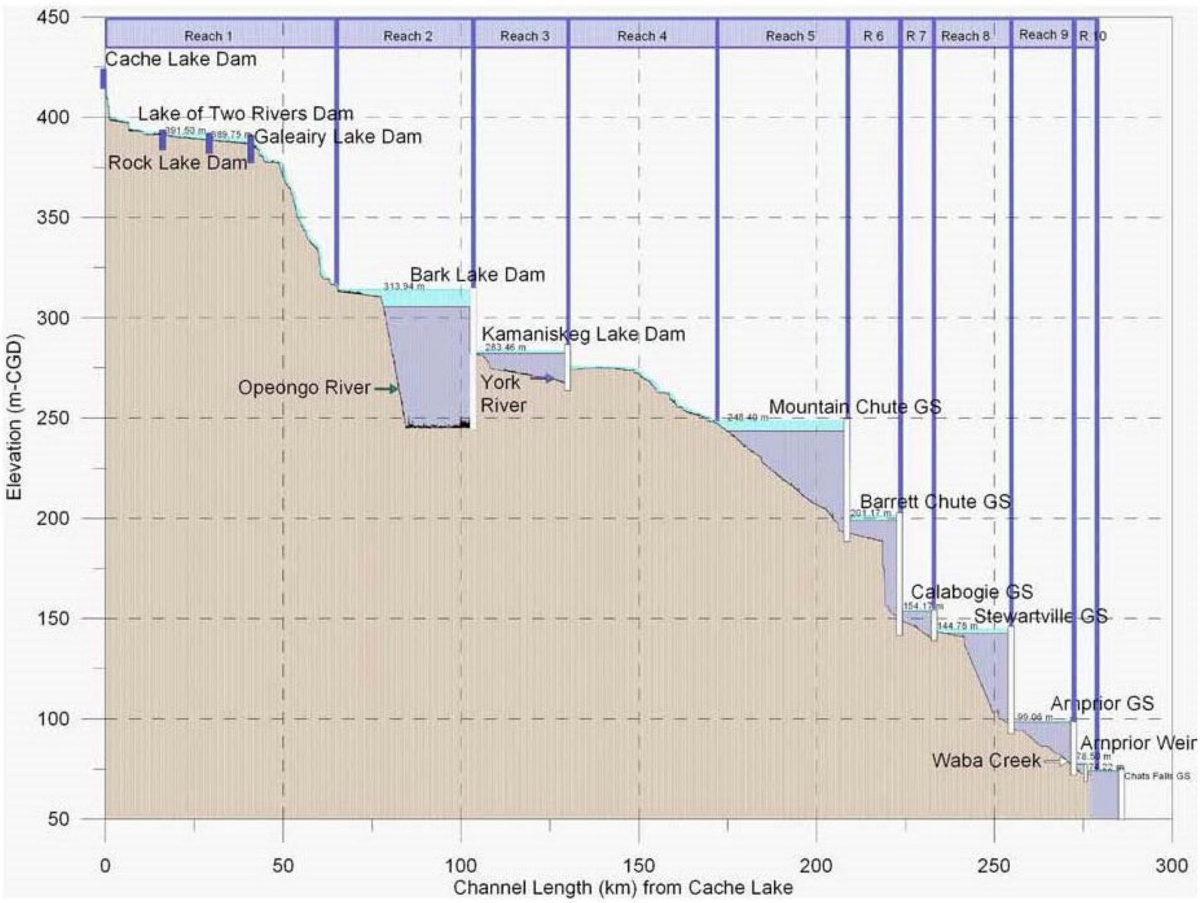
Over its entire course, the Madawaska River drops 350 meters. Most of the vertical drop occurs between Bark Lake and Arnprior. The change in relief from higher elevations in the upstream part of the watershed to the lower elevations in the downstream can be visualized through two Figures below (3-2 and 3-3).

Figure 3-2. Madawaska River Watershed Relief Map



Source: OPG, 2009

Figure 3-3. Madawaska River Watershed Elevation Profile



Source: OPG, 2009

The main tributaries of the Madawaska are the Madawaska, Opeongo and York Rivers as well as Waba Creek (OPG, 2009). There are a total of forty-one dams on the Madawaska River of which OPG owns and controls seven: Bark Lake Dam, Kamaniskeg (Palmer Rapids) Lake Dam, Mountain Chute GS, Barrett Chute GS, Calabogie GS, Stewartville GS and Arnprior GS. OPG also has two weirs on the Madawaska River at Arnprior and on Mackie Creek.

The flows and levels on the Madawaska River are the product of a series of complex interactions between the unique characteristics of the watershed and the evolving direct human interventions at dams and hydroelectric facilities and additional human-induced indirect changes to the landscape (OPG, 2009).

Flows and levels on the Madawaska watershed have been impacted and manipulated by people since the mid 1800s. The general operating pattern of dams and hydroelectric facilities on the Madawaska River can be found in section 2.3.2 of the Madawaska River Water Management Plan. As indicated in this section, similar to other Rivers in areas of Ontario the hydrology of the River is influenced by a variety of factors in the watershed that is driven by complex interactions of climate, geology, land use, physiography, vegetation and soils, combined with direct human intervention at dams and hydroelectric facilities.

Climate (i.e. snow and rain) is the major factor that influences water levels and flows. The WMP identified annual precipitation figures at four meteorological stations near the Madawaska River watershed and presented them in Table 3-1 (OPG, 2009). An assessment on future climate conditions in the Madawaska River watershed can be found in section 4.6 of the Environment Report.

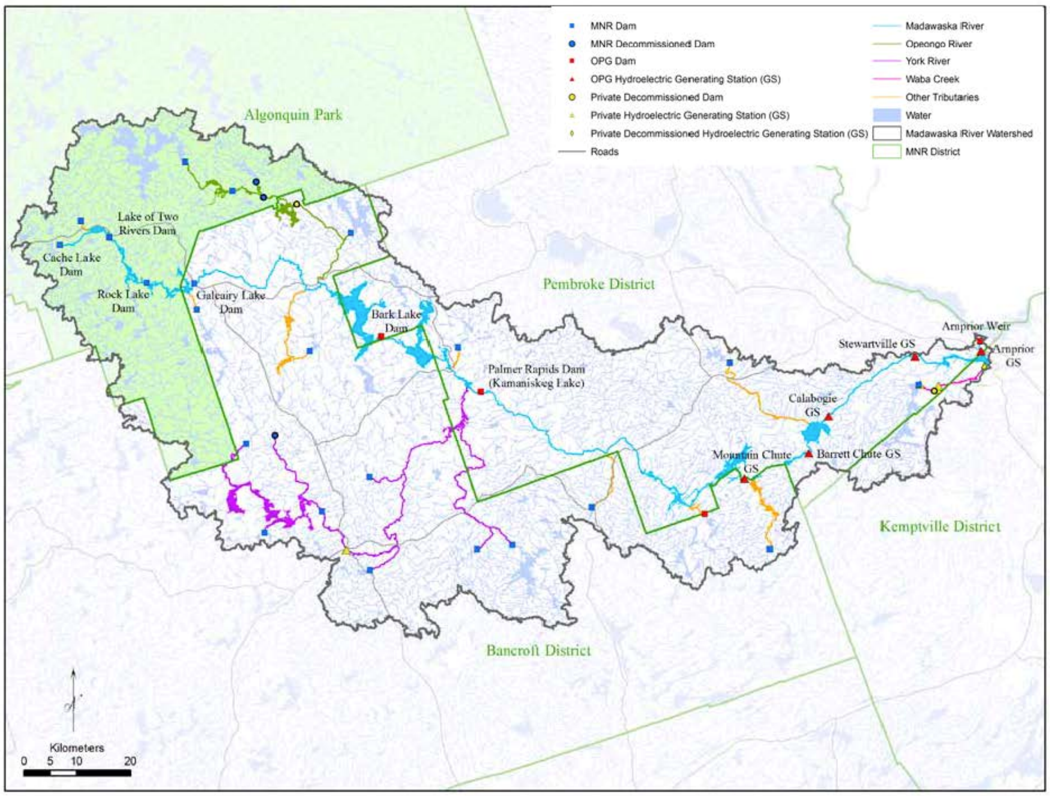
Table 3-1. Annual Precipitation

Station	Annual Precipitation (mm)		
	Minimum	Average	Maximum
Combermere (6101820)	651	847	1026
Ottawa Airport (6106000)	621	901	1166
Petawawa Nat. Forestry	657	835	1092
Muskoka Airport (6115525)	778	1049	1486

As previously indicated, there are forty-one dams within the Madawaska River watershed and these are graphically pictured in Figure 3-4 below (OPG, 2009).

Figure 3-4. Dams on the Madawaska River

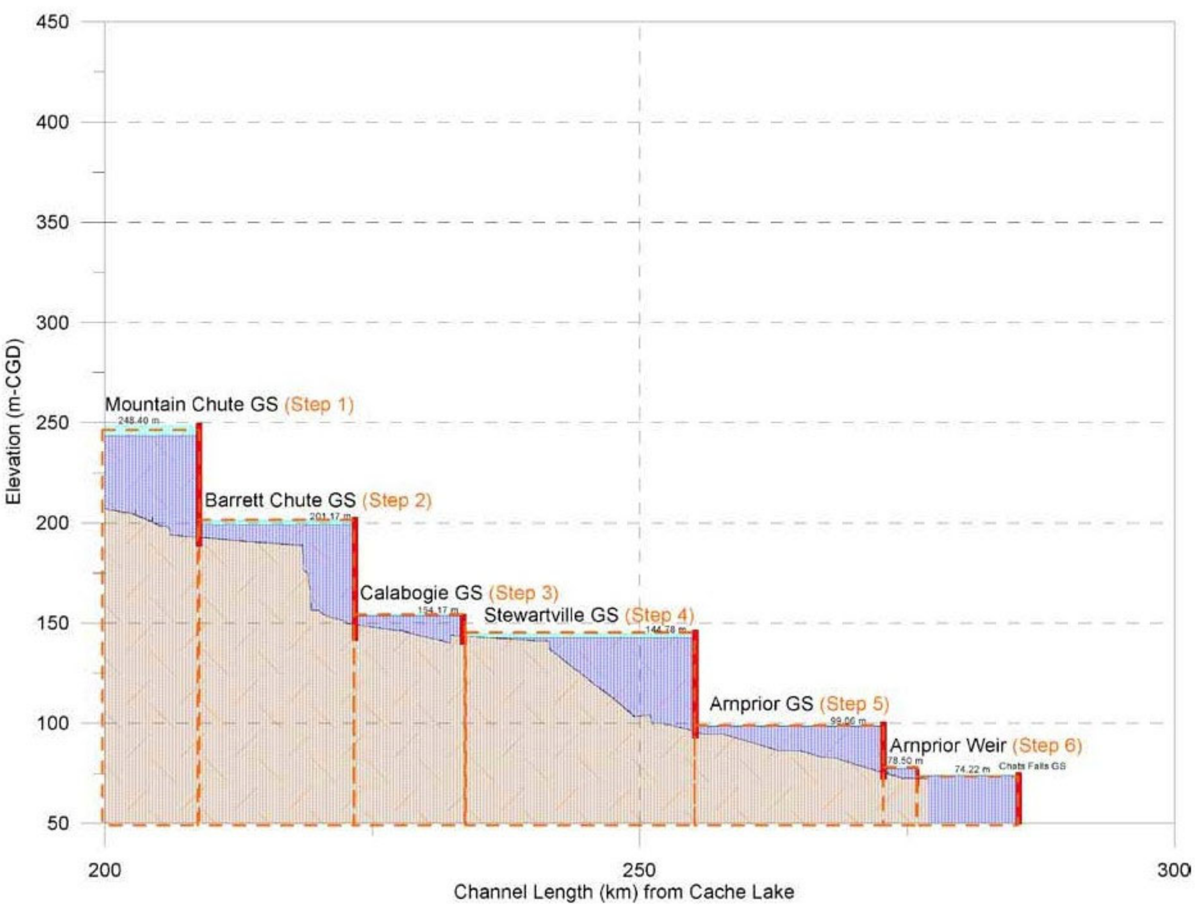
40 **Figure 4.02: Dams on the Madawaska River**



Madawaska River Water Management Plan

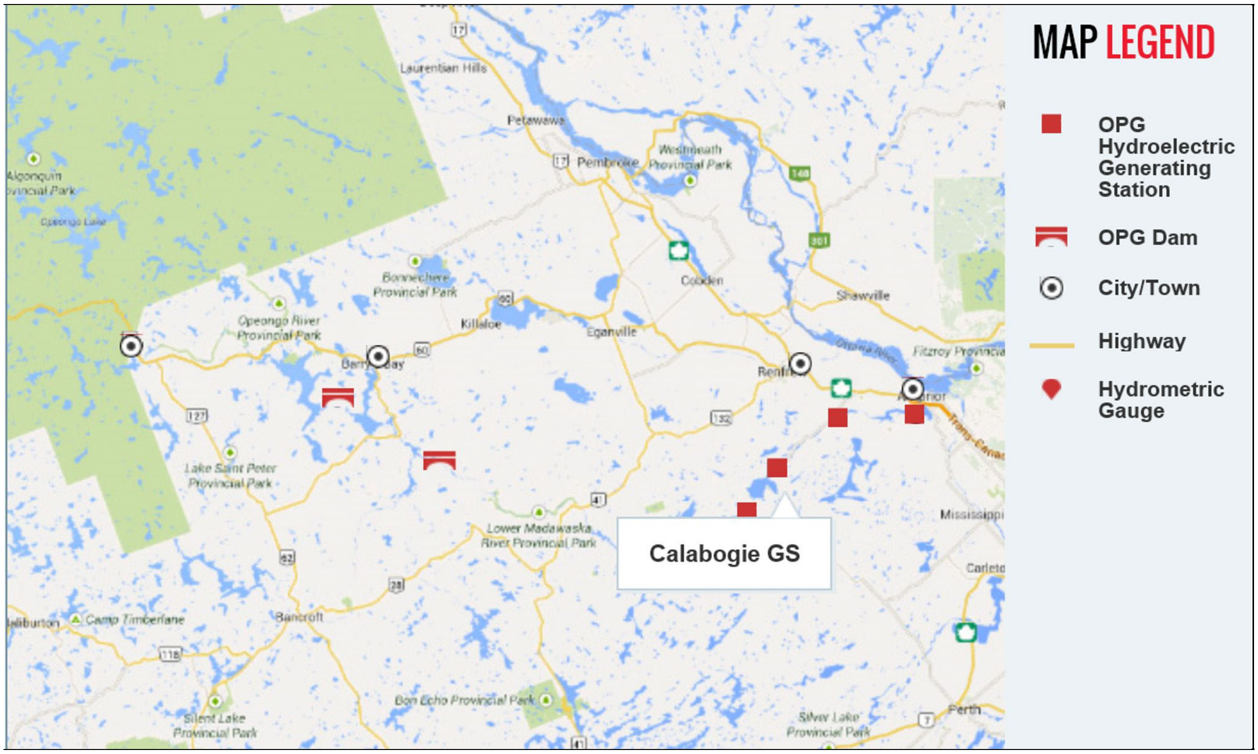
The OPG generating facilities on the Madawaska River are considered a cascade river system. The Figure 3-5 below is Figure 2.05 of the MRWMP and graphically depicts the River as a series of cascading waterfalls that can be considered a series of steps in which the water travels over. As indicated in the MRWMP, at each of the facilities the water level upstream of the facility is fairly flat and then falls vertically at the dam into the next facility. The level downstream of each facility is essentially the same as the upstream level of the next facility in the cascade.

Figure 3-5. Madawaska River Cascade System



The only large water storage facilities on the Madawaska River are Bark Lake and Centennial Lake. Bark Lake is the largest flood storage reservoir on the River. The lake has a winter drawdown of approximately 9 m providing 339 million m^3 of storage. Centennial Lake which is the Mountain Chute GS forebay has a winter drawdown of approximately 4.0 m and provides 104 million m^3 of storage. These reservoirs are used to store water during the spring and reduce peak flows in the river. The other OPG facilities have some storage but are insignificant for flood control use. Bark Lake is normally emptied by the end of February. Once the Bark Lake drawdown is complete, Mountain Chute GS is emptied during March (OPG, 2009).

Figure 3-6. OPG Dams and Generating Stations along the Madawaska River System



Calabogie GS is approximately 10 km downstream of Barrett Chute GS and 20 km upstream of Stewartville GS, both OPG hydroelectric facilities.

The powerhouse is situated on the South Branch of the Madawaska River about 800 metres downstream of the outlet at Calabogie Lake.

The drainage area for the Calabogie GS is 7,647 square kilometers (OPG, 2009).

As already indicated Calabogie Lake is situated approximately 1 km upstream of the Calabogie GS. Water from Calabogie Lake has three paths downstream: through the North Channel, which is one of the original natural river channels; the South Channel Sluiceway, and; the GS (Figure 3-7).

Figure 3-7. Madawaska River in the Vicinity of the Calabogie GS

As outlined in the 2009 Madawaska River Water Management Plan, Calabogie GS presently operates as a peaking plant in conjunction with the four other OPG owned GSs on the Madawaska River. The generating units at the station have limited flow capacity (66 m^3/s), but the operation of the units and sluice gates are integrated with the rest of the peaking system on the Madawaska River. Calabogie is a generation bottleneck on the Madawaska River, and the small turbine capacity results in frequent spill past the station.

The operation of the existing plant is based on a daily/weekly cycle, with the inflow passed through the plant over a daily or weekly period. The 2009 WMP notes that operation of the plant takes into consideration energy demands, recreational opportunities as well as walleye spawning activities.

Other than the Madawaska River there are no other watercourses or water features within the Calabogie GS.

3.1.2 Groundwater

The MoECC has requested specifically to assess whether the project site is in an area of source water protection. Examination of the MoECC's Source Protection Information Atlas website (https://www.gisapplication.lrc.gov.on.ca/SourceWaterProtection/Index.html?viewer=SourceWaterProtection.SWPViewer&locale=en-US) identified that the Calabogie GS is not located within a source water protection area near Calabogie GS (retrieved July 10, 2018). It appears the closest one is near Almonte to the southeast by over 20 km. It should be noted there is no Conservation Authority for the Madawaska River watershed.

Previous groundwater investigations at the site have been undertaken by both Golder (2001) and more recently WSP (2016). Both Golder and WSP have inferred that groundwater similar to surface water drains towards the Madawaska River. WSP has determined that groundwater levels and gradients at the site are generally controlled by the Madawaska River with the overburden appearing to be the pathway for the groundwater flow. The stable groundwater level was measured between 2 meters and 3.5 meters above the overburden-bedrock interface. Water infiltration occurs within the unsaturated overburden, and increased horizontal flow is to be expected within the overburden with precipitation, snow melting and other climatic events.

WSP carried out sampling and analysis of the groundwater quality. They reported the following with respect to water quality.

The metals and inorganics chemical test results for the submitted groundwater samples were below the MoECC 2011 Table 1 SCSs, except for Copper in Monitoring Well (MW) 15-2 during the second sampling event. These results are show in Table 3-2 below.

Table 3-2. Groundwater Chemical Test Results

Chemical	SCS	Units	MW15-5 22-Nov-15	MW15-5 21-Dec-15
Copper	5	ug/L	8-2	4.4

With respect to petroleum hydrocarbons and VOCs, they noted that: "The reported PHC F1 to F4 and VOC's concentrations were below the MoECC 2011 Table 1 SCSs for both sampling events." (p. 11)

WSP compared the results to the PWQO standards. Several parameters were detected at concentrations above the PWQOs during both sampling events and area shown in Table 3-3 below.

Table 3-3. Reported PWQO Exceedances

Chemical	PWQO	Units	MW15-2 01-Dec-15	MW 15-2 22-Dec-15	MW15-3 01-Dec-15	MW15-3 22-Dec-15
Cadmium	0.0002	mg/L				0.0005
Cobalt	0.0009	mg/L	0.0012	0.0035	0.0024	0.0281
Copper	0.005	mg/L		0.014	0.012	0.143
Iron	0.3	mg/L	1.01	3.93	3.77	19.3
Lead	0.005	mg/L			0.006	0.072
Nickel	0.025	mg/L				0.047
Silver		mg/L				0.0002
Uranium		mg/L				0.016
Vanadium		mg/L		0.013	0.013	0.067
Zinc		mg/L				0.117
Zinconium		mg/L			0.013	

Note: blanks indicate that the concentrations were below the standard.

3.2 Aquatic Environment Resources

3.2.1 Surface Water Quality

Communications with MoECC identified that water quality data would not need to be obtained for the environmental assessment stage of the project but that water quality data would be obtained prior to construction to assist in construction monitoring (Orpana, MoECC, 2018). On page 5 of that letter it was stated that:

> *"I just wanted to confirm that the MOECC will not require water quality assessment or fish tissue monitoring as part of the Environmental Assessment. This is based on the understanding that the inundation area is not affected by the project (which is my understanding at this time). Water quality monitoring will most likely be required during construction, which can be addressed through the Permit to Take Water."*

3.2.2 Substrate and Sediments

Substrate mapping is presented in Figures 3-8, 3-9, 3-10, and 3-11. The spillway is scoured bedrock at the upstream end, immediately downstream of the South Channel Sluiceway (Figure 3-12), changing to large boulders farther from the sluiceway (Figure 3-13), and grading to smaller boulders and cobble with a small portion of sand and gravel where the spillway ends and the velocities are lower (Figure 3-14). Figure 3-9 also illustrates the effect of flow velocity on substrate composition. Bedrock and large boulders dominate in the upper South Channel spillway where the bulk of the high river flows are passed. Areas sheltered from the flows, such as the embayment to the west of the downstream end of the South Channel spillway and the downstream end of Cross Island (Figure 3-9), have finer substrates.

The downstream riffle/rapids section of the North Channel (Figure 3-10) has substrates of boulder and bedrock with some cobble (Figures 3-15 and 3-16). Substrate downstream of the rapids is also primarily boulders and cobble, but there are finer substrates in sheltered locations closer to shore. The upstream riffle/rapids section of the North Channel (Figure 3-11) is mainly bolder/cobble, but there is a sizeable section at the downstream end of this set of rapids, with substrates of cobble/boulder/gravel (Figures 3-17 and 3-18).

Limited observations, downstream of the mapped substrates to Cherry Point (Figure 3-8), suggest a patchwork of substrates in this portion of the river, including bedrock, sand, and large areas with various proportions of cobble, boulder and gravel. Sandy areas tended to be in deeper sections, or in small sheltered shoreline locations.

Figure 3-19 shows the forebay when it was dewatered in October of 2018. The substrate is cobble over a lot of the forebay but ranges from silt to boulder.

Figure 3-8. Madawaska River in the Vicinity of the Calabogie GS, Showing the Location of the Following Three Substrate Maps

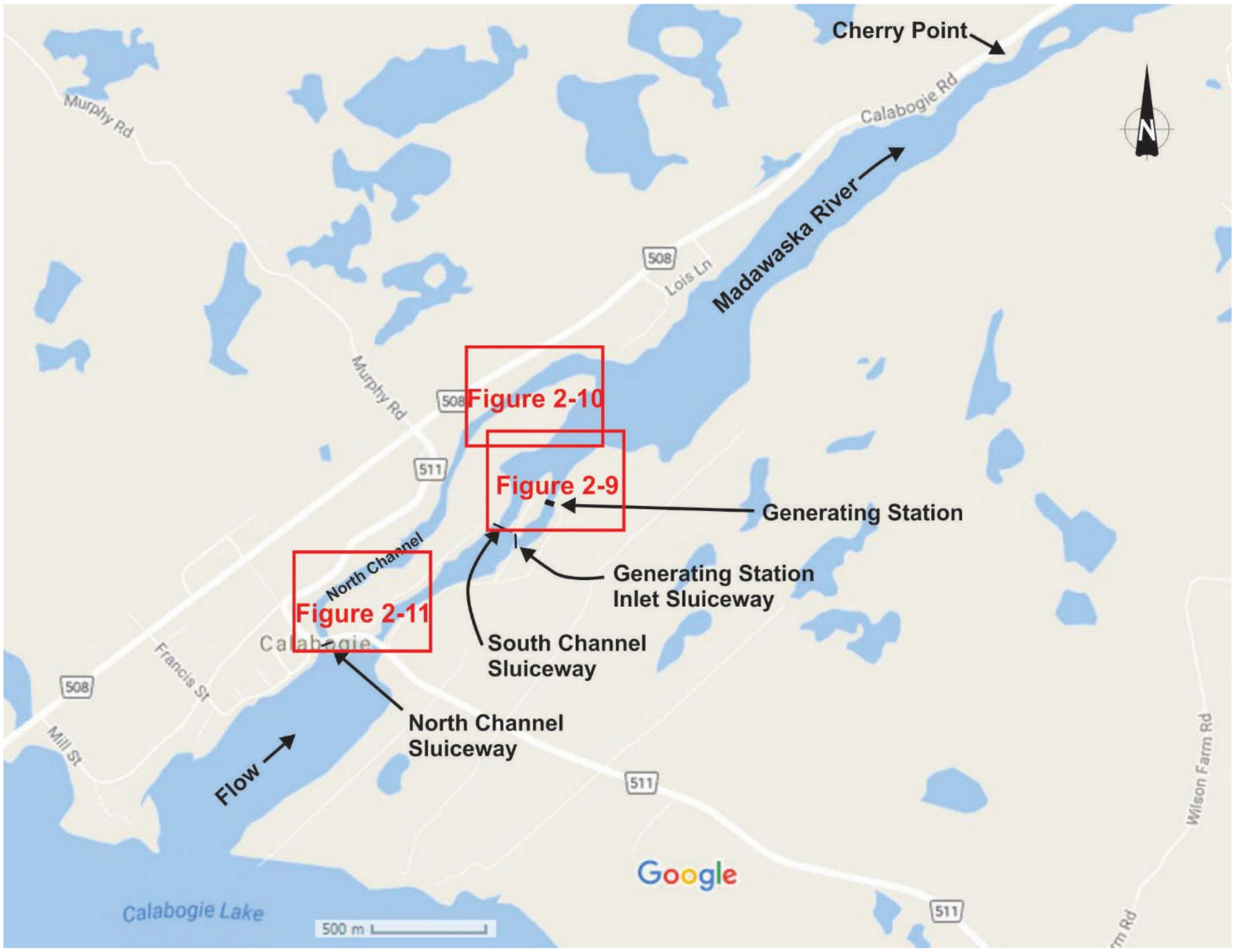


Figure 3-9. Substrate in the Vicinity of the Calabogie GS

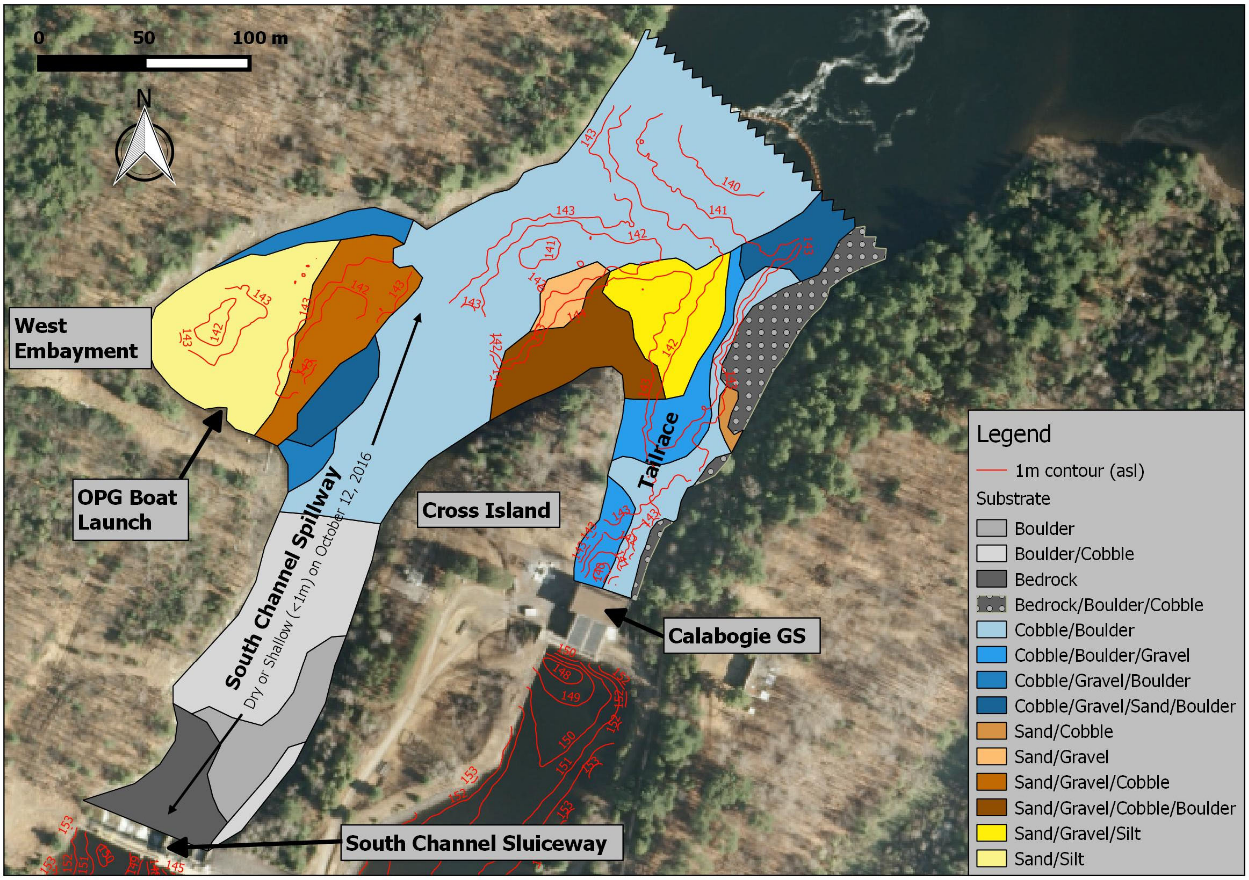


Figure 3-10. Substrate in the Downstream Portion of the North River Channel

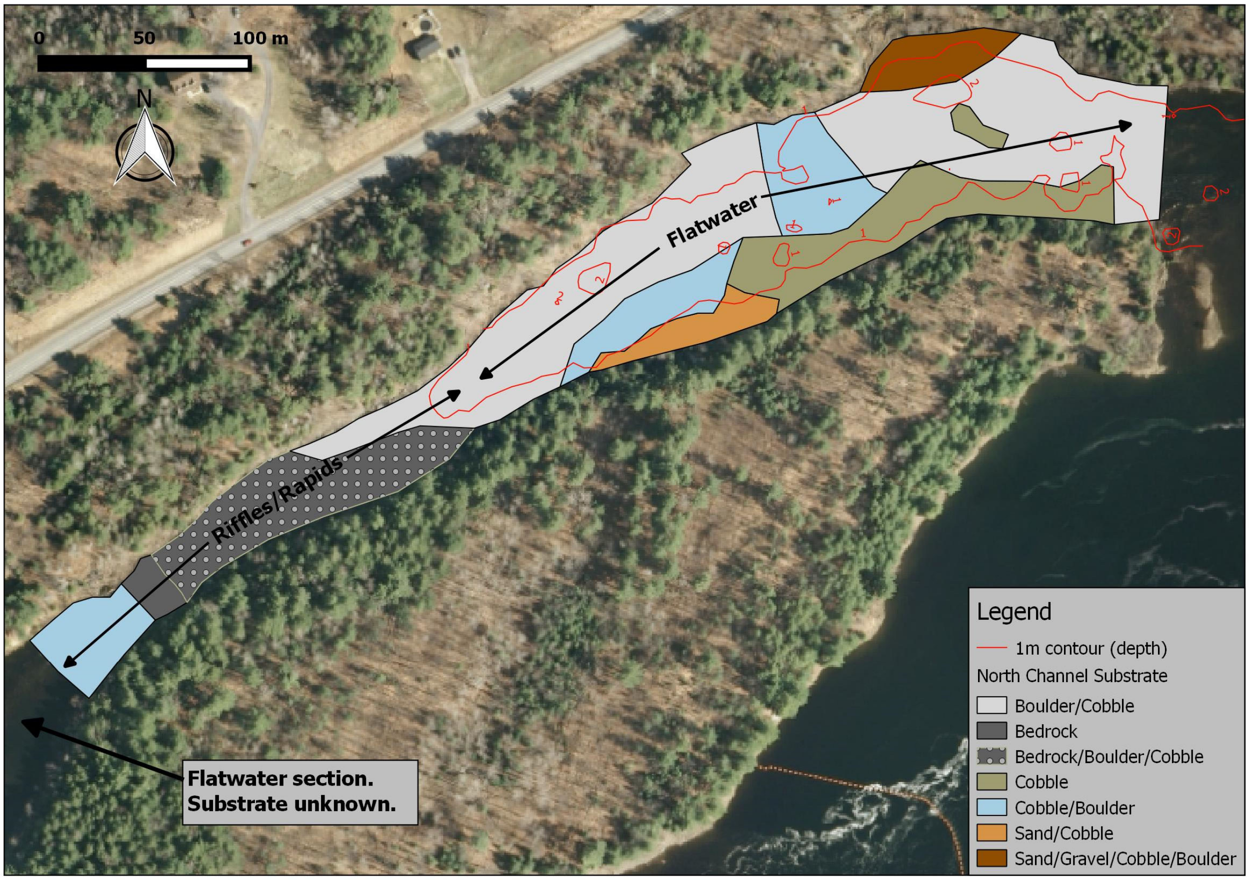


Figure 3-11. Substrate in the Upstream Portion of the North River Channel

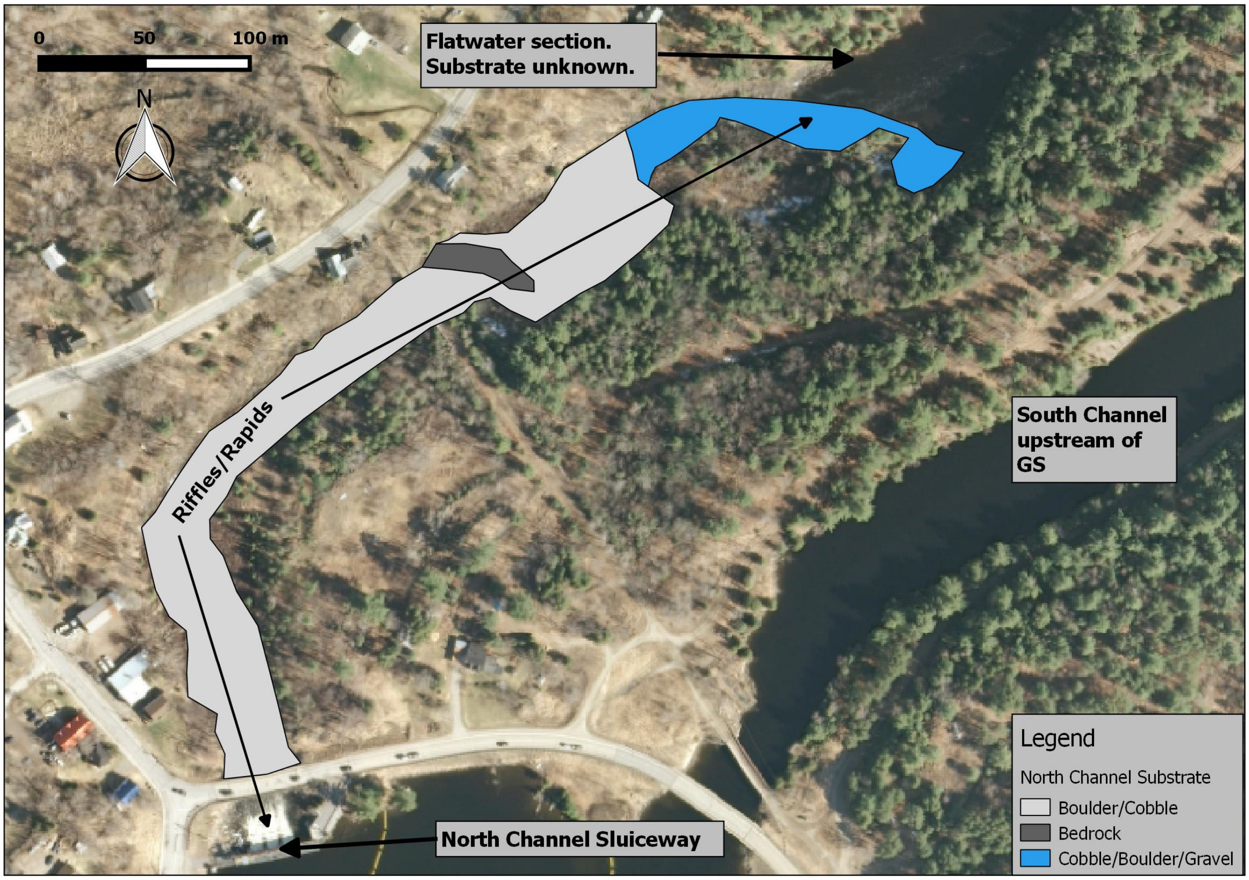


Figure 3-12. Upstream View Toward the South Channel Sluiceway from within the South Channel Spillway. Dominated by Bedrock and Very Large Boulders. October 12, 2016

Figure 3-13. Downstream View of the South Channel Spillway from Same Location as Figure 3-12. Boulder with Some Cobble. October 12, 2016

Figure 3-14. Upstream View from Just Downstream of the South Channel Spillway. Mainly Cobble with Some Boulder. October 12, 2016. South Channel Sluiceway is in the Background, on the Right Side

Figure 3-15. Predominantly Boulder, with Some Cobble, Substrate in the Downstream Portion of the Downstream Riffles/Rapids in the North Channel. June 11, 2017

Figure 3-16. Downstream View in the Upstream Portion of the Downstream Riffles/Rapids in the North Channel. Bedrock with Scattered Boulder and Cobble on Top. October 12, 2016

Figure 3-17. Upstream View in the Downstream Portion of the Upstream Riffle/Rapids in the North Channel. Mainly Cobble, with Some Boulder and Gravel. June 11, 2017

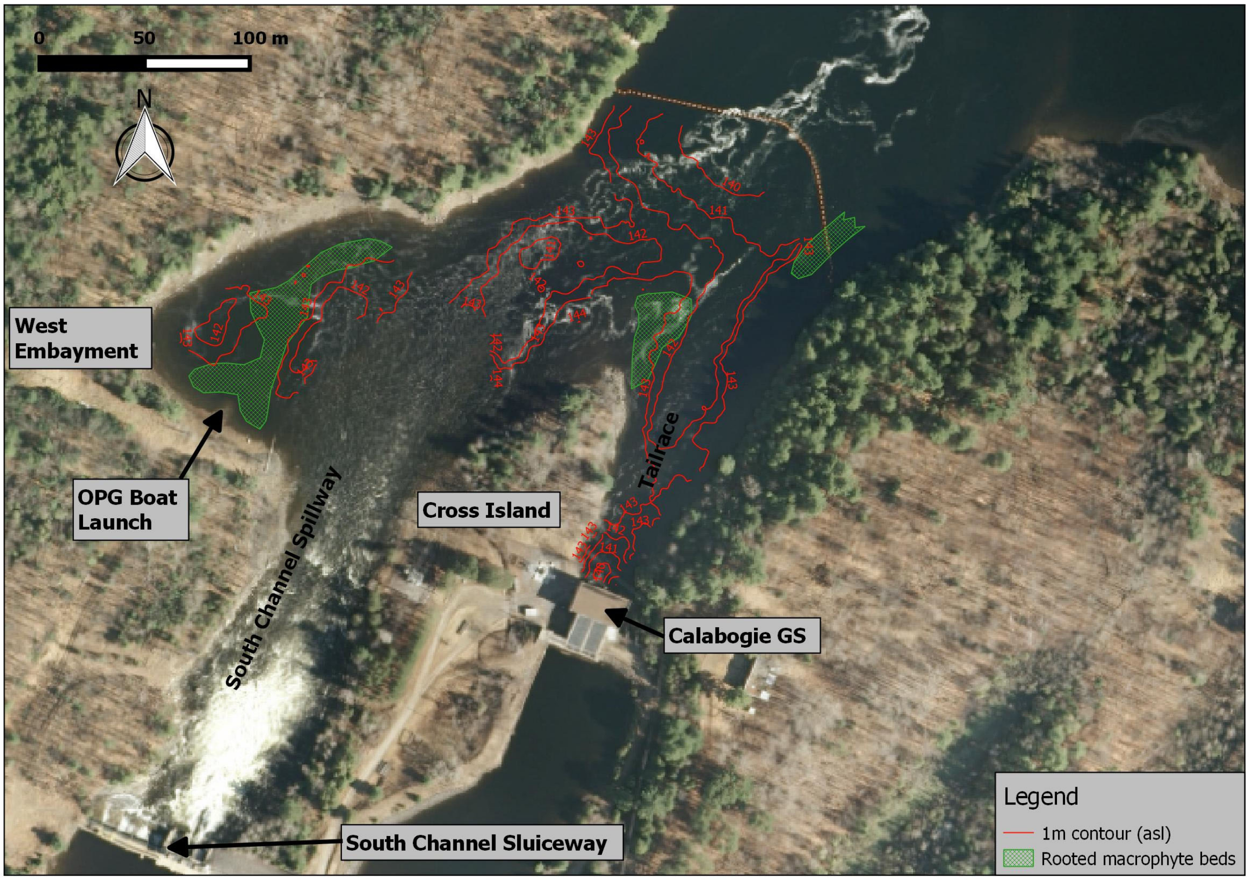
Figure 3-18. Downstream End of the Upstream Riffle/Rapids in the North Channel. Mainly Cobble, with Some Boulder and Gravel. June 11, 2017

Figure 3-19. Looking Upstream at the Dewatered Forebay. Mainly cobble, with Some Boulder, Gravel and Silt. October 18, 2018

3.2.3 Aquatic Vegetation

Rooted aquatic macrophytes (plants) were mapped in the areas that were also mapped for substrate. Dense plant beds were observed in the vicinity of the GS (Figure 3-20), coincident with deposits of finer substrates, though there were widely scattered individual plants in most locations where there was little flow velocity. Limited observations, downstream of the mapped areas near the GS to Cherry Point (Figure 3-8), also found widely scattered individual plants, but unobserved dense aquatic plant beds may also occur in small sheltered shoreline locations with finer substrates.

Figure 3-20. Rooted Aquatic Macrophyte Beds in the Vicinity of the Calabogie GS. October 12, 2016



3.2.3.1 Significant Plant Species

There are no known at-risk aquatic plants or aquatic plants that are harvested in the vicinity of the project.

3.2.4 Benthic Macroinvertebrates

No benthic macroinvertebrate studies or collections were undertaken during the field component of this study. However, during fish and fish habitat investigations, mussels were observed at various densities in areas of finer substrates, and crayfish were observed in places with hard coarse substrates. The nets of Caddisflies were observed in the tailrace and the North Channel, likely somewhat due to the consistent flows in these areas. Other Caddisflies were observed clinging to stones adjacent to the South Channel Spillway. Generally, the coarse substrates in the faster-flowing sections of the river and tailrace are likely occupied by a variety of Caddisfly species, as well as stoneflies, mayflies, Simuliidae and others, while the finer substrates in the slower-flowing sections are likely occupied by a variety of Chironomidae (midges), Oligochaetes (worms), and others.

3.2.5 Fisheries Resources

3.2.5.1 Existing Aquatic Habitat

The results of the habitat mapping are presented in Figures 3-8 to 3-11 and 3-20. Due to the safety requirement to shut down the flow through the GS and the South Channel Sluiceway during the habitat mapping for the location shown in Figure 3-9, the sloped spillway downstream of the South Channel Sluiceway had only leakage flow, resulting in some areas of the spillway being dry and the remainder shallow (Figures 3-12, 3-13 and 3-14). Flow in the spillway is highly variable, due to the fact that the Madawaska River has a managed flow regime with consistent set flows in the North Channel (for Walleye spawn and incubation: 5 m^3/s; and, minimum flow: 0.8 m^3/s) to maintain habitat there, and then through the GS and tailrace up to the maximum GS capacity to generate electricity, with whatever remains, after further allotment of water for the maintenance of upstream and downstream water levels, discharged through the South Channel Spillway. The high flows that occur at times in the South Channel Spillway have affected the substrate composition with scoured bedrock at the upstream end, immediately downstream of the South Channel Sluiceway (Figure 3-12), changing to large boulders farther from the sluiceway (Figure 3-13), and grading to smaller boulders and cobble with a small portion of sand and gravel where the spillway ends and the velocities are lower (Figure 3-14). The range of flow, and the sometimes short period of time between high (Figure 3-21) and low (Figure 3-13) flow, likely reduces the diversity of aquatic organisms that would be found in the South Channel Spillway. Areas sheltered from the flows, such as the embayment to the west of the downstream end of the South Channel spillway and the downstream end of Cross Island (Figure 3-9), have finer substrates and aquatic macrophyte beds. These different habitats will attract/support different assemblages of fish and invertebrate species.

In contrast to the South Channel Spillway, the GS tailrace is at a lower elevation and remains wetted at all water levels within the typical range of the Madawaska River (Figure 3-22). Flow in the tailrace is also quite consistent, only trending lower once the total river flow drops below the small amount of flow allotted to the North Channel plus the capacity of the GS. Consequently, the flow velocity is also less variable, without the extreme high velocities that can occur in the South Channel Spillway. A much greater number and variety of aquatic organisms, therefore, can become established in and occupy the tailrace, as compared to the spillway, making the tailrace more productive and better general fish habitat.

Figure 3-21. South Channel Spillway with Spring Flows. April 25, 2017

Figure 3-22. Calabogie GS Tailrace. April 27, 2016

The downstream riffle/rapids section of the North Channel (Figure 3-10) has substrates of boulder and bedrock with some cobble (Figure 3-16), and would likely not be considered high quality fish habitat because of the reduced substrate structure due to the significant bedrock component. Structural habitat such as boulders and cobble and gravel provide interstitial spaces and complex currents for small fishes and diverse communities of invertebrates upon which fish feed, as well spawning substrates that protect the eggs and young of larger fishes, while bedrock does not. In the deeper water downstream of the rapids, the substrate is primarily boulders and cobble (Figure 3-15), but there are finer substrates in sheltered locations closer to shore, together providing lots of habitat structure and some habitat variability to provide good general fish habitat. The upstream riffle/rapids section of the North Channel (Figure 3-11) is mainly bolder/cobble, which provides habitat for the above-mentioned invertebrates and small riffle-dwelling fishes, but there is a sizeable section at the downstream end of this set of rapids, with substrates of cobble/boulder/gravel (Figure 3-17), that could also be the best potential Walleye and White Sucker spawning habitat in the North Channel.

3.2.5.2 Fish Community Composition

A diverse community of fish is known to exist in the vicinity of the Calabogie GS (Table 3-4). The part of the Madawaska River between the Calabogie GS and the Stewartville GS is managed as a coolwater fishery (MNR, 2008), with Northern Pike, Smallmouth Bass, Largemouth Bass, Walleye, Rock Bass, Pumpkinseed, Yellow Perch, White Sucker, and Redhorses (Table 3-4). Historically, three species at-risk were present in the system: River Redhorse, American Eel, and Lake Sturgeon. Sturgeon has not been known from this portion of the Madawaska River for many years (Kirby Punt, MNRF Management Biologist, Pembroke District. Pers. comm. September 9, 2016), nor has American Eel (Kirby Punt, MNRF Management Biologist, Pembroke District. Pers. Comm. April 26, 2017). River Redhorse still occur in the system.

Small-bodied fish collections were undertaken as part of the investigations undertaken at this site in 2016 and 2017 (Table 3-5). The species found during these small-bodied fish collections are typical for the habitats sampled in this part of Ontario. The South Channel Spillway and Cross Island collections (Table 3-5) are typical for the shoreline areas of larger rivers, where there is a broad range in flow velocity adjacent to areas of faster water. The presence of Longnose Dace and Stonecat in the upper portion of the North Channel (Table 3-5), reflect the fast flowing rocky riffles at that location. The four Smallmouth Bass collected at that location were captured at the downstream end of the riffles in much slower velocity flow.

Table 3-4. Fish Species Found in the Vicinity of the Calabogie GS (MNR, 2008)

Common Name (*Scientific name*)	Upstream of Calabogie to Barrett Chute	Downstream of Calabogie to Stewartville
Lake Sturgeon (*Acipenser fulvescens*)		x
Splake (*Salvelinus namaycush* x *Salvelinus fontinalis*)	x	
Cisco (*Coregonus artedi*)	x	
Northern Pike (*Esox lucius*)	x	x
White Sucker (*Catostomus commersonii*)	x	x
River Redhorse (*Moxostoma carinatum*)	x	x
Shorthead Redhorse (*Moxostoma macrolepidotum*)	x	x
Fallfish (*Semotilus corporalis*)	x	
Northern Redbelly Dace (*Chrosomus eos*)	x	
Golden Shiner (*Notemigonus crysoleucas*)	x	x
Bluntnose Minnow (*Pimephales notatus*)	x	x
Common Shiner (*Luxilus cornutus*)		x
Spottail Shiner (*Notropis hudsonius*)		x
Brown Bullhead (*Ameiurus nebulosus*)	x	
Channel Catfish (*Ictalurus punctatus*)	x	
Banded Killifish (*Fundulus diaphanus*)		x
Trout-Perch (*Percopsis omiscomaycus*)	x	
Smallmouth Bass (*Micropterus dolomieu*)	x	x
Largemouth Bass (*Micropterus salmoides*)	x	x
Rock Bass (*Ambloplites rupestris*)	x	x
Pumpkinseed (*Lepomis gibbosus*)	x	x
Walleye (*Sander vitreus*)	x	x
Yellow Perch (*Perca flavescens*)	x	x
Logperch (*Percina caprodes*)		x
Johnny Darter (*Etheostoma nigrum*)		x

Note: During this study, Channel Catfish were observed downstream of the Calabogie GS (Table 3-8); Mimic Shiner (*Notropis volucellus*) and Iowa Darter (*Etheostoma exile*) were captured downstream of the Calabogie GS by seine (Table 3-5); and Longnose Dace (*Rhinichthys cataractae*) and Stonecat (*Noturus flavus*) were captured in the North Channel by electrofishing (Table 3-5).

Table 3-5. Results of Small-Bodied Fish Collections in the Vicinity of the Calabogie GS in 2016 and 2017

	South Channel Spillway, North side. Oct. 12, 2016	South Channel Spillway, North side. Jun. 10 and 11, 2017	Cross Island, between the tailrace and the South Channel Spillway. Aug. 16, 2017	North Channel, downstream portion. Aug. 16, 2017	North Channel, upstream portion. Aug. 16, 2017	South Channel Spillway, North side. Aug. 16, 2017
Collection method	Electrofisher	Electrofisher	Electrofisher	Electrofisher	Electrofisher	Sein
Effort	1223 s	1222 s	928 s	434 s	990 s	8 hauls
Smallmouth Bass	-	-	4 YOY	2 Juvenile	1 Juv, 3 YOY	15 YOY
Largemouth Bass	-	1	-	-	-	-
Rock Bass	-	-	2	2	-	8 YOY
Pumpkinseed	2	-	-	-	-	3 YOY
Mimic Shiner	-	1	-	-	-	-
Bluntnose Minnow	2 YOY	7	-	-	-	11 YOY
Golden Shiner	-	-	-	-	-	5
Longnose Dace	-	-	-	1 Juvenile	13	-
Logperch	10	1	4	1	-	2
Johnny Darter	7	-	-	-	-	19
Iowa Darter	-	-	-	-	-	1
Yellow Perch	-	-	-	-	-	5 YOY
Stonecat	-	-	-	-	1	-

3.2.5.3 Fish Movement

The Madawaska River is a managed river system with a number of dams that have fragmented the river into discrete sections, with little opportunity for upstream fish movement between them, though fish can be washed downstream. The Calabogie GS is the division between two of these sections. Upstream there is a short section of river and Calabogie Lake, with the Barrett Chute hydro-electric station blocking fish movement upstream from Calabogie Lake. The natural barrier to upstream movement past Barrett Chute is High Falls. Downstream is a 21.4 km section of river that has its downstream end at the Stewartville GS that also blocks upstream fish movement. At Calabogie, the North Channel has a relatively short stoplog dam at its upstream end that may be of a construction that might allow American Eel to move over the dam into Calabogie Lake, if eels are able to find their way upstream through this channel.

Fish that migrate from deeper general habitat to shallow flowing habitats to spawn, such as Walleye and White Suckers, move into the flowing waters of the tailrace, spillway, and North Channel.

3.2.5.4 Fish Spawning Habitat

To the best of OPGs knowledge no fall-spawning fishes are known to occur in the reach of the Madawaska River between the Calabogie GS and the Stewartville GS. The fish species that are present in the Madawaska River are listed, by reach, in *Fisheries Management in Renfrew County: A State of the Resource Report and a Focused Review of Fisheries Issues* (MNRF. 2008. 101 p). This document indicates that Lake Whitefish and Cisco are not present in the reach between Calabogie Dam and Stewartville Dam. Lake Whitefish and Cisco occur in the reach upstream, between Calabogie and Barrett Chute. Lake Whitefish occur in the reach downstream, between the Stewartville Dam and Arnprior. C. Portt and Associates staff (consultants to OPG) confirmed that fall spawning investigations were not required for the project with MNRF staff prior to conducting field investigations.

Of those fish listed in Table 3-4 that occur downstream of the Calabogie GS, only Lake Sturgeon, White Sucker, River Redhorse, Shorthead Redhorse, Common Shiner, Walleye and Logperch could potentially utilize habitat in the flowing water associated with the tailrace or the spillway of the GS for spawning, but potentially suitable spawning habitat is also present downstream of the GS in the Madawaska River. Walleye and White Sucker may have marginally overlapping spawning periods and spawning areas in the early spring, where they both utilize coarse substrates in shallow flowing water. River Redhorse and Shorthead Redhorse spawn over somewhat smaller substrates (i.e. gravel) later in the spring. Logperch and Common Shiner are both common small-bodied fishes that likely occur and spawn in suitable habitats in the Madawaska River downstream between the Calabogie GS and the Stewartville GS. The remaining species, including Northern Pike, Smallmouth Bass, Largemouth Bass, Yellow Perch, American Eel, etc., are not dependent upon the flowing water habitat associated with the GS for any particular life-stage.

3.2.5.5 American Eel

American Eel is listed as Endangered under the Endangered Species Act (Ontario), but is not listed at this time under the Species At Risk Act (Federal). Recent dramatic declines in American Eel abundance have occurred in the Ottawa River (COSEWIC, 2012). COSEWIC (2012) reported that eel were now only being found in low numbers below the last dam in the Ottawa River (Carillon Dam), suggesting that they may be close to extirpation there. However, while MNRF does not believe American Eel currently occur in the vicinity of the Calabogie GS, more recent sampling by the MNRF has found some eel in the Ottawa River and in the tailwater of the Arnprior GS (Kirby Punt, MNRF Management Biologist, Pembroke District. Pers. Comm. April 26, 2017).

Habitat use by eels is very diverse, and eels are frequently reported as habitat generalists in freshwater (MacGregor *et al*, 2013). Wiley *et al* (2004) evaluated the importance of 17 physical habitat, chemical, and biological variables on the density of American Eels in 5 major Maryland river basins. While the results of Wiley *et al* (2004) were generally consistent with other studies suggesting a general lack of significant stream habitat associations, velocity-depth diversity was identified as the only important habitat variable positively correlated with eel density (Wiley *et al*, 2004). American Eels also exhibit daily, seasonal, and ontogenetic (e.g. size/age) variation in habitat use (Johnson and Nack, 2013). Vegetation and interstitial spaces such as found in rock piles, logs and other complex structures, as well as deciduous leaf litter, are important to eels as cover, especially during daylight hours (MacGregor *et al*, 2013). Given the fact that American Eel is not known to display any significant stream habitat associations, it is assumed that if they were to regain their former range, they could be found in any of the habitats in the vicinity of the Calabogie GS.

The primary concern for American Eel at the Calabogie GS is whether or not they could effectively migrate upstream, and whether or not they would be able to safely pass downstream. While the South Channel Sluiceway and the GS are likely impassible to up-migrating American Eel, the North Channel has a relatively short stoplog dam (Figure 3-7: North Channel Sluiceway) at its upstream end that may be of a construction that might allow American Eel to move over this dam into Calabogie Lake. However, the North Channel conveys a small portion of the total Madawaska River flow, and the downstream confluence with the mainstream is approximately 750 m downstream from the South Channel Sluiceway and, therefore, it is believed that few eel could find their way into the North Channel (Figure 3-7). Similarly, for down-migrating American Eel the small amount of flow passing into the North Channel likely results in them following the mainstream through the spillway (during higher flows only) or, more likely, through the GS where there is a reasonably good chance that large adult eels will be killed or injured in the turbines.

3.2.5.6 Walleye

Walleye are found in lakes and streams in a wide variety of coolwater habitats (Holm *et al*. 2009). Because its eyes are light sensitive, in clear water it is typically found in deeper areas during the day, or in the shelter of sunken logs, weed beds or boulder shoals, and feeds mainly in twilight or dark periods (Scott and Crossman, 1973). In more turbid water it feeds throughout the day (Scott and Crossman, 1973).

Walleye normally spawn at temperatures of 6.7 to 8.9°C over boulder to coarse gravel (Scott and Crossman, 1973), generally in water less than 1.2 m deep (Smith, 1985), and in velocities from 0.3-1.0 m/s (McMahon *et al*, 1984). Interpretation of the graphs in Gillenwater *et al*. (2006), indicate that water velocity is optimal for Walleye spawning at 0.3 to 0.95 m/s, and marginal below 0.3 m/s or between 0.95 and 1.2 m/s. They have been known to spawn at temperatures as low as around 2ºC (Coad *et al*. 1995; Holm *et al.* 2009), and as high as 17.2ºC (Becker, 1983). Male Walleye arrive on the spawning grounds first (Scott and Crossman, 1973).

The results of the 2016 and 2017 Walleye spawning observations at Calabogie are summarized in Tables 3-6 and 3-7, respectively. Numbers of Walleye observed in the vicinity of the Calabogie GS were low relative to the numbers observed at the reference site below Barrett Chute, even though only a small proportion of the potential spawning area at the reference location could be examined.

Table 3-6. Number of Walleye Observed for Each Area on April 27 and 28, 2016. Locations and Extents for Areas 1 to 9 are Provided in Figure 3-23

Area	April 27, 2016	April 28, 2016
1 - North Channel	0	No observation
2 - North Channel	0	0
3 - North Channel	0	No observation
4 - North Channel	4 (large females)	0
5 - South Channel below sluiceway	0	0
6 - South Channel below sluiceway	0	0
7 - South Channel below sluiceway	0	3 (extreme downstream end)
8 - GS Tailrace	8 (near GS)	1 (downstream end)
9 - Cherry Point Park	No observation	3 (plus White Suckers)
10 - Barrett Chute	28+	No observation
11 - Constance Creek	1	No observation

Table 3-7. Number of Walleye Observed for Each Area on April 25 and 26, 2017. Locations and Extents for Areas 1 to 9 are Provided in Figure 3-23

Area	April 25, 2017	April 26, 2017
1 - North Channel	0	1
2 - North Channel	1	1
3 - North Channel	No observation	No observation
4 - North Channel	1	0
5 - South Channel below sluiceway	1	0
6 - South Channel below sluiceway	0	0
7 - South Channel below sluiceway	0	0
8 - GS Tailrace	1 (near GS)	1 (near GS)
9 - Cherry Point Park	No observation	No observation
10 - Barrett Chute	No observation	25+
11 - Constance Creek	No observation	0 (White Suckers only)

Figure 3-23. Locations Where Walleye and River Redhorse Spawning Surveys Were Conducted

Note to Figure 3-23. Locations where Walleye (delineated in red) and River Redhorse (delineated in yellow) spawning observations were conducted. The number labels identify the investigation areas for both Walleye spawning and River Redhorse spawning. In 2016, Walleye observations were conducted at all locations shown. In 2017, Walleye observations were conducted at the locations shown, except Areas 3 and 9, and the downstream portion of Area 2. River Redhorse observations were only conducted in 2017.

In 2016 the water temperature on April 27 at 17:25 was 7.6°C, and on April 28 at 22:00 it was 7.3°C, which is about the mid-point of the typical temperature range for Walleye spawning. In 2017 the water temperature on April 25 at 17:24 was 6.9°C, and on April 26 at 22:22 was also 6.9°C. The presence of significant numbers of spawning Walleye below Barrett Chute confirmed that the timing of the field investigations in 2016 and 2017 was appropriate.

In the vicinity of the Calabogie GS the North Channel appears to offer the most suitable flow velocities and water depths for Walleye spawning, but where suitable flow velocities occur in the downstream portion of this area the substrate in many places is either bedrock or boulders (Figure 3-24; Figure 3-10; Figure 3-16), and therefore would provide only limited potential spawning habitat. In the upper portion of the North Channel, from the North Channel Sluiceway to the downstream end of Walleye spawning observation Area 2 (Figure 3-23), the presence of some cobble and gravel substrates (Figures 3-11, 3-17 and 3-18), combined with suitable water depths and flow velocities, provides better potential Walleye spawning habitat. The flatwater sections of the North Channel, though they may have suitable substrates, do not have flow velocities suitable for Walleye spawning. In 2016, one group of four large female Walleye was observed on one night in the North Channel, in Area 4 (Figure 3-23), while no Walleye were observed in Areas 1, 2 and 3. In 2017, a single Walleye was observed in each of Areas 2 and 4 during the first night of observation, and in Areas 1 and 2 during the second night of observation.

Figure 3-24. Bedrock Dominated Section of the North Channel. April 28, 2016

The spill channel below the South Channel Sluiceway was passing the majority of spring flow at the time of the Walleye spawning observations in both 2016 and 2017, and the high turbulent flows (Figure 3-22) and bedrock and large boulder substrate (Figures 3-9 and 3-12) made this area generally unsuitable for Walleye spawning. However, there are small areas of potential Walleye spawning habitat immediately downstream from the South Channel Spillway, where the flow velocity slows and the substrate contains some patches of gravel and sand (Figures 3-9 and 3-14), which could be suitable in some years if there was significantly less flow through the spillway than was observed in 2016 and 2017. These locations could not be fully examined at night for spawning Walleye, due to safety concerns with the high flows. In 2016, a few individual Walleye were observed near shore at the extreme downstream end of the spillway (Figure 3-23: Area 7), but they appeared to be resting in slack-water areas. In 2017 a single Walleye was observed in Area 5 (Figure 3-23) on the first night of observation and none were observed on the second night.

Most of the tailrace of the Calabogie GS is considered to be deeper than typical Walleye spawning habitat, even though substrates in the tailrace might be suitable (Figure 3-9). A few areas of suitable substrate were observed in a narrow band of shallow water along the north side of the tailrace (see substrate in Figure 3-22), but the flow velocity there was too slow to be optimal for Walleye spawning at the time of the field observations. Regardless, low numbers of Walleye were observed in the tailrace in 2016 and 2017, indicating that they are attracted to it. In 2016 eight Walleye were observed in an eddy on the north side of the tailrace just downstream from the GS on April 27, and one Walleye was observed at the downstream end of the tailrace on April 28, 2016 (Table 3-6: Area 8). In 2017 only one Walleye was observed in the tailrace on each of the two nights of observation (Table 3-7: Area 8). No young-of-the-year Walleye were captured in the small-bodied fish collections undertaken in the vicinity of the Calabogie GS in 2016 and 2017 (Table 3-5).

The South Spillway does not reliably provide habitat suitable for Walleye spawning under current conditions. The volume of flow through the South Spillway during the walleye spawning period varies from zero (except for dam leakage) in dry springs to >400 cms (refer to graph in response to comment 41) in a wet year. At zero flow through the spillway there is abundant suitable spawning substrate (Rosien, 1999) but velocities would not be conducive to walleye spawning except at the very base of the dam where leakage would result in higher velocities than in most of the spillway. At high spill rates velocities in most of the South Spillway are too high for walleye to spawn there (Tarandus, 1991, 1992; this study).

Tarandus conducted a Walleye spawning study in 1992 that included the South Spillway and reported that “minimal suitable walleye spawning habitat exists in the spillway” mainly due to the substrate and relatively high water velocities and no walleye eggs were found there post-spawning (Tarandus 1992, cited in Pope, 1999). Tarandus (1992) did find walleye eggs in the North Channel. Pope (1999) reported that local residents regarded the North Channel to be the main spawning area. A spawning study conducted by Rosien in 1999, when spring flow was low and there was no spill through the South Spillway, found that numbers of Walleye observed during the spawning season were higher downstream at Cherry Beach Rapids than in either the South Spillway or the tailrace at Calabogie (Table 3-8). Rosien (1999) stated that the due to adverse conditions at this site during high flow freshets, the South Spillway is dependent upon low flow freshets that warrant reduced spilling in order to be suitable for spawning.

Table 3-8. Number of Walleye Observed During Night Spawning Surveys in 1999 (Rosien, 1999)

Cherry Beach rapids		Date	Number of Walleye	
Date	Number of Walleye		Calabogie GS Spillway	Calabogie GS Tailrace
19-Apr-99	3	19-Apr-99	0	2
21-Apr-99	38	22-Apr-99	7	6
24-Apr-99	33	24-Apr-99	0	1
26-Apr-99	41	26-Apr-99	3	1
28-Apr-99	24	28-Apr-99	1	4
2-May-99	6	2-May-99	3	3

With the existing generating station conditions in the south spillway range from extremely high flows and velocities during peak flows, typically during spring freshet, to zero flow and velocity during periods when there is no flow through the spillway. At peak flows the upper portion of the South Spillway has velocities so high that it is probably not occupied by fish; if it is it will be by species that are tolerant of high water velocities (i.e. longnose dace) that can shelter among boulder. At low flows and velocities that area is suitable for a wide range of species (walleye, centrarchids, catostomids, most cyprinids), but less so for species that prefer higher velocities (i.e. longnose dace).

3.2.5.7 River Redhorse

River Redhorse has been found in recent years in the vicinity of the Calabogie GS. This species is listed as Special Concern under the ESA and as Special Concern on Schedule 1 of SARA.

Adult River Redhorse have been reported from both rivers and lakes, but it relies on rivers for spawning (DFO, 2016). The River Redhorse is primarily an inhabitant of the deeper portions of moderate to large rivers, where the water is relatively clear and fast flowing, substrates are clean stones, rubble, and bedrock, and where siltation is at a minimum (Trautman 1981; Parker, 1988; Smith, 1979). Like most *Moxostoma* species, it is reportedly intolerant of turbidity, siltation, and pollution (Trautman, 1981; Smith, 1979; Parker and McKee, 1984).

Parker (1988) reported that River Redhorse is not often captured in sluggish environments with an abundance of macrophytes and/or soft sediments such as sand and silt. However, young-of-the-year in the Richelieu River, Quebec, are found along vegetated shores with substrates of silt, clay and sand, at an average depth of 1.5 m (3 m maximum), and age 1+ specimens are found in greater abundance in vegetated areas in the early spring (COSEWIC, 2006). Jenkins and Burkhead (1993) reports that adults apparently avoid the shallow portions of pools, but young and small juveniles often are found there and in backwaters. Yoder and Beaumier (1986) reported that in the Sandusky River the highest numbers of River Redhorse were found in habitats with moderate to swift current, riffle/run structure, and convoluted bedrock, boulder, rubble, and gravel substrates. Similar habitat attributes are present in the Mississippi River, Ontario, where they were captured in fast-flowing pools in a 300 m long chute and in the plunge-pool of a waterfall (Parker and McKee, 1984).

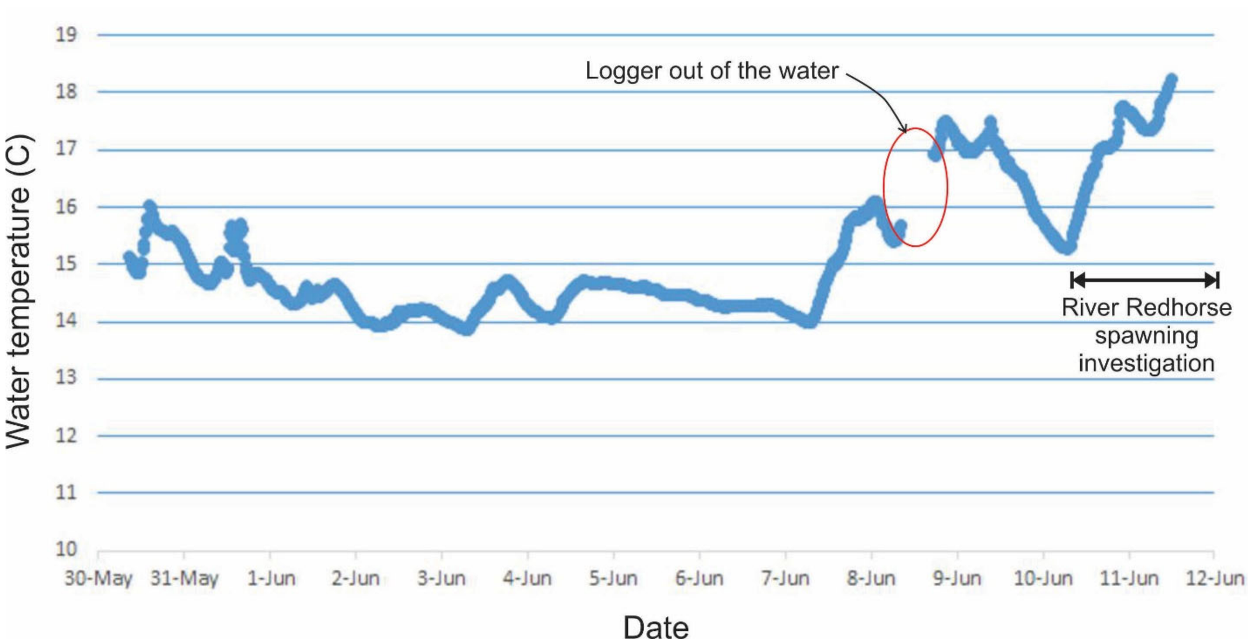
Spawning of River Redhorse reportedly occurs at water temperatures of 18-24.3°C, over gravel or gravel/cobble/rubble shoals at depths of 0.2-1.2 m, and where water velocity is 0.6-1.0 m/s (Jenkins and Burkhead, 1993; Becker, 1983). However, in northern populations spawning is known to occur at water temperatures of 17-20°C (COSEWIC, 2006). At a location on the Trent River in Ontario, River Redhorse were captured and observed in aggregations over a shallow shoal, in spawning condition (*i.e.* runny milt or eggs) on June 3 and 11, 2002, when water temperature was 16 and 17°C respectively (Scott Reid, personal communication), and some of the females were spent on June 11, 2002. At this same Trent River location on June 4, 2009, when water temperature was 16.1°C, a spawning aggregation of approximately 8-10 River Redhorse were observed within a small area of distinct habitat, less than 1 m deep with substrates of gravel, cobble and some sand (G. Coker, personal observation).

Investigations for River Redhorse spawning were conducted on May 29 and June 10, 11, and 12, 2017. Upon arrival at the Calabogie GS on May 29, 2017, it became apparent that it was too early for River Redhorse spawning, since the water temperature was only 14.5°C, and the known spawning temperatures for other Canadian populations is a minimum of 16°C. Regardless, the area below the South Channel Spillway and within the GS tailrace were examined from a boat for spawning River Redhorse with an underwater video camera. The shallow downstream section of the North Channel was also examined from a boat, and the nearshore of Cherry Point was examined from shore, but no River Redhorse were observed. A temperature logger was deployed in a shaded area within the tailrace to record water temperatures at 15 minute intervals (Figure 3-25).

The second attempt to observe spawning of River Redhorse was initiated on June 10, 2017, when water temperature was within the known spawning range for River Redhorse (Figure 3-25). The results of roving boat-based video investigations are presented in Table 3-8. Two River Redhorse were observed using this method, but they were not part of any spawning aggregation and were likely foraging.

An action camera on a weighted tripod was deployed in the outwash from the Spill Channel (Figure 3-23: Area 5) on June 10, 2017, and recorded 8 minutes of useable video, in which no fish were observed. Another Action Camera deployment in the tailrace (Figure 3-23: Area 8) on June 11, 2017, recorded 19 Smallmouth Bass, 5 Shorthead Redhorse, and 2 River Redhorse over 80 minutes of video. These redhorses in the tailrace appeared to be foraging in the swift current among the cobble and boulders which comprised the substrate in this portion of the tailrace.

Figure 3-25. Water Temperature Taken at 15 Minute Intervals in the Calabogie GS Tailrace. May 30 – June 11, 2017



An aggregation of spawning River Redhorse (Figure 3-26) was observed at the downstream end of Area 9 (Figure 3-23) on June 11 and 12, 2017, at water temperatures of 18.2-18.3°C. These fish were in a limited, somewhat protected location adjacent to a set of rapids, where complex currents result in a deposit of gravel/sand among protruding boulders. The River Redhorse were observed spawning in the gravel/sand deposit at water depths of 1-2 m, in the current. No River Redhorse were observed at any other location in Area 9 searched by direct observation from the water surface, either from shore or from the boat, on June 11 (Figure 3-23). Areas where it was thought that habitat similar to this spawning area was present were re-examined on June 12, including the downstream portion of Area 4, areas of sand and gravel deposits on the north side of Area 5, and the downstream portions of Areas 7 and 8 (Figure 3-23). None of these locations proved to have the same habitat conditions as were observed at the spawning location in Area 9, and no spawning fish of any type were observed. Therefore, the only known spawning location for River Redhorse in the vicinity of the Calabogie GS is in the small location within Area 9 (Figure 3-23). No young-of-the-year River Redhorse (or of any other sucker species) were captured in the small-bodied fish collections undertaken in these areas in 2016 and 2017 (Table 3-5).

Table 3-9. Roving Boat-Based Observations using an Underwater Video Camera. June 10-12, 2017

Area	Date	Number of passes (total time)	Fish observed
Area 4 (North Channel)	June 10	2 (17min: 3sec)	1 White Sucker 1 Smallmouth Bass 1 River Redhorse
	June 11	1 (12min: 30sec)	1 Smallmouth Bass
Area 5 (spillway north side)	June 10	6 (20min: 10sec)	9 Smallmouth Bass
	June 11	7 (19min: 10sec)	2 Smallmouth Bass
	June 12	1 (2min: 30sec)	no fish
Area 7 (spillway south side)	June 10	2 (10min: 50sec)	2 Smallmouth Bass 1 Channel Catfish
	June 11	2 (8min: 0sec)	1 Smallmouth Bass
	June 12	1 (4min: 30sec)	1 Smallmouth Bass
Area 8 (GS tailrace)	June 10	5 (24min: 40sec)	5 Smallmouth Bass 1 River Redhorse 1 Walleye 1 unidentified fish (distant)
	June 11	3 (7min: 15sec)	2 Smallmouth Bass
	June 12	1 (3min: 15sec)	no fish
Area 9 (Cherry Point)	June 10	7 (16min: 25sec)	1 Channel Catfish
	June 11	3 (9min: 30sec)	1 unidentified fish

Figure 3-26. River Redhorse in the Madawaska River at Cherry Point, Resting Adjacent to the Spawning Area. June 12, 2017

3.2.6 Significant Species

There are three aquatic species-at-risk that are known to have occurred in the vicinity of the Calabogie GS. These are Lake Sturgeon, American Eel, and River Redhorse. Lake Sturgeon and American Eel no longer occur here, but the River Redhorse does. Assessments at Calabogie, for American Eel and River Redhorse, are provided above in sections 3.2.5.5 and 3.2.5.7, respectively.

4 EFFECTS ASSESSMENT AND MITIGATION MEASURES

The available environmental baseline information and site-specific investigations, provided the basis for an assessment of potential construction and operational effects of the proposed Calabogie Generating Station Redevelopment Project on the aquatic environment.

Recommended mitigation measures for the potential effects on the terrestrial environment considered best industry practices and various sources such as OWA (2012b) "Best Management Practices Guide for the Mitigation of Impacts of Waterpower Facility Construction", standard environmental construction guidelines, e.g., Cheminfo (2005), DFO Ontario Operational Statements, as well as government agency and other organization consultation.

The selection and application of measures to mitigate potential effects of proposed construction and operation are based on the following five principles:

1. Avoidance of sensitive areas, where practicable, through siting of facilities.
2. Appropriate timing of construction activities, whenever practicable, to avoid sensitive time periods, e.g., vegetation clearing outside migratory bird nesting periods.
3. Construction in wetlands or areas too wet to access should be undertaken during frozen or dry conditions.
4. Implementation of conventional, proven mitigation measures during construction, e.g. OWA (2018) Class Environmental Assessment for Waterpower Projects Appendix B – Examples of Typical Mitigation Measures; Environment Canada "Best Practices for the Reduction of Air Emissions from Construction and Demolition Activities" (Cheminfo, 2005); "Best Management Practices Guide for the Mitigation of Impacts of Waterpower Facility Construction" and Hydro One (2008) "Environmental Guidelines for the Construction and Maintenance of Transmission Facilities".
5. Development of environmental enhancement/compensation measures to offset the unavoidable effects of construction and operation.

The significance of potential impacts was based on their magnitude, duration and extent after the implementation of recommended mitigation measures.

4.1 Potential Construction Effects and Associated Mitigation

4.1.1 Surface and Groundwater Hydrology

Other than the Madawaska River there are no other watercourses or water features within the Calabogie GS property. There is a wetland on the adjacent Township lands that is discussed in more detail in the Terrestrial Environment TSD.

During construction water will not pass through the powerhouse and therefore all water will flow around the GS through the existing South Channel Sluiceway.

With respect to groundwater quality, Golder, in their Phase II Report (2001), identified that the Madawaska River is considered a regional groundwater discharge area and based on that it is unlikely that the Calabogie site could impact the groundwater of nearby drilled wells.

> *"Direct groundwater contact via ingestion (GW-1 pathway for on- and off-site users). There are presently no drinking water wells on site. The Village of Calabogie, located approximately 0.5 km upgradient of the site, receives their water supply from private wells.*
>
> *It is likely that groundwater from the site flows toward the Madawaska River, and given that the distance to the nearest downgradient groundwater user is greater than 1 km upgradient of the site, it is unlikely that groundwater used as drinking water would be affected. Therefore, off-site ingestion by people would most likely not lead to exposures to chemicals of potential concern present in groundwater. " (Golder, Phase II, section 5.5)*

As described in the Project Description in Chapter 2, excavation of the new powerhouse and forebay area will be required for the project to occur, consideration will need to be given to groundwater infiltration into this excavated area. Groundwater infiltration into this excavated area is expected and the anticipated flow rate along with the duration of construction, a Permit to Take Water is likely required. To combat the water infiltration, sumps will be blasted into key areas of the excavation and pumps will be installed to dewater the area. If necessary, the water will be pumped into settling pond(s), silt treatment bags, and vegetated areas to mitigate any environmental issues that may arise from the dewatering. Should the groundwater require secondary treatment for dissolved metals, proper measures will be taken.

4.1.2 Water Quality

During construction, water quality in the Madawaska River and groundwater may be affected by soil erosion and turbidity generation, in-water construction activities, blasting, acid rock drainage, incidental spills and/or waste material dispersion, and stormwater.

Overall, based on the mitigation measures described below, the effects of the construction of the proposed Project on water quality are expected to be localized, temporary and negligible.

4.1.2.1 Erosion and Sediment Control

There is a risk to the Madawaska River by sediment loadings due to accelerated soil erosion during construction. Till and gully erosion caused by channelized overland flow can also be a major source of soil erosion to the watercourses. Sheet erosion can be an additional source of sediment.

Erosion and sediment control will be an integral component of the construction planning process. All personnel involved with the proposed works will be briefed on erosion and sediment control including engineers, contractors, inspectors and environmental staff.

Sediment and erosion control measures should be implemented as required prior to work and maintained during the work phase, to prevent entry of sediment into the water. This should include sediment removal from water pumped from within the work areas such as the powerhouse foundation area, draft pit and tailrace excavation. It should also include the use of silt curtains or cofferdams, if appropriate, during any in-water work to prevent deleterious substances from entering fish habitat.

The MoECC has directed OPG (Orpana, MoECC, 2018) that if and "Where dredging is required, consideration should be given to appropriate storage, handling, dewatering and disposal of excavated material. Excavated materials must be disposed of in accordance with this Ministry's legislation and guidelines. Guidance on nearshore construction and dredging may be obtained from this Ministry's *Guidelines for Evaluating Construction Activities Impacting on Water Resources* dated January 1995 and *Evaluating Construction Activities Impacting on Water Resources, Part III A, Part III B, and Part III C* dated February 1994."

As previously explained, the construction of the new GS at Calabogie will require a significant amount of sediment and rock to be removed from the forebay area. It is estimated that approximately 16,000 cubic meters of sediment and 47,000 cubic meters of rock would need to be removed.

In the summer of 2018, sediment and soil samples were collected from 13 test pits in the Forebay and in the vicinity of the Powerhouse. Soil sampling was collected from 5 boreholes drilled in various areas across the site. Laboratory analyses were completed by ALS Canada Ltd. in Ottawa, Ontario, for detection of potential contaminants of concern (PCOC). These were compared to soil and sediment site condition standards of Tables 1 and 8 of O. Reg. 153/04. Some sediment in the bed of the forebay contained concentrations of selected metals that exceed the MOE Table 1 and Table 8 site condition standards. As well, some soil in the vicinity of the Powerhouse, the forebay retaining wall and in the forebay contained concentrations of selected metals, PHCs and PAHs that exceed MOE Table 1 and Table 8 site condition standards. Composite soil sample TCLP leachate analyses suggest that soil and sediment at the site would be classified as solid non-hazardous waste if disposed at a landfill.

It is Arcadis' understanding that the rock is uncontaminated and non-acid generating and, therefore, can be re-used on OPG's property without restrictions. However, because of the exceedances with respect to the sediment it is our understanding that OPG can place the sediment on site but it is recommended that it not be placed within 30 meters of any surface waterbody and that actions may be required to mitigate risks to the environment from the emplaced sediment. MoECC provided concurrence with this approach in an e-mail dated May 6, 2019 (MacLeod, 2019). The Site Plan presented in the Project Description as Figure 2-5 depicts the soil/sediment deposition areas. OPG is not aware of any other contaminated soils at the Calabogie site.

Management of dredged material and control of runoff will be addressed by the site-specific Sediment and Erosion Control Plan and Stormwater Management Plan to be prepared by the DBC.

During construction, the removal of natural shoreline vegetation should be minimized, and consideration made to armour potentially affected shoreline proximate to the proposed GS.

In general, the following guidelines will be applied in the development of the Erosion and Sediment Control Plan:

- fitting of proposed works to the terrain (i.e., using the natural topography of the land in the placement and organization of the construction site);
- timing of grading and construction activities to minimize soil exposure;

- retention of existing vegetation where feasible;
- restriction of the use of heavy construction equipment to within the approved work areas to minimize soil disturbance and vegetation destruction;
- storage of stripped soil at upland locations with a minimum of 5 m from the edge of the River;
- implementation of erosion control measures, e.g., rip-rap berms underlain by filter geotextile, straw bales used as filters, silt fencing along the shoreline and/or mulching for interim stabilization;
- diversion of runoff away from exposed areas;
- minimization of the length and steepness of slopes;
- maintenance of low runoff velocities;
- design of drainage works, such as ditches and outfalls, to handle concentrated runoff;
- retention of sediment on site;
- routine inspection and maintenance of erosion and sediment control measures; and
- re-vegetation of disturbed areas by seeding and/or planting following construction as soon as seasonal conditions permit.

The use of settling ponds will require Environmental Compliance Approvals under the *OWRA*. The DBC will be responsible for the final design of the settling ponds, including locations of such works, treatment options, volumes, discharges to the environment, proposed monitoring plans and effluent criteria for parameters of concern (e.g., pH, TSS, turbidity, hydrocarbons, total ammonia).

As indicated in the Terrestrial Environment TSD, site-specific Erosion and Sediment Control Plans, addressing the construction will be prepared and implemented during construction. The site-specific Erosion and Sediment Control Plans will be part of a broader Environmental Management Plan.

With the implementation of the site-specific Erosion and Sediment Control Plans, the potential effects of soil erosion and turbidity generation will be minimized or obviated.

4.1.2.2 In-Water Construction Activities

As indicated in Chapter 2 (“Project Description”), OPG intends to minimize all in-water works by constructing work in the dry. The forebay area for the new powerhouse has been isolated by closing off the existing inlet structure (carried out under a separate permitting process).

Following the July 15th fish window, an upstream cofferdam will be constructed to allow removal of the existing inlet structure in the dry and rock excavation to continue (see Figure 2-9). A fish salvage plan will be developed for the project and any fish will be collected and liberated into appropriate adjacent habitat. A mussel relocation will occur as part of the fish relocation program if they are present during cofferdam dewatering.

The upstream cofferdam will be constructed from blasted rock that has been excavated to accommodate the new powerhouse. Blast rock will be used to construct a 5.8 metres wide cofferdam, with a slope of 1.5H:1V up to elevation 155.17masl. The upstream face of the cofferdam will be lined with a heavy-duty cofferdam membrane and sealed to the riverbed with a bentonite clay seal. Upon completion of the powerhouse, the liner, blasted rock and overburden will be removed, and the channel will be graded with rockfill.

A downstream cofferdam is required to isolate the downstream side of the construction and allow for: the demolition of the existing powerhouse and construction of the new powerhouse and tailrace. The proposed cofferdam is a rockfill dam with an impervious geomembrane on the water side of the cofferdam. Seepage through the cofferdam will be collected and directed to a settling pond prior to discharge back into the river.

The downstream side of the site can be isolated by the cofferdam shown in Figures 2-7 and 2-9. Cofferdam and other in-water work installation will be undertaken outside the designated in-water construction exclusion period, which is from March 15 to July 15. The area from upstream cofferdam to downstream cofferdam is approximately 22,000 m^2. The duration of the dewatered forebay is 9 months for the upstream side (from upstream cofferdam to intake) and 13.5 months for the downstream side (from tailrace to d/s cofferdam). The 9 month duration for the upstream occurs during the 13.5 month duration downstream.

Temporary cofferdam construction will require the use of heavy equipment along the shoreline and on the rockfill wall as it is built up around the sites. An impervious geotextile will be placed on the cofferdam face to preclude water ingress. The work will also involve dewatering to the area downstream of the cofferdam and as necessary the placement of erosion control structures. Fish within the area to be dewatered will be collected by electrofishing/netting during drawdown and released to the Madawasaka River under a Fish Scientific Collectors Permit obtained from MNR under the *Fish and Wildlife Conservation Act*.

The use of clean rock fill, the placement of rock fill over similar coarse substrate at the intake weir location and judicious selection of the discharge location and water pressure during dewatering will minimize potential effects of in-water construction activities on water quality in the Madawaska River. The placement of rockfill over finer substrate in the Madawaska River will result in resuspension of bottom sediments resulting in temporary and localized increased turbidity prior to redeposition. Similarly, the removal of the cofferdam in the Madawaska River will result in temporary and localized increased turbidity.

Cofferdam installation and removal will comply with the conditions of the Work Permit issued by the MNR.

Water taking requirements for dewatering activities (e.g., types, location, water taking rates and volumes) will be defined in the detailed engineering design prepared by the DBC.

4.1.2.3 Use of Explosives

Blasting will likely be required to remove the rock for the new powerhouse and in the forebay and potentially for the removal of the piers at the existing upstream control structure. A third-party firm will be hired to implement a vibration monitoring program, provide engineered blast designs, and consult in all blasting operations as required. Any residual by-product of explosive material will be fish friendly.

Explosives used in construction will be closely controlled, with their use restricted to authorized personnel who have been trained in the use of explosives in a manner so as to minimize impacts on the environment.

Appropriate government agencies and local residents will be informed of the blasting schedule in advance of construction, as well as just prior to the detonation program. All necessary permits will be obtained by the DBC, who will also comply with all legal requirements in connection with the use, storage and transportation of explosives, including, but not limited to, the *Canada Explosives Act* and the *Transportation of Dangerous Goods Act*. The DBC will be required to retain a consulting engineer with technical expertise in blasting to provide advice on maximum loading of explosives for all blasting, as well as an engineering report indicating recommended charges and blasting methods to be used at specific locations. All blasting will occur in such a way as to be in compliance with federal regulations and directions.

Blasting could have a potential effect on groundwater quality and flow in the immediate vicinity of the blasting operations. It has been estimated that peak particle velocities produced from blasting operations in excess of 600 mm/s will cause cracks and discontinuities in sedimentary rock up to a 5 m radial distance from the blast using the sophisticated techniques and control measures employed in modern blasting practice (L. McAnuff, VME/Explotech Associates Ltd., 1991). Damage (seam creation) will be less and more localized in Precambrian rocks. Minimization of the physical effects of blasting will be ensured by following the recommendations of the blasting engineer.

The DFO has developed a number of Operational Statements on methods and practices which are intended to prevent or avoid the destruction of fish, or any potentially harmful effects to fish habitat that could result from the use of explosives (Wright and Hopky, 1998). The use of temporary cofferdams to permit blasting within the dewatered areas and adherence to the DFO Guidelines and blasting engineer recommendations will avoid the death of fish and/or any permanent alteration to, or destruction of, fish habitat.

4.1.2.4 Acid Rock Drainage Potential

Acid base accounting (ABA) was carried out by WSP as part of the geotechnical investigation in 2016 (WSP, 2016). Three samples were completed in the investigation area and it was determined that there was no potential for acid rock drainage.

4.1.2.5 Management and Control of Hazardous Materials, Construction Wastes, Groundwater and Incidental Spills

Management and control of hazardous materials, construction wastes, groundwater and incidental spills is described in detail in the Terrestrial Environment TSD and takes into account best industry practices listed at the beginning of Chapter 4.0.

In summary, all materials and equipment used for the purpose of site preparation and proposed Project completion should be operated and stored in a manner that prevents any deleterious substance (e.g., petroleum products, debris, etc.) from entering the water. Incidental spills of oil, gas, diesel fuel and other liquids to the environment could occur during construction. Fuelling and lubrication of construction equipment should be carried out in a manner that minimizes the possibility of releases to the environment. Measures for containment and cleanup of contaminant releases should be followed to minimize contamination of the natural environment, e.g., placement of fuel tanks and generators on an appropriate form of containment where possible, monitoring and other measures documented in the Environmental Management Plan. At all times where spills are a risk, appropriate materials for cleanup and approved disposal locations should be available. Spills or other discharges should be reported to the MOE as required by provincial legislation. Interim sanitary waste collection and availability of treatment facilities should be arranged for the duration of the construction period. All construction waste, washwater and wastewater should be disposed of in accordance with regulatory requirements.

During powerhouse construction, there is a potential for accidental loss of cement during surface application. Any dripped cement should be recovered from the river bottom for suitable disposal. All trash and other solid debris should also be collected for appropriate disposal.

As described in Section 3.1.2, Groundwater, there were several PWQO exceedances in the existing groundwater quality. As such, groundwater is/may be expected to infiltrate into areas were construction below grade is occurring, WSP recommended the groundwater will need to be properly treated prior to discharge to surface waters unless the MoECP provides approval of elevated concentrations during the construction period. Mitigation options include filtration of discharge water to reduce heavy metals content but also may require further methods such as polymerization/chemical coagulation and filtration or chemical reduction processes specifically designed for the type of groundwater and flow rate (WSP, 2016). Should the groundwater require secondary treatment for dissolved metals, proper measures will be taken. Monitoring of the groundwater will be required as will the efficacy of the treatment system. The DBC will need to review approval requirements with the MoECP which may include an Environmental Compliance Approval or mobile Certificate of Authorization. Other options could be considered.

A Hazardous Materials Management Plan, Waste Management Plan and a Spills Emergency Preparedness and Response Plan will be developed as part of the broader Environmental Management Plan. The implementation of these pollution prevention plans will obviate or minimize the environmental effects of accidental releases to the natural environment that have the potential to affect surface water and groundwater quality in the proposed Project area.

4.1.2.6 Stormwater Management

The final site grading and elevations will be designed to minimize erosion and manage stormwater.

4.1.3 Aquatic Habitat

As indicated in subsection 2.1.5 of the Provincial Policy Statement (OMMAH, 2005), development and site alteration shall not be permitted in fish habitat except in accordance with provincial and federal requirements. The following sections present the recommended mitigation measures to be implemented for the proposed CGSRDP to meet regulatory requirements.

4.1.3.1 Timing of In-Water Construction

In-water construction activities should be timed to avoid the spawning and egg incubation period of spring spawning fishes, such as Walleye. According to the MNRF in-water work guidelines for the southern region of Ontario (https://www.ontario.ca/document/water-work-timing-window-guidelines), and due to the presence of Walleye, Northern Pike, Smallmouth Bass, Largemouth Bass, and other spring spawning species (e.g. River Redhorse, Shorthead Redhorse, White Sucker) in the Madawaska River, the broadest in-water work exclusion period, from March 15 to July 15, will apply.

The area between the temporary cofferdam at the downstream end of the tailrace and the existing control structure at the upstream end of the forebay will be dewatered during construction. An impervious geotextile will be placed on the cofferdam face to preclude water ingress. Fish within the area to be dewatered will be collected by electrofishing/netting during drawdown and released to the Madawaska River. The temporary unavailability of this habitat during the construction period will have negligible effect on the local fish populations.

4.1.3.2 Use of Explosives

Blasting of bedrock will be required in the areas to be excavated within the dewatered area. Numerous studies have been undertaken to assess fish mortality due to in-water blasting (e.g., Hubbs and Rechnitzer, 1952; Fry and Cox, 1953; Ferguson, 1962; Foye and Scott, 1965; Chamberlain, 1976, 1979; Teleki and Chamberlain, 1978; McAnuff and Booren, 1989; Keevin *et al.,* 1997). The degree of blasting impact on fish will depend on the type of explosive, type of substrate blasted, blasting technique, fish physiology and timing. Injury to fish from in-water blasting will result from physical abrasion from ejected debris and from pressure changes associated with the blast shock waves.

Common blast-induced injuries to fish include haemorrhage in the coelomic or pericardial cavity and rupture of the swim bladder. Differences in species-specific susceptibility to blast injuries are a function of the fish's shape and swim bladder formation (Teleki and Chamberlain, 1978). Physoclistic (with swim bladder isolated from oesophagus) and laterally compressed fish such as the centrarchids, e.g., Smallmouth Bass, are the most sensitive to pressure changes. Mortality within this group varies with orientation of the laterally-compressed body to the pressure front at the time of a blast. Physostomic (with swim bladder connected to the oesophagus by an open duct, which provides pressure release) fish with fusiform shape, such as the White Sucker, are most resistant to pressure changes.

To obviate injury to fish, blasting will be undertaken in the “dry”, i.e., after dewatering and removal of fish, and will adhere to the DFO guidelines for use of explosives in or near fish habitat (Wright and Hopky, 1998). The shockwaves (peak particle velocities) produced from blasting using the sophisticated techniques and control measures employed in modern blasting practice will be attenuated rapidly within the bedrock. With the width of the cofferdam and its sufficient distance from the limit of blasting, no injury to fish from pressure changes associated with the blast shockwaves is expected. Moreover, blasting mats will be used to minimize the occurrence of fly-rock.

4.1.3.3 Sediments

Bottom substrate in the Madawaska River near the powerhouse and in the tailrace is predominantly bedrock, overlain with boulder, cobble and gravel. As indicated in Sections 4.1.2.3 and 4.1.3.2, blasting will be required. The potential use of fragmented rock generated by blasting activities for fish habitat enhancement and/or nearshore/shoreline erosion protection will be discussed with DFO. Otherwise, the excess rock will be removed from the dewatered areas behind the temporary cofferdams for suitable upland disposal.

As indicated in Chapter 2, construction of much of the in-water portion of the tailrace will be undertaken in the “dry” using a cofferdam. The tailrace area will require rip-rap lining to protect against erosion and sloughing of the overburden. Upon completion of tailrace construction, the temporary cofferdam material will be re-used as rip rap. Portions of the Madawaska Riverbank in the immediate vicinity of the tailrace area may also require shoreline rip-rap protection to minimize toe erosion due to scouring and lower bank sloughing along the riverbank.

4.1.3.4 Plankton

Plankton populations will not be affected by construction of the proposed Project. Any plankton confined behind the cofferdams will be returned to the Madawaska River during dewatering.

4.1.3.5 Aquatic Vegetation

No aquatic vegetation will be affected by construction activities.

4.1.3.6 Benthic Macroinvertebrates

The placement of rock fill may have a localized, but temporary, adverse effect on benthic macroinvertebrate communities on the surface and within the substrate. The extent of disruption depends on the type of bottom substrate, the extent of the disturbed area, any resultant turbidity and sedimentation, and the timing of construction. Substrate in the Madawaska River at the proposed cofferdam location is predominantly cobble, boulder and gravel. The placement of rock fill on this substrate will have minimal detrimental effect on the benthic macroinvertebrate communities. With the use of the larger-size rockfill, sufficient interstitial spaces will be available for the survival and migration of mobile benthic fauna.

Recovery after cofferdam removal is expected to be rapid. Recovery is defined as the return of aquatic biotypes after disturbance to an abundance and diversity comparable to that in an adjacent undisturbed control area (Rosenberg and Snow, 1977). The principal mechanism of recolonization by invertebrates is drift (Luedtke and Brusven, 1976; Williams and Hynes, 1977), but other mechanisms, such as lateral migration, vertical migration from within the hyporheic zone (i.e., after burial) and larval recruitment from aerial sources are also important (Luedtke and Brusven, 1976; Williams and Hynes, 1977; Griffiths and Walton, 1978; Hirsch *et al*., 1978). The rate of recovery is dependent on ambient environmental conditions, the type of organisms present and the size of the disturbed area. In general, there will be less impact upon benthic communities associated with a naturally variable, high energy environment. The benthic organisms are adapted to the high-energy, unstable conditions, and have life cycles that allow them to better withstand these stresses (Hirsch *et al*., 1978).

Blasting in the dewatered nearshore areas may result in localized destruction of benthic communities. Benthic mortality will be a function of distance from and intensity of the blast (Schwartz, 1961). However, recovery from blasting is expected to be rapid (see above).

4.1.3.7 Site-Specific Habitat Considerations

Changes to aquatic habitat will occur directly due to construction of the new station and indirectly as a result of more flow being directed through the powerhouse and less flow through the south sluiceway. The minimum flows through the north channel are not expected to change.

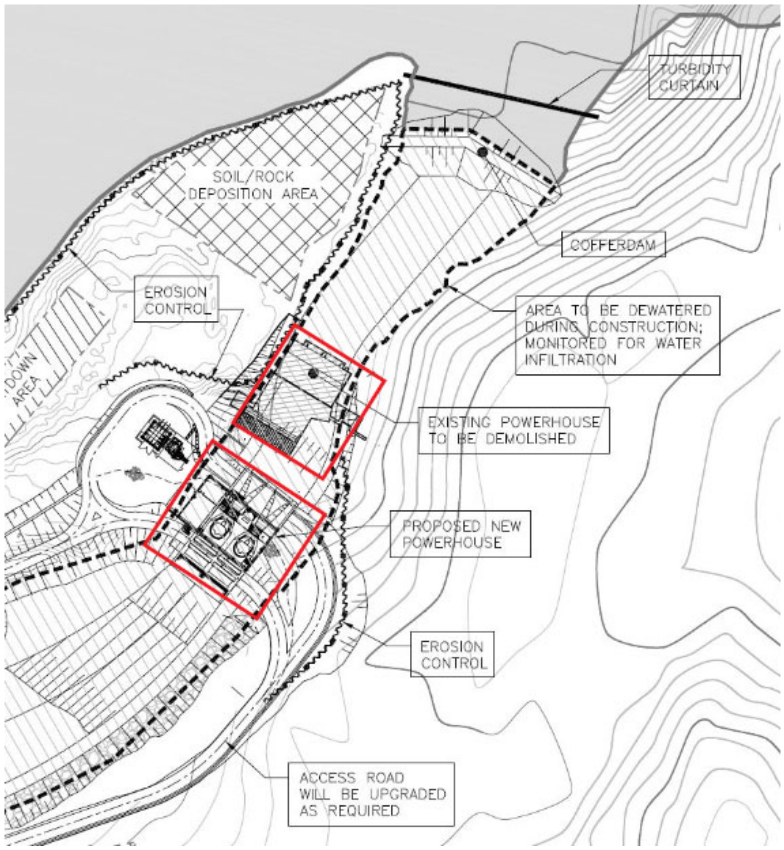
4.1.3.7.1 Direct Changes

Powerhouse footprint

The new powerhouse will be located approximately 50 meters upstream from the existing powerhouse. Consequently, the new powerhouse will occupy habitat that is in the forebay under existing conditions and the area occupied by the existing powerhouse will become part of the new tailrace.

The footprint inside the existing forebay is approximately 2,400m2 (shown in Figure 4-1 below). The exact foot footprint will be provided in the final design and will be included in the habitat balance for the project as part of the DFO RFR process.

Figure 4-1. Powerhouse Footprints in the Existing Forebay



Tailrace

The new tailrace will be approximately 50 m longer than the existing tailrace, due to the new powerhouse being further upstream. The upstream portion of the new tailrace will be excavated in bedrock. The exact downstream limit of excavation is not yet known, but it may result in a change in the substrate from the existing boulder/cobble to bedrock.

The tailrace receiving environment is being modeled to understand the depth and velocity profiles relative to fish preferences. This information will be used to understand the distribution of bed material that could be used as spawning or rearing habitat. SNC-Sullivan are currently exploring a range of habitat variables (Habitat Suitability Indices) that are specific to walleye spawning and rearing (E.G. McMahon 1984 - Habitat Suitability Index Models: Walleye (Depth 0.5 to 1.8 m, Velocity 0.6-0.9m/s). The figures presented below illustrate existing fish depth and velocity preferences for the existing vs the project conditions at the same discharge.

Figure 4-2. Tailrace Existing Conditions (160 cms)

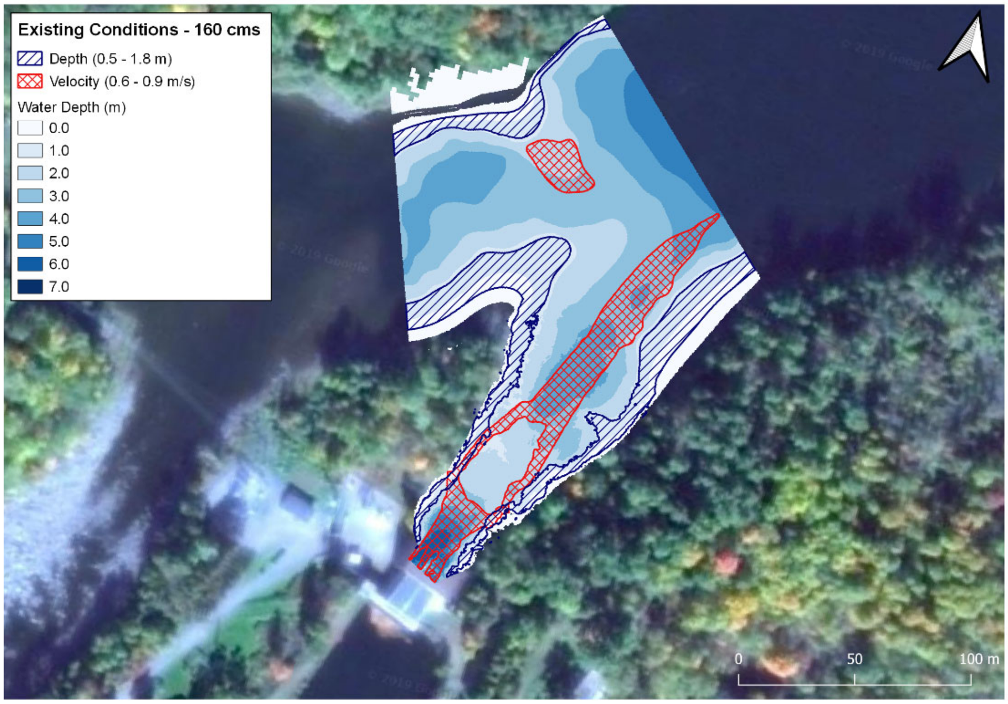
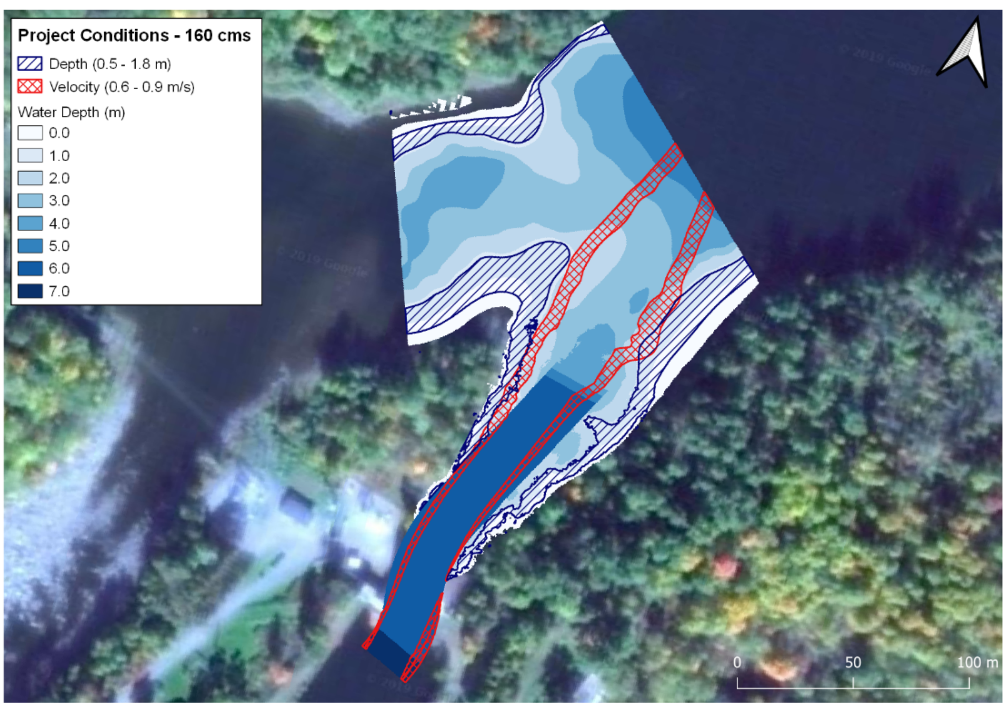


Figure 4-3. Tailrace Proposed Conditions (160 cms)



Forebay

The forebay will be approximately 50 meters shorter because the new powerhouse will be further upstream than the existing powerhouse. Some excavation will be required in the forebay upstream from the new powerhouse, for hydraulic optimization. This will result in changes in depth and substrate. The intake will have training walls on either side to contain the new embankments away from the intake structure. Upon completion embankments will be provided with suitably sized rock protection to ensure bank stability against the forces of erosion and ice action.

The average excavation depth in the upstream side of the powerhouse is 3 m. Excavation is approximately 12 m for the powerhouse and the tailrace varies with average of 1 m. The substrate of the entire forebay will be modified and will mostly be in drilled and blasted rock with riprap on the channel sides.

The existing control structure at the upstream end of the forebay will be removed and the forebay inlet will be slightly widened, which will result in an increase in the area of fish habitat.

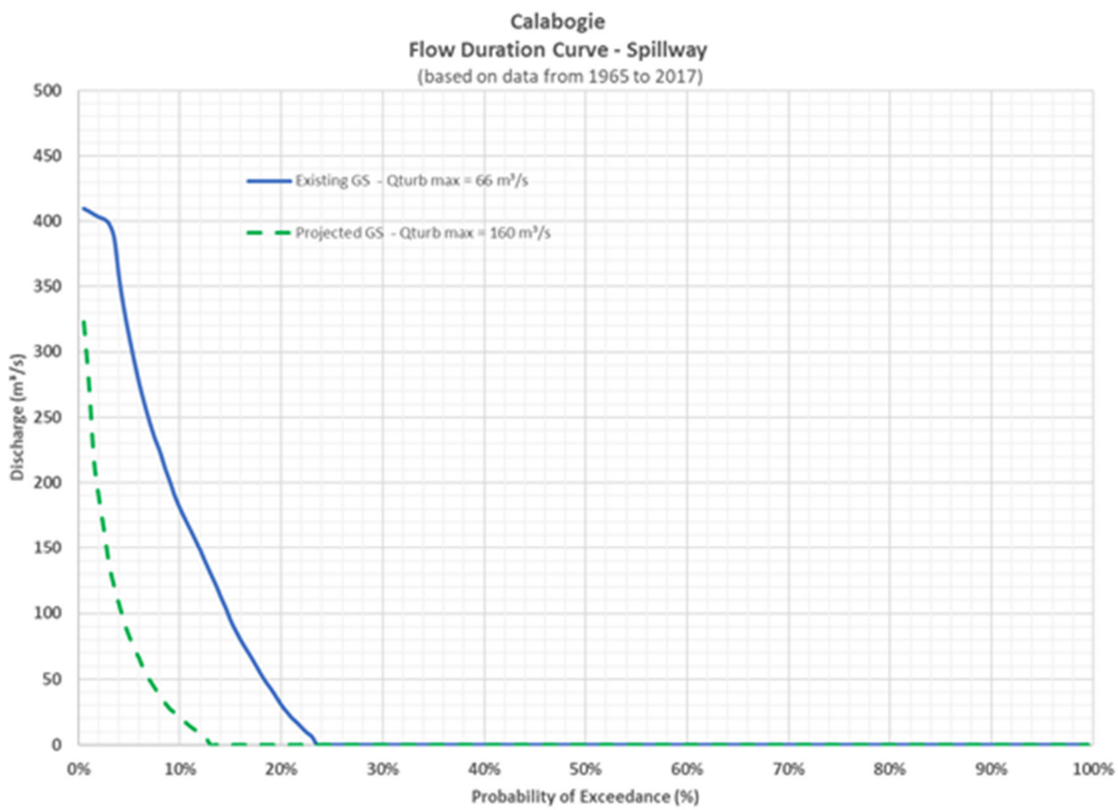
Under existing condition, at full flow the highest velocities, which are approximately 1.0 m/s, occur where water passes through the piers of the structure at the entrance to the forebay. With the removal of that structure and widening and deepening of the inlet, the proposed velocities in the approach channel at full flow would be under 1 m/s, varying between 0.25 and 1.0 m/s across the channel.

South Channel Sluiceway Downstream

With the previous station, flow ceased (except for leakage) through the south sluiceway when total discharge from Calabogie Lake was less than 60 cms plus the flow through the north channel. With the new GS flow through the south sluiceway will cease once total discharge is less than 160 cms plus the flow through the north channel. Consequently, there will be no flow through the south sluiceway for a greater portion of the year.

The South Channel Sluiceway will remain backwatered at a minimum elevation of 144.2 and will not have any periods where there is no water in channel. The flow reduction rates in the spillway will be maintained as in current conditions and are not known to strand fish. Figure 4-4 below shows the expected changes of discharge through the spillway (existing GS vs projected GS). With the existing GS, the spillway was in operation about 24% of the time during the January – March periods and with the projected GS, the spillway will be in operation about 13% of the timed during the January – March period. It should be noted that the overall discharge downstream the junction between the GS tailrace channel and the spillway channel should be the same.

Figure 4-4. Calabogie South Channel Sluiceway – Flow Duration Curve



4.1.3.7.2 Assessment of Direct Changes

A full assessment of the direct changes would be completed once the final design of the GS is completed. This assessment would be expected to be part of the submission to DFO.

4.2 Potential Operational Effects and Associated Mitigation, Enhancement and Monitoring Measures

4.2.1 Madawaska River Water Management

As outlined in the 2009 Madawaska River Water Management Plan, Calabogie GS operated (prior to the September 2018 tornado) as a peaking plant in conjunction with the four other OPG owned GSs on the Madawaska River. The generating units at the station had limited flow capacity (66 m^3/s), but the operation of the units and sluice gates are integrated with the rest of the peaking system on the Madawaska River. Calabogie was a generation bottleneck on the Madawaska River, and the small turbine capacity results in frequent spill past the station.

The operation of the existing plant is based on a daily/weekly cycle, with the inflow passed through the plant over a daily or weekly period. The 2009 WMP notes that operation of the plant takes into consideration energy demands, recreational opportunities as well as walleye spawning activities.

OPG does not propose to alter the existing water management compliance requirements associated with this facility. The redevelopment of Calabogie GS will continue to be operated in full accordance with all of the flow and water level targets and compliance conditions identified in the WMP including all fisheries and other aquatic life requirements. Daily flows will remain unchanged, but additional portion of river flow will pass through the plant to generate electricity rather than just passing through the spillway gates.

4.2.2 Groundwater Hydrology and Quality

No effects on groundwater hydrology are anticipated as a result of the operation of the proposed GS; therefore, no mitigation is required.

4.2.3 Water Quality

The re-developed Calabogie Generating Station is not expected to have any negative effects on water quality. Water will go through the powerhouse and be returned to the River in roughly the same locations as presented.

The proposed project does not result in any inundation which might also impair water quality.

All of OPG's powerhouses have an oil-water separator in place that separates an oily substances and presents them from entering the River.

4.2.4 Sediment Erosion and Transport

Once the site is fully re-developed and any unstable areas stabilized, the erosion and sediment control measures will be removed from the site except for any permanent ditches, berms or other features that are recommended to prevent any sediment from entering the River and erosion from occurring.

As the proposed project will be operating according to the requirements of the MRWMP, OPG does not anticipate any changes to localized erosion patterns on the River.

4.2.5 Plankton, Aquatic Vegetation and Benthic Macroinvertebrates

As there is no alteration to seasonal or daily levels and flows there are no anticipated effects on plankton, aquatic vegetation and/or benthic macroinvertebrates.

4.2.6 American Eel Migration

American Eel have historically migrated upstream and downstream in the Madawaska River, but have been extirpated from the vicinity of the Calabogie GS for approximately 40 years (MNR, 2008) and there are dams downstream that currently block the upstream passage of American Eel. However, it hoped that re-establishment of American Eel will occur in the Ottawa River system, including the Madawaska River. Therefore, the generating station will be constructed ‘eel-ready’ so that of adaptive management strategies that can be applied as circumstances change around the presence of American eel in the vicinity of the station.

Specific measures have been scoped into the design of the station to accommodate potential future needs for upstream and downstream passage of American Eel including:

- including a trap and transport system at the plant tailrace, including the provision of attractant flow, to allow monitoring for eel presence below the station and provision of upstream transport when eels appear;
- intake velocities and bar exclusion screen layouts that facilitate implementation of future effective safe passage of eels downstream through the project;
- provision for retrofitting the station with an inclined screen and downstream flow bypass for downstream passage with bar spacing in the screen at no more than19 mm during periods of downstream movement;
- leaving room for permanent upstream and downstream passage infrastructure to be retrofitted.

Measures to permit downstream migration wouldn’t be deployed until eels approaching the downstream phase of their life-history phase are present in the upper portion of the watershed. Putting fine spaced trash rack mitigations in place introduces head losses and negatively affects operations, however OPG specifically designed approach velocities and trash rack spacing to prevent impingement and fish mortality with the understanding that a population of eels will eventually be re-established.

An adaptive management approach will be applied during operations to determine the best course of action to implement or install specific measures to support recovery as circumstances change. It is expected that if American Eel are trapped in the tailrace they will be transported upstream and that retrofitting to permit safe downstream passage will be implemented prior to the first eels that are moved upstream migrate. The tailrace receiving environment is being modeled to understand the depth and velocity profiles relative to fish preferences. Changes due to increased powerhouse capacity.

No change is predicted in the flow through the North Channel, where the minimum flow is mandated under the existing operating regime.

4.2.6.1 Walleye Spawning

The proportion of the flow that passes through the powerhouse will increase as a result of station capacity increasing from 60 cms to 160 cms and there will be a commensurate decrease in the volume of flow through the south sluiceway. An initial assessment of the implications to fish habitat are discussed below. A final assessment will be based on the final design.

As previously stated, large aggregations of spawning Walleye have not been observed in the vicinity of the Calabogie GS. Regardless, there is likely some limited spawning occurring in the tailrace, at the downstream end of the South Channel Spillway, and in the North Channel.

The tailrace receiving environment is being modeled to understand the depth and velocity profiles relative to fish preferences. This information will be used to understand the distribution of bed material that could be used as spawning or rearing habitat. SNC-Sullivan are currently exploring a range of habitat variables (Habitat Suitability Indices) that are specific to walleye spawning and rearing (e.g., McMahon 1984 - Habitat Suitability Index Models: Walleye (Depth 0.5 to 1.8 m, Velocity 0.6-0.9 m/s). Figures 4-2 and 4-3 presented previously illustrate exiting fish depth and velocity preferences for the existing vs the project conditions at the same discharge.

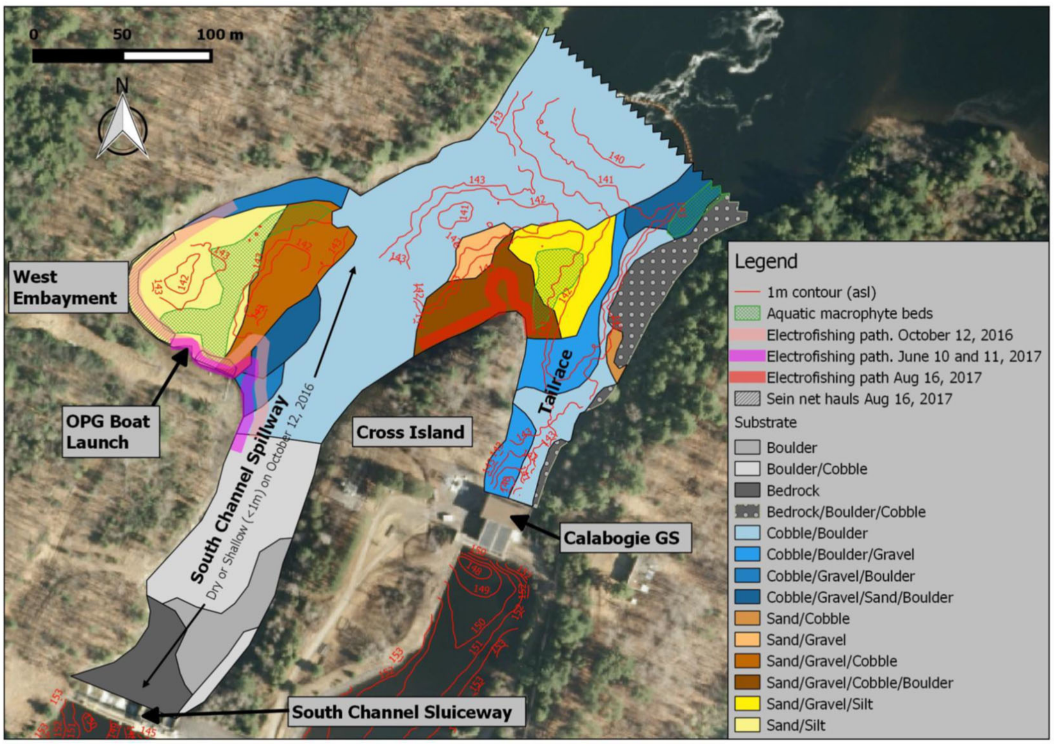
The habitat value of the tailrace is not expected to change substantially with the proposed reconstruction of the Calabogie GS. At peak flow of 160 cms through the powerhouse, the maximum flow velocity in the tailrace will be approximately 2 m/s in places along the center of the tailrace with velocities approaching zero along the margins. This range of velocities spans the typical Walleye spawning velocities, so areas with velocities suitable for spawning will be present. Placement of suitable spawning substrate may be required along the tailrace margins. High velocities are likely to mobilize suitable spawning substrate in the centre of the tailrace. Given the limited use of the existing tailrace by spawning Walleye, it is expected that the future tailrace will provide the same or improved habitat opportunities for spawning.

The South Channel Spillway generally has very high spring flows during the typical Walleye spawning period, with fast, turbulent water (Figure 3-21) that limits any possible Walleye spawning to small areas of potential habitat in the periphery of the downstream end of the spillway. When spring spillway flows are reduced by the diversion of a greater amount of flow through the enlarged GS, it is possible that shallow areas at the downstream end of the spillway that have cobble, gravel and sand substrates (Figure 3-14) will become suitable Walleye spawning habitat, providing an overall gain in potential Walleye spawning habitat at the Calabogie GS. If this were to occur it is possible that a seasonally extended minimum flow through the South Channel Spillway may become necessary to maintain proper embryo incubation conditions.

The Flow Duration Curve for the South Channel Sluiceway shown in Figure 4-4 shows the expected changes of discharge through the spillway (existing GS vs projected GS). With the existing GS, the spillway was in operation about 24% of the time and with the projected GS, the spillway will be in operation about 13% of the time. It should be noted that the overall discharge downstream the junction between the GS tailrace channel and the spillway channel should be the same.

Consistent with the historical operation of the facilities the south spillway channel will remain watered at a minimum elevation of 144.2 masl and there will not be any periods when there is no water in channel. Figure 4-5 below illustrates the receiving environment bed elevations and substrate in environment of the south spillway. The elevations at the end of the South spillway where fish habitat was observed range from 140-143 masl and the upper portion of the spill way will remain backwatered to minimum elevation of 144.2 masl.

Figure 4-5. Elevations in the South Channel Sluiceway



Flow velocity in the South Spillway Channel will be lower since more water will go through the projected GS. For the tailrace channel the flow velocity for the projected conditions at 160 m^3/s will be in the same range than the flow velocity for the existing conditions at 66 m^3/s. The figures below shows the existing velocities at the current powerhouse at 66 cms and 0 cms through South Channel spillway. These figures below (Figures 4-6 to 4-8) show receiving environment flow conditions for existing and future conditions and shows that the existing powerhouse has relatively high exit velocities (>1.4 m/s) downstream of the powerhouse. The new powerhouse receiving environment has been specifically designed to have lower velocities (~1.0 m/s maximum) despite increased plant flow of 160 m^3/s.

Figure 4-6. Existing Condition Velocities (66 cms)

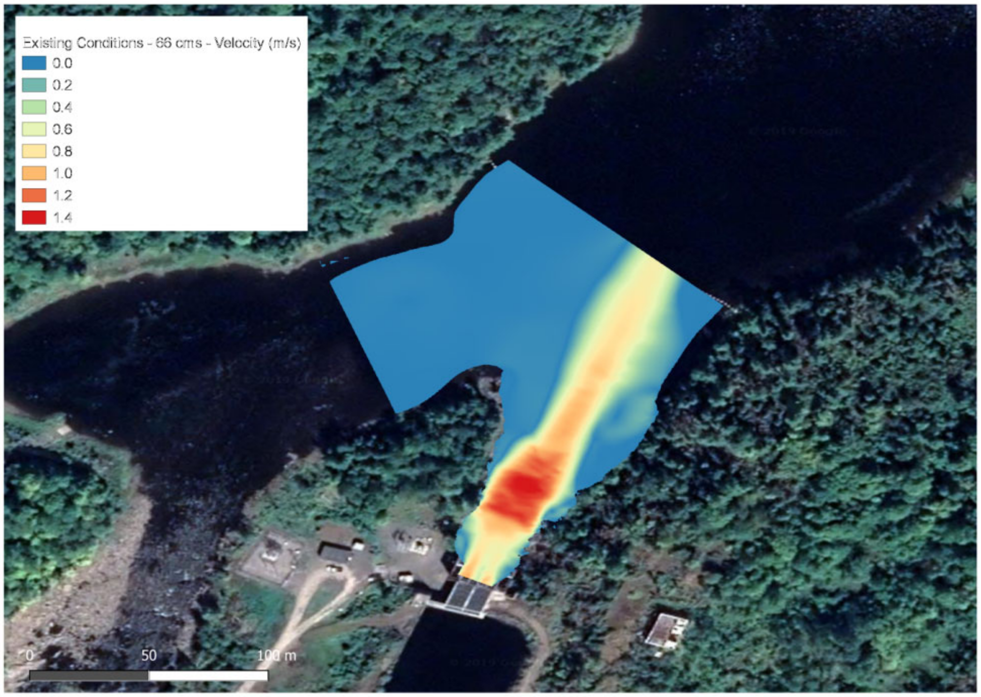


Figure 4-7. Existing Condition Velocities (160 cms, 66 through Powerhouse and Balance through South Dam Sluiceway)

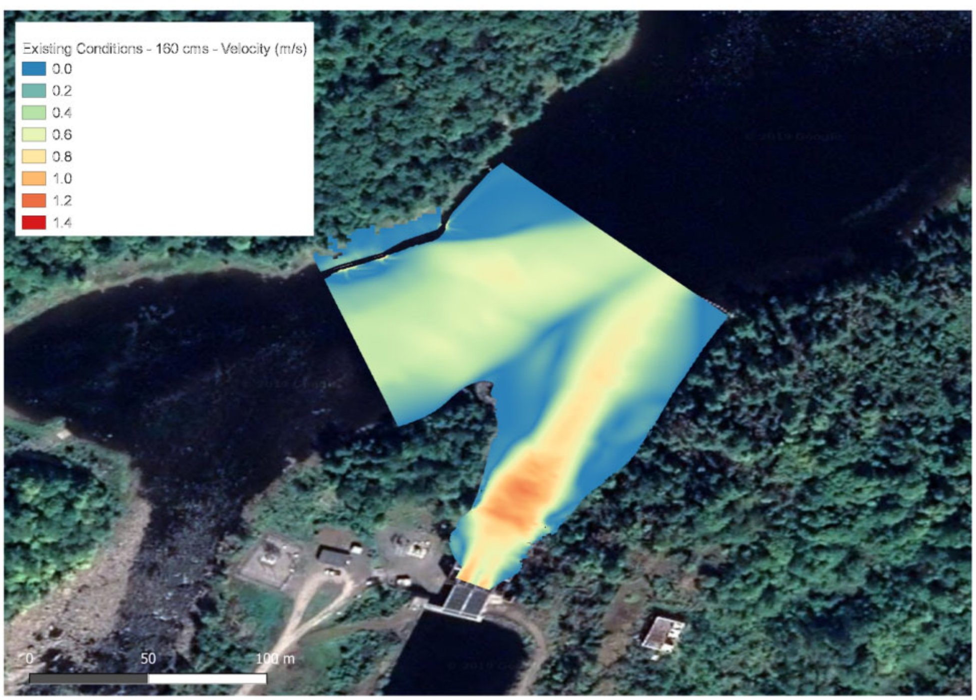
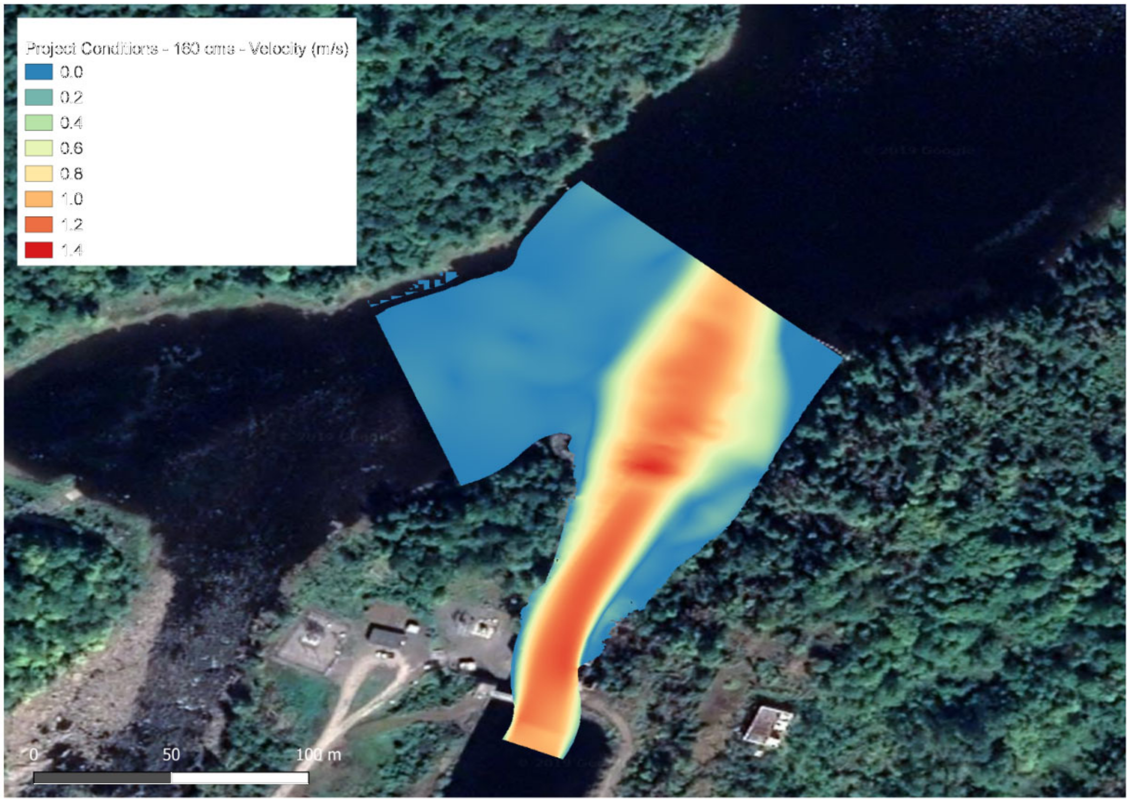


Figure 4-8. Proposed Condition Velocities (160 cms)



The South Spillway does not reliably provide habitat suitable for Walleye spawning under current conditions. The volume of flow through the South Spillway during the walleye spawning period varies from zero (except for dam leakage) in dry springs to >400 cms (refer to graph in response to comment 41) in a wet year. At zero flow through the spillway there is abundant suitable spawning substrate (Rosien, 1999) but velocities would not be conducive to walleye spawning except at the very base of the dam where leakage would result in a small area of potentially suitable velocities. At high spill rates velocities in most of the South Spillway are too high for walleye to spawn there (Tarandus, 1991, 1992; this study). Tarandus conducted a Walleye spawning study in 1992 that included the South Spillway and reported that “minimal suitable walleye spawning habitat exists in the spillway” mainly due to the substrate and relatively high water velocities and no walleye eggs were found there post-spawning (Tarandus 1992, cited in Pope, 1999). Tarandus (1992) did find walleye eggs in the North Channel. Pope (1999) reported that local residents regarded the North Channel to be the main spawning area. A spawning study conducted by Rosien in 1999, when spring flow was low and there was no spill through the South Spillway, found that numbers of Walleye observed were higher downstream at Cherry Beach Rapids than in either the South Spillway or the tailrace at Calabogie (Table 4-1). Rosien (1999) stated that the due to adverse conditions at this site during high flow freshets, the South Spillway is dependent upon low flow freshets that warrant reduced spilling in order to be suitable for spawning.

Table 4-1. Number of Walleye Observed during Night Spawning Surveys in 1999 (Rosien, 1999)

Cherry Beach rapids		Date	Number of Walleye	
Date	Number of Walleye		Calabogie GS Spillway	Calabogie GS Tailrace
19-Apr-99	3	19-Apr-99	0	2
21-Apr-99	38	22-Apr-99	7	6
24-Apr-99	33	24-Apr-99	0	1
26-Apr-99	41	26-Apr-99	3	1
28-Apr-99	24	28-Apr-99	1	4
2-May-99	6	2-May-99	3	3

With the existing generating station conditions in the south spillway range from extremely high flows and velocities during peak flows, typically during spring freshet, to zero flow and velocity during periods when there is no flow through the spillway. At peak flows the upper portion of the South Spillway has velocities so high that it is probably not occupied by fish; if it is it will be by species that are tolerant of high water velocities (i.e. longnose dace) that can shelter among boulder. At low flows and velocities that area is suitable for a wide range of species (walleye, centrarchids, catostomids, most cyprinids), but less so for species that prefer higher velocities (i.e. longnose dace). With the new generating station flows in the South Spillway will be lower during periods of high flow and zero for more of the year. This will extend the period that flows are suitable for species that prefer lower velocities but reduce the length of time that it is suitable for species that prefer high velocities. With the new generating stations, changes in flow through the South Spillway will be less frequent.

This increased stability of habitat conditions can be expected to benefit species that utilize the lower velocity habitats, whether it be for spawning, nursery, or foraging,

A monitoring plan could be developed as the discussions with DFO progress, however the current flow reduction rates in the spillway will be maintained as in current conditions and are not known to strand fish. There is little or no potential for fish stranding in the South Spillway because it remains backwatered even when it receives zero flow.

Under current conditions OPG is required to pass a minimum flow through the North Channel, and this is not expected to change under future conditions. The North Channel conditions for spawning Walleye will remain the same with the new GS.

4.2.6.2 River Redhorse Spawning

The only spawning location of this species was found 2.6 km downstream from the Calabogie GS, at the downstream end of Area 9 (Figure 3-23). Once this spawning location was discovered, locations where similar habitat conditions occurred, or were thought to potentially occur, were examined within or near the North Channel, the South Channel Spillway, and the tailrace of the Calabogie GS. No other spawning aggregations of River Redhorse were found, nor were any habitats that were considered a good match to the habitat in Area 9 within which the spawning River Redhorse were observed. The reconstruction of the Calabogie GS, will not impact any habitats in Area 9 (Figure 3-23) and is not predicted to have any impact on River Redhorse spawning.

4.2.6.3 Other Fish Spawning and Habitat Utilization

Potential impacts to spawning and general habitat of other fishes, essentially follow the impacts to spawning Walleye and River Redhorse that are detailed above in Sections 4.2.7.1 and 4.2.7.2, respectively. The existing flow regime through the North Channel will be maintained, and because the Calabogie GS will remain a run-of-the-river plant and OPG is obligated to maintain the existing water level regimes upstream and downstream of the GS, it is believed that the reconstructed GS will not affect habitat utilization by any fish species, except in the immediate vicinity of the South Channel Spillway and the GS tailrace. As well, a portion of the footprint of the existing intake channel immediately upstream of the old generating station will become the new generating station and will not be fish habitat.

In the future, at total flows above approximately 60 cms, flow velocities in the tailrace will be similar or higher and flow velocities in South Channel Spillway will be lower than they are currently.

Flows in the South Channel Spillway are highly variable under existing conditions. The South Channel Spillway has very high spring flows, with fast, turbulent water (Figure 3-21) that limits habitat utilization by fish. If spillway flows are reduced during high flow periods, habitat conditions may improve. It is possible that the shallow areas at the downstream end of the spillway that have cobble, gravel and sand substrates (Figure 3-14), will become suitable as Walleye spawning habitat and may also provide spawning habitat for other species such as White Sucker. There will be no flow in the South Channel Spillway for a longer period each year. When there is no flow through the South Channel Spillway the backwater effect limits the area that is dry to immediately below the sluicegates. This area is primarily bedrock and very large boulders and is unlikely to provide spawning to any fish species under existing of future conditions. However, as previously explained the south spillway channel will remain watered at a minimum elevation of 144.2 masl. This is consistent with the historical and existing operation of the facilities. The figure below illustrates the receiving environment bed elevations and substrate in environment of the south spillway. The elevations at the end of the South spillway where fish habitat was observed range from 140-143 masl and the upper portion of the spill way will remain backwatered to minimum elevation of 144.2 masl.

As previously discussed, the downstream receiving environment is being modeled to understand the depth and velocity profiles relative to fish preferences. This information will be used to understand the distribution of bed material that could be used as spawning or rearing habitat. We are currently exploring a range of habitat variables (Habitat Suitability Indices) that are specific to walleye spawning and rearing (E.G. McMahon 1984 - Habitat Suitability Index Models: Walleye (Depth 0.5 to 1.8 m, Velocity 0.6-0.9m/s) Figures 4-2 and 4-3 previously presented illustrate exiting fish depth and velocity preferences for the existing vs the project conditions at the same discharge (i.e. south spillway is spilling).

4.2.7 Fish Habitat Loss and Gain/Enhancement

As detailed above in Section 4.1.3.7, net changes in habitat area as a result of the demolition of the existing generations station and construction of the new generation station will be small. The area of the tailrace will increase as a result of the new generating station being located approximately 50 meters upstream. This will shorten the forebay, but removal of the piers and widening of the forebay entrance will increase the area of habitat so that, there too, the net change in habitat area will be small.

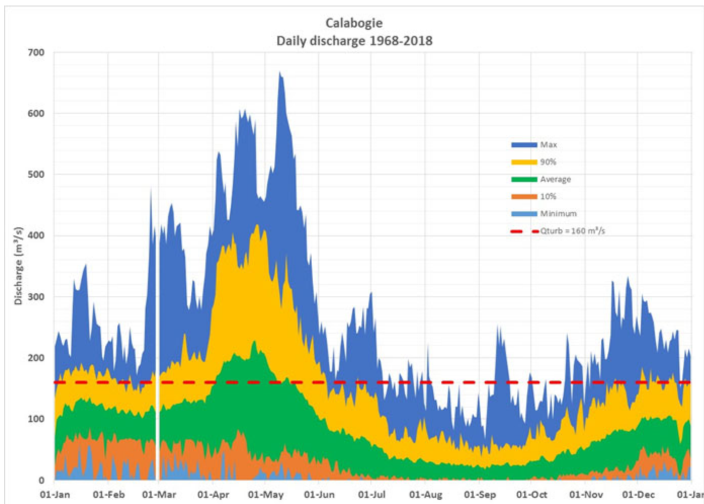
Areas within the forebay and tailrace that that are excavated to or in bedrock will be mitigated by the placement of 0.5 m of granular material (boulders, cobble, and gravel) over exposed bedrock. This will maintain the habitat function within these areas. The downstream receiving environment is being modeled to understand the depth and velocity profiles relative to fish preferences. This information will be used to understand the distribution of bed material that could be used as spawning or rearing habitat. We are currently exploring a range of habitat variables (Habitat Suitability Indices) that are specific to walleye spawning and rearing (e.g., McMahon 1984 - Habitat Suitability Index Models: Walleye (Depth 0.5 to 1.8 m, Velocity 0.6-0.9 m/s). The figures presented below illustrate exiting fish depth and velocity preferences for the existing vs the project conditions at the same discharge (i.e. south spillway is spilling). It is thought that the diversion of a portion of the high flow volumes, that presently pass through the South Channel Spillway during the spring, to the GS, will provide better functionality of habitat within the spillway, provided that a seasonal minimum flow is initiated to maintain those habitats through to about the middle of June (the end time could be a fixed date, or determined annually as a function of degree days). The flow reduction will allow more spawning opportunities for Walleye, White Sucker, and other species such as Logperch, while the minimum flow will ensure that any embryos deposited by these species will have sufficient flow to fully develop and swim out from the spawning area.

OPG will provide a detailed assessment of habitat changes associated with the new project as part of the DFO review process. The assessment will account for both temporary and permanent changes and opportunities to balance habitat productivity will be investigated. The goal of the fish habitat design process is to balance the effects from the project so there is a no-net-loss of fish habitat.

The habitat conditions in the South Spillway change markedly as flow varies over the course of a year and between years. At peak flows the upper portion of the South Spillway has velocities so high that it is probably not occupied by fish; if it is it will be by species that are tolerant of high water velocities (i.e. longnose dace) that can shelter among boulder. At low flows and velocities that area is suitable for a wide range of species (walleye, centrarchids, catostomids, most cyprinids), but less so for species that prefer higher velocities (i.e. longnose dace). With the new generating station flows in the South Spillway will be lower during periods of high flow and zero for more of the year. This will extend the period that flows are suitable for species that prefer lower velocities but reduce the length of time that it is suitable for species that prefer high velocities. With the new generating stations, changes in flow through the South Spillway will be less frequent.

This increased stability of habitat conditions can be expected to benefit species that utilize lower velocity habitats and be to the detriment of species that prefer higher velocity spawning, nursery, or foraging habitats.

The average historical inflow for the period between 1965 and 2017 at Calabogie is approximately 90 m^3/s with a median of 72 m^3/s. The freshet level flows are shown in the historical flow calculations below and illustrate periods when spring walleye spawning and subsequent incubation occurs. The elevation in the receiving environment is not anticipated change during periods of spring incubation. The seasonality of inflows for the facility is highlighted in the inflow figure below.



As previously explained, the change in operations is not expected to result in in an increased risk to fish stranding as the conditions are expected to continue. The south spillway channel will remain watered at a minimum elevation of 144.2 masl and there will not be any periods where there is no water in channel. This is consistent with the historical and existing operation of the facilities. The figure below illustrates the receiving environment bed elevations and substrate in environment of the south spillway. The elevations at the end of the South spillway where fish habitat was observed range from 140-143 masl and the upper portion of the spill way will remain backwatered to minimum elevation of 144.2 masl.

In summary, it is believed that the proposed development with the suggested mitigation, will not have a negative impact upon the fisheries of the Madawaska River, and there may be a positive impact.

4.2.8 Fish Entrainment and Survival

Potential fish injury and/or mortality due to entrainment at power plants is an issue that has received technical consideration and analysis. Entrainment potential varies with approach velocities and intake screen bar spacing, and also varies among fish species and with fish size. The rate of individual fish injury/mortality varies with turbine design, generating station head, fish species and fish size. The number of fish injured or killed will depend upon the fish abundance and the volume of flow through the generating station.

The powerhouse design incorporates trashracks that cover the entire area of the turbine water passage intakes. The trashrack bar spacing will match the existing Calabogie GS, with 50 mm clear space between bars. An approach velocity of 0.9 m/s has been the design criteria. The current design has velocities no more than 0.9 m/s, modeled 75mm upstream of trash rack at the normal minimum reservoir elevation.

With the increase in proportional flow through the GS increased fish entrainment can be anticipated. The powerhouse will house two horizontal-axis Kaplan type turbines. Each turbine runner will have four blades and will operate at 156.5 rpm. Turbine mortality will be modelled using this information so that it can be considered by the regulatory agencies, including DFO, in their determination of whether offsetting will be required for the project.

4.3 Summary of Mitigation, Enhancement and Monitoring Measures

Table 4-2 summarizes potential construction and operation effects, the recommended mitigation/remedial measures to minimize or obviate these effects and the net effects of the proposed Calabogie Re-Development Project.

Table 4-2. Potential Construction and Operation Effects

Effect/Activity	Recommended Mitigation/Remedial Measures	Net Effect
Construction		
Soil erosion	• Adherence to Erosion and Sediment Control Plan.	No adverse residual effect
Incidental spills	• Adherence to Spills Emergency Preparedness and Response Plan.	No adverse residual effect
Hazardous Materials/Waste	• Adherence to Hazardous Materials Management Plan and Waste Management Plan. • Waste disposal in accordance with regulatory requirements.	No adverse residual effect
Bedrock Excavation resulting in Groundwater Ingress	• Use of sump pumps. If necessary, the water will be directed to settling pond(s), silt treatment bags, and vegetated areas to mitigate any environmental issues that may arise from the dewatering. Should the groundwater require secondary treatment for dissolved metals, proper measures will be taken.	No adverse residual effect
Blasting	• Adherence to DFO guidelines (Wright and Hopky, 1998) and blasting engineer recommendations. • Potential use of blast rock for fish habitat enhancement and/or nearshore/shoreline erosion protection, or removal for suitable upland disposal.	No adverse residual effect

Table 4-2. Potential Construction and Operation Effects (Cont'd)

Effect/Activity	Recommended Mitigation/Remedial Measures	Net Effect
Construction (Cont'd)		
In-water construction activities	• Use of clean rock fill for cofferdam. • Judicious selection of discharge location and water pressure during dewatering. • Adherence to in-water construction timing restrictions. • Transfer of fish stranded behind cofferdam prior to complete dewatering. • The different fish habitat areas that have potential to be affected by the project will be assessed for productive capacity and a habitat balance for the project will be presented for DFO review.	No adverse residual effect
Isolation and dewatering of the forebay and tailrace	• Capture and relocation fish and mussels trapped in the area that will be dewatered. • The different fish habitat areas that have potential to be affected by the project will be assessed for productive capacity and a habitat balance for the project will be presented for DFO review.	Eliminates or minimizes fish mortality due to dewatering
Sportfish populations	• As a condition of employment, prohibition of sportfishing by construction workers while working.	No adverse residual effect
Operation		
Incidental spills	• Adherence to Spills Emergency Preparedness and Response Plan.	No adverse residual effect
Water management operations	• None recommended: no changes predicted.	No adverse residual effect
Sediment erosion and transport	• Protect banks where there is erosion potential with suitably sized substrate.	No adverse residual effect
Loss/gain of fish habitat	• Minimize the area of habitat losses and maximize he area of habitat gains that result form result of station reconstruction. • Provide suitable substrate in areas where bedrock is exposed, if possible. • Potential improvement in spawning habitat for Walleye and other species at the downstream end of the South Channel Spillway. • As part of the DFO RFR process a detailed assessment of habitat changes associated with the new project will occur.	Potential net benefit
Fish entrainment and survival	• Fish entrainment and mortality expected to be low. However, a model-based assessment will be required.	To be quantified.

During construction and operation, an Environmental Compliance Monitoring Program will be implemented to ensure that all construction and operation related commitments are met. Details on the Environmental Compliance Program are provided in the ER.

Flow discharge, water levels and water temperature will be monitored throughout proposed Project operation.

Recommended aquatic environment monitoring during plant operation includes:

- Monitoring for American Eel downstream from the tailrace;
- Habitat assessment and monitoring of the enlarged tailrace during early spring (Walleye spawning) and in early June (check for River Redhorse, and general habitat function compared to pre-expansion condition);
- Habitat assessment and monitoring of the South Channel Spillway during early spring (Walleye spawning) and in early June (check adequacy of seasonal minimum flow).

5 SUMMARY AND CONCLUSIONS

This TSD provides an aquatic environment baseline, as well as the potential effects of the proposed project on the aquatic environment and the recommended mitigation measures to minimize these effects.

During Project construction, potential effects on the aquatic environment may occur due to dewatering, soil erosion causing turbidity and sedimentation in surface waters, waste generation, incidental spills, hazardous materials usage, blasting, in-water construction activities and fish habitat enhancement/creation. Based on assessment of the available baseline information and potential effects, as well as the implementation of the recommended mitigation measures, it is concluded that effects during construction will be minimal, localized and short-term with no adverse residual effects.

During the operation of the proposed Project, potential effects on the aquatic environment may occur due to incidental spills, increased flow through the generation station and commensurately less flow through the south channel spillway, fish habitat loss/gain, and fish entrainment. Based on assessment of the baseline information and potential effects, and implementation of recommended mitigation measured, it is concluded that the operation of the proposed Project will have no adverse residual effects on the aquatic environment.

The proposed Calabogie Project will not have a negative effect upon the fish communities of the Madawaska River. There will be no significant changes to river conditions upstream or downstream of the plant as a result of the Project with the exception of the South Channel Spillway and the GS forebay and tailrace. Net changes in the area of fish habitat will be minor. More of the total river flow will pass through the forebay, GS and tailrace, and less will pass through the South Channel Spillway. This transfer of flow is expected to result in less extreme flows in the spill channel, potentially creating better conditions for spawning Walleye and other spring-spawning fishes (e.g. White Sucker). Flow through the South Channel Spillway will be zero for longer each year. This area experiences no flow for part of the year under the current conditions. Most of the area remains submerged due to the backwater effect from downstream and the area effected is primarily bedrock and very large boulders. No significant effect on the fish communities is expected.

OPG is committed to supporting the recovery of American Eel in consultation with Indigenous Peoples and in accordance with provincial recovery strategies and policy direction. On the Madawaska River, there are no known occurrences of American Eel, including at or in the immediate area of Arnprior GS, Stewartville GS and Calabogie GS. Therefore, these facilities are currently compliant with the *Endangered Species Act*. Over time, and as recovery strategies advance and succeed, American Eel may once again be present in the Madawaska River. This will signal that recovery strategies are working. OPG is using this redevelopment project to make the redeveloped Calabogie GS eel ready. Eel ready means that the redevelopment will be planned, designed and executed in anticipation of adaptive management strategies that can be applied to allow Eel passage. The proposed project represents an improvement over the existing situation of a GS that is not able to pass American Eel and therefore represents an overall net benefit.

Environmental protection during proposed Calabogie Project construction and operation will be ensured by adherence to the site-specific Environmental Management Plan, as well as compliance with regulatory standards and guidelines.

The Environment Management Plan ensures that environmental protection will be achieved during construction by describing government agency requirements, proposed Project commitments and recommended mitigation measures to be undertaken. The Environmental Management Plan will include the Erosion and Sediment Control Plan, Spills Emergency Preparedness and Response Plan, Hazardous Materials Management Plan and Waste Management Plan.

During operation, environmental protection will be achieved by adherence to the Spills Emergency Preparedness and Response Plan and the Calabogie River System WMP, deployment of public safety measures and environmental monitoring.

6 REFERENCES

Baxter, R.M. and P. Glaude. 1980. *Environmental Effects of Dams and Impoundments in Canada: Experience and Prospects*. Can. Bull. Fish. Aquat. Sci. 205: 34 p.

Becker, G.C. 1983. *Fishes of Wisconsin*. University of Wisconsin Press, Madison, Wisconsin. 1,052 p.

Bird Studies Canada. 2006. Ontario Breeding Bird Atlas. www.birdsontario.org/atlas/atlasmain.html

Cada, G.F. 1990. *A Review of Studies Relating to the Effects of Propeller-type Turbine Passage on Fish Early Life Stages*. N. Amer. J. Fish. Manage. 10: 416-426.

Cadman, M.D., D.A. Sutherland, G.G. Beck, D. Lepage and A.R. Couturier [Eds.]. 2007. *Atlas of the Breeding Birds of Ontario, 2001-2005*. Bird Studies Canada, Environment Canada, Ontario Field Ornithologists, Ontario Ministry of Natural Resources and Ontario Nature. 706 p.

Chamberlain, A.J. 1976. *The Acute and Subacute Effects of Underwater Rock Blasting, Dredging and other Construction Activity on the Fishes in the Nanticoke Region of Long Point Bay, Lake Erie*. Report No. 1, Construction Phase 1 March-November 1975. Ministry of Natural Resources. 117 p.

Chamberlain, A.J. 1979. *Short-term Effects of Dock Construction Activity on Fishes in the Nanticoke Region of Long Point Bay, Lake Erie.* Report 2, Construction Phase 2, March-November 1976. Ministry of Natural Resources. 50 p.

Coad, B.W., H. Waszczuk, and I. Labignan. 1995. Encyclopedia of Canadian fishes. Canadian Museum of Nature and Canadian Sportfishing Productions Inc. 928 p.

Committee on the Status of Endangered Wildlife in Canada (COSEWIC). 2006. COSEWIC assessment and update status report on the River Redhorse Moxostoma carinatum in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 31 pp. (www.sararegistry.gc.ca/status/status_e.cfm).

Committee on the Status of Endangered Wildlife in Canada (COSEWIC). 2012. *Canadian Wildlife Species at Risk, October 2012*. Ottawa, Ontario. 98 p.

Dedual, M. 2007. *Survival of Juvenile Rainbow Trout Passing Through a Francis Turbine*. N. Amer. J. Fish. Manage. 27: 181-186.

DFO. 2016. Management plan for the River Redhorse (Moxostoma carinatum) in Canada [Proposed]. Species at Risk Act Management Plan Series. Fisheries and Oceans Canada, Ottawa. v + 48 pp.

Diaz, R.J. 1994. *Response of Tidal Freshwater Macrobenthos to Sediment Disturbance.* Hydrobiologia 278: 201-212.

Environment Canada, Canadian Wildlife Service (CWS). 2010/2011. Species at Risk Web Mapping Application (http://www.sis.ec.gc.ca/ec_species/ec_species_e.phtml).

Ferguson, R.C. 1962. *The Effects of Underwater Explosions on Yellow Perch (Perca flavescens).* Can. Fish. Cult. 29: 31-39.

Fitchko, J., M. Ernst, B. McCormick and L. Gresock. 2008. *Lake Erie Link Project: Assessment of Potential Construction Effects of Electric Cable Crossing(s) of Lake Erie*, pp. 655-663. *In*: J.W. Goodrich-Mahoney, L.P. Abrahamson, J.L. Ballard and S.M. Tikalsky [Eds.]. The Eighth International Symposium on Environmental Concerns in Rights-of-Way Management, 12-16 September 2004, Saratoga Springs, New York, USA. Elsevier B.V., Amsterdam, The Netherlands.

Foye, R.E. and M. Scott. 1965. *Effects of Pressure on Survival of Six Species of Fish*. Trans. Am. Fish. Soc. 94: 88-91.

Fry, D.H., Jr. and K.W. Cox. 1953. *Observations on the Effect of Black Powder Explosions on Fish Life*. Calif. Fish Game 39: 233-236.

Gillenwater, D., T. Granata, and U. Zika. 2006. GIS-based modeling of spawning habitat suitability for Walleye in the Sandusky River, Ohio, and implications for dam removal and river restoration. Ecological Engineering 28 (2006): 311-323.

Golder Associates. 2001. *Phase II – Environmental Site Assessment and Screening Level Risk Assessment of Specific Issues/Areas at Calabogie Generating Station, Ontario Power Generation Inc., Ottawa/St Lawrence Plant Group, Calabogie, Ontario*.

Golder Associates. 2001. Phase III (Remediation) – Environmental Site Assessment of Specific Issues/Areas at Calabogie Generating Station, Ontario Power Generation Inc., Ottawa/St Lawrence Plant Group, Calabogie, Ontario.

Griffith, J.S. and D.A. Andrews. 1981. *Effects of a Small Suction Dredge on Fishes and Aquatic Invertebrates in Idaho Streams*. N. Amer. J. Fish. Mgt. 1: 21-28.

Griffiths, W.H. and B.D. Walton. 1978. *The Effects of Sedimentation on the Aquatic Biota*. Prepared for the Alberta Oil Sands Environmental Research Program by Renewable Resources Consulting Services Ltd. AOSERP Report 35.

Hirsch, N.D., L.H. DiSalvo and R. Peddicord. 1978. *Effects of Dredging and Disposal on Aquatic Organisms*. U.S. Army Engineer Waterways Experiment Station, Vicksburg, Miss., Tech. Rpt. DS-78-5: 41 p.

Holm, E., N.E. Mandrak, and M.E. Burridge. 2009. The ROM field guide to freshwater fishes of Ontario. Royal Ontario Museum, Toronto. 462 p.

Hubbs, C.L. and A.B. Rechnitzer. 1952. *Report on Experiments Designed to Determine Effects of Underwater Explosions on Fish Life*. Calif. Fish Game 38: 333-366.

Jenkins, R.E., and N.M. Burkhead. 1993. Freshwater fishes of Virginia. American Fisheries Society, Bethesda, Maryland. 1079 p.

Johnson, J.H., and C.C. Nack. 2013. Habitat use of American eel (Anguilla rostrata) in a tributary of the Hudson River, New York. Journal of Applied Ichthyology 29: 1073–1079.

Keevin, T.M., G.L. Hempen and D.J. Schaeffer. 1997. *Use of a Bubble Curtain to Reduce Fish Mortality during Explosive Demolition of Locks and Dam 26, Mississippi River*, pp. 197-206. *In*: Proc. 23rd Ann. Conf. Explosives and Blasting Technique, February 1997, Las Vegas, Nevada. International Society of Explosive Engineers, Cleveland, Ohio.

Lammers, W., K.T. Wang, M.J. German and A.C. Roy. 1972. *Water Resources in the Onakawana Area and the Anticipated Impact of the Proposed Lignite and Power Development*. Ontario Ministry of the Environment, Task Force Onakawana Working Paper #2: 63 p.

Luedtke, R.J. and M.A. Brusven. 1976. *Effects of Sand Sedimentation on Colonization of Stream Insects*. J. Fish. Res. Board Can. 33: 1881-1886.

MacGregor, R., J. Casselman, L. Greig, J. Dettmers, W.A. Allen, L. McDermott, and T. Haxton. 2013. Recovery Strategy for the American Eel (Anguilla rostrata) in Ontario. Ontario Recovery Strategy Series. Prepared for Ontario Ministry of Natural Resources, Peterborough, Ontario. x + 119 pp.

MacLeod, Gillian. E-mail Correspondence with Brad Eckert, MoECP. May 3, 2019.

McAnuff, A.L. and R.T. Booren. 1989. *Fish Mortality Study During Underwater Blasting Operations in Lake Erie Off Nanticoke, Ontario*. Paper Presented at the 15th Ann. Conf. Explosives and Blasting Technique, February 1989, New Orleans, Louisiana. International Society of Explosive Engineers, Cleveland, Ohio.

McCabe, G.T., Jr., S.A. Hinton and R.L. Emmett. 1998. *Benthic Invertebrates and Sediment Characteristics in a Shallow Navigation Channel of the Lower Columbia River, Before and After Dredging*. Northwest Sci. 72: 116-126.

McMahon, T.E., J.W. Terrell, and P.C. Nelson. 1984. Habitat suitability information: walleye. U.S. Dept. Int. Fish Wildl. Serv., FWS/OBS-82/10.56.

Ministry of Environment, Conservation and Parks. 2019. Source Protection Information Atlas. (https://www.gisapplication.lrc.gov.on.ca/SourceWaterProtection/Index.html?viewer=SourceWaterProtection.SWPViewer&locale=en-US). Retrieved May 1, 2019.

Ontario Ministry of Municipal Affairs and Housing (OMMAH). 2005. 2005 Provincial Policy Statement. 37 p.

Ontario Ministry of Natural Resources (MNR). 2008. Fisheries Management in Renfrew County: A State of the Resource Report and a Focused Review of Fisheries Issues. January 2008. 101 p.

Ontario Power Generation. 2009. Madawaska River Water Management Plan.

Ontario Waterpower Association (OWA). 2012b. *Best Management Practices Guide for the Mitigation of Impacts of Waterpower Facility Construction*. 86 p.

Ontario Waterpower Association. 2018. Class Environmental Assessment for Waterpower Projects. Eighth Edition.

Orpana, John. Ministry of the Environment and Climate Change (MoECC). Letter to Gillian MacLeod. Ontario Power Generation Expansion Project Calabogie Generation Station. March 5, 2018.

Orpana, John. 2018. Ministry of the Environmental and Climate Change. Ontario Power Generation Expansion to Calabogie Generation Station.

Parker, B.J. 1988. Updated status of the river redhorse, Moxostoma carinatum, in Canada. Canadian Field-Naturalist 102:140-146.

Parker, B.J., and P. McKee. 1984. Status of the river redhorse, Moxostoma carinatum, in Canada. Canadian Field-Naturalist 98(1):110-114.

Pope, G. F. 1999. *Madawaska River Water Management Review. Effects of Hydroelectric Operations on Walleye Spawning Interim Report 1997-1998.* Report prepared for OMNR/OPG Madawaska River Water Management Review Working Group. xx pp. + appendices.

Price, W.A. 1997. *Draft Guidelines and Recommended Methods for Prediction of Metal Leaching and Acid Rock Drainage at Minesites in British Columbia*. B.C. Ministry of Employment and Investment. 141 p.

Rosenberg, D.M. and N.B. Snow. 1977. *A Design for Environmental Impact Studies with Special Reference to Sedimentation in Aquatic Systems of the MacKenzie and Porcupine River Drainages*, pp. 65-78. *In*: Proc. Circumpolar Conf. Northern Ecology. 15-18 September 1975, Ottawa, Ontario.

Rosien, D.A., 1999. An Assessment of Hydroelectric Operating Effects on Northern Pike, Muskellunge and Walleye Reproduction in the Madawaska River, Spring 1999. Report prepared for OMNR/OPG Madawaska River Water Management Review Working Group. 69 pp.

Round, F.E. 1973. *The Biology of the Algae*. Edward Arnold (Publishers) Limited, London, Great Britain. 278 p.

Scott, W.B. and E.J. Crossman. 1973. *Freshwater Fishes of Canada*. Fisheries Research Board of Canada Bulletin 184: 966 p.

Smith, C.L. 1985. The inland fishes of New York State. New York State Department of Environmental Conservation. 522 p.

Smith, P.W. 1979. Fishes of Illinois. University of Illinois Press. 314 p.

Tarandus Associates Ltd. 1991. *Madawaska River Fisheries Studies at Stewartville, Mountain Chute, and Bells Rapids.* Report for OMNR Pembroke District. Pp. 62.

Tarandus Associates Ltd. 1992. *1992 Walleye Spawning Surveys in the Vicinity of the Calabogie GS.* Report prepared for Ontario Hydro Environmental Studies and Assessments.

Trautman, M.B. 1981. The fishes of Ohio. Ohio State University Press. 782pp.

Wiley, D.J., R.P. Morgan II, R.H. Hilderbrand, R.L. Raesly, and D.L. Shumway. 2004. Relations between Physical Habitat and American Eel Abundance in Five River Basins in Maryland. Transactions of the American Fisheries Society 133(3): 515-526.

Wright, D.G. and G.E. Hopky. 1998. *Guidelines for the Use of Explosives in or near Canadian Fisheries Waters*. Canadian Technical Report of Fisheries and Aquatic Sciences 2107: 34 p.

WSP. *Calabogie GS Strategic Assessment*. *Geotechnical Baseline Report*. July 2016.

Yoder, C.O. and R.A. Beaumier. 1986. The occurrence and distribution of river redhorse, Moxostoma carinatum and greater redhorse, Moxostoma valenciennesi in the Sandusky River, Ohio. Ohio Journal of Science 86:18-21.

7 ACRONYMS AND ABBREVIATIONS

~	Approximately
=	Equals
>	Greater than
<	Less than
#	Number
+	Plus
x	Times or By
ABA	Acid Base Accounting
AMP	Adaptive Management Program
AoC	Area of Concern
AP	Acid Potential
ARD	Acid Rock Drainage
ATV	All-terrain vehicle
Beacon	Beacon Environmental
c.	Chapter
$CaCO_3$	Calcium carbonate
CEAA	*Canadian Environmental Assessment Act*
CEAA 2012	*Canadian Environmental Assessment Act, 2012*
circa	At approximately; around; used of dates
Cl.	Class
CLI	Canada Land Inventory
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
COSSARO	Committee on the Status of Species at Risk in Ontario
CO_2	Carbon dioxide
CWS	Canadian Wildlife Service
DBC	Design Build Contractor
DFO	Department of Fisheries and Oceans
D.O.	Dissolved oxygen
EA	Environmental assessment
EA Act	*Environmental Assessment Act*

Ed.	Editor
e.g.	For example (exempli gratia)
EPRI	Electric Power Research Institute, Inc.
EPT Index	Ephemeroptera/Plecoptera/Trichoptera Index
ER	Environmental Report
ERDE	Environmental and Resource Development Engineering Inc.
ESA	*Endangered Species Act*
et al.	And others (et alia)
etc.	And so on (et cetera)
F.	Family
FRL	Forest Resource Licence
FSL	Full Supply Level
GPS	Global Positioning System
GS	Generating Station
H	Horizontal
HSI	Habitat Suitability Index
Hydro One	Hydro One Networks Inc.
ID	Identification
ID#	Identification number
i.e.	That is (id est)
IESO	Independent Electricity System Operator
IFN	In-stream Flow Need
Inc.	Incorporated
LP	Limited Partnership
Ltd.	Limited
Max	Maximum
MeHg	Methylmercury
Min	Minimum
MNR	Ontario Ministry of Natural Resources
MOE	Ontario Ministry of the Environment
MOEE	Ontario Ministry of Environment and Energy

MoU	Memorandum of Understanding
N	North or Nitrogen
NA	Not applicable
NHIC	Natural Heritage Information Centre
No.	Number
NP	Neutralization Potential
NP/AP	Neutralizing Potential to Acid Potential
O.	Order
OMMAH	Ontario Ministry of Municipal Affairs and Housing
OPG	Ontario Power Generation Inc.
O.Reg.	Ontario Regulation
OWA	Ontario Waterpower Association
OWA Class EA	Class Environmental Assessment for Waterpower Projects
OWRA	*Ontario Water Resources Act*
P	Phosphorus
P.	Phylum
PCBs	Polychlorinated biphenyls
pers. comm.	Personal communication
PPCRA	*Provincial Parks and Conservation Reserves Act*
PTTW	Permit-To-Take-Water
PWQO	Provincial Water Quality Objective
ROW	Right-of-way
S1	Critically imperiled – due to extreme rarity (often five or fewer occurrences) or because of some other factor(s) such as very steep declines making it especially vulnerable to extirpation from the Province
S3	Vulnerable – due to a restricted range, relatively few populations (often 80 or fewer), recent and widespread declines, or other factors.
S4	Apparently secure – uncommon but not rare with some cause for long-term concern due to declines or other factors
S4?	Apparently secure – uncommon but not rare with some cause for long-term concern due to declines or other factors – rank uncertain
S4S5	Apparently secure to secure
S5	Secure – common, widespread and abundant in the Province

SAR	Species at risk
SARA	*Species at Risk Act*
SARO List	Species at Risk in Ontario List
S.C.	Statutes of Canada
S.F.	Subfamily
SIA	System Impact Assessment
sp.	Species
spp.	Two of more species
Sr.	Senior
ssp.	Subspecies
2D	Two-dimensional
TDS	Total dissolved solids
THg	Total mercury
TP	Total phosphorus
TSD	Technical Support Document
TSS	Total Suspended Solids
U.S. EPA	United States Environmental Protection Agency
V	Vertical
W	West
WMP	Water Management Plan
WSC	Water Survey of Canada
YOY	Young-of-the-year

MEASUREMENT UNITS

°	degree
‘	minute
“	second
cm	centimetre
°C	degree Celsius
ft	foot
FTU	Formazin Turbidity Unit
g	gram
GWh	gigawatt hour
h	hour
ha	hectare
JTU	Jackson Turbidity Unit
kg	kilogram
kg $CaCO_3$/t	kilogram calcium carbonate per tonne
km	kilometre
km^2	square kilometre
KP	Kilometre Post
kV	kilovolt
kW	kilowatt
L	litre
L/s	litre per second
m	metre
m.a.s.l.	metre above sea level
m^2	square metre
m^3	cubic metre
m/km	metre per kilometre

m^3/s	cubic metre per second
mi	mile
µg/g	microgram per gram
µg/L	microgram per litre
µmhos/cm	micromhos per centimetre
µ	micron (micrometre)
µS/cm	microsiemens per centimetre
mg/L	milligram per litre
mm	millimetre
mm/s	millimetre per second
MW	megawatt
NTU	Nephelometric Turbidity Unit
%	percent
rpm	revolution per minute
TCU	True Colour Unit

8 GLOSSARY

Acarina	Mites and ticks.
Aerobic	Denotes the presence of gaseous or dissolved oxygen.
Algae (Algal)	A group of unrelated simple plant organisms that live in aquatic habitats.
Algal bloom	Proliferation of living algae usually due to nutrient enrichment.
Alkalinity	Measure of a water's capacity to neutralize an acid.
Alluvial (alluvium)	Of material deposited by rivers.
Amphipoda (Amphipods)	Order of crustaceans of the subclass Malacostraca commonly known as scuds.
Anaerobic	Denotes the absence of gaseous or dissolved oxygen.
Anion	A negatively charged ion
Annelida	A phylum of invertebrates comprising the segmented worms.
Anode Cathodic Protection	Technique use to control corrosion of a metal surface by making it a cathode of an electrochemical cell by connecting the metal to be protected with another more easily corroded metal to act as the anode of the electrochemical cell.
Anoxic	See anaerobic.
Anthropogenic	Human-caused; due to human activities.
AoC Prescription	Mitigation direction prescribed by the MNR to minimize or obviate a potential adverse effect on a habitat value or feature.
Aquatic macrophyte	Rooted, usually vascular, aquatic plants, such as water lily, cattail, coontail, etc.
Arachnida	A class of joint- and eight-legged invertebrates with the body separated into two parts, including spiders, ticks, mites, chiggers and scorpions.
Arthropoda (Arthropods)	Highly specialized invertebrates including insects.
Avifauna	Birds.
Bedload	The solid debris transported in a stream on or near its bed; because this material is too heavy to be carried in suspension, it is moved by rolling, sliding or saltation (sudden jumps) along the bottom.
Benthic	Pertaining to the bottom of aquatic habitats and the organisms that inhabit the bottom.
Benthic macroinvertebrates	Larger bottom-dwelling organisms, e.g., snails, clams, worms, insect larvae, crustaceans, etc. living on or within the sediment substrate of waterbodies.

Benthivorous (benthivores)	Bottom-feeding.
Biological Oxygen Demand	The amount of oxygen required to oxidize the organic matter by aerobic microbial decomposition to a stable inorganic form.
Bivalvia	Pelecypoda; clams
Bog	Peatland with the water table at or near the surface with the surface often raised above the surrounding terrain; strongly acidic and extremely nutrient-poor; ground cover of *Sphagnum*, usually with ericaceous shrubs (of the family Ericaceae).
Brownian movement	The random movement of microscopic particles suspended in a gas or liquid.
Bryophyte	Moss.
Bulkhead	A steep or vertical wall retaining an embankment, often used to line shorelines, maintain embankment stability and absorb the energy of waves and currents.
Canal	A channel dug or built to carry water.
Capacity	The greatest load which a unit, station or system can supply (usually measured in kilowatts, megawatts, etc.)
Catastomidae (catostomid)	Sucker family.
Cation	A positively charged ion.
Centrarchidae (centrarchid)	Sunfish family.
Chaeta	Chitinous bristle or seta found on an insect, arthropod or annelid worms.
Chlorophyll	A class of pigments found in all photosynthetic organisms; chlorophyll molecules are the principal sites of light absorption in the light reaction of photosynthesis.
Class	A category used in the classification of organisms that consists of similar or closely related orders.
Cofferdam	A temporary dam made of concrete, rockfill, sheet-steel piling, timber/timber-crib or other non-erodible material and commonly utilized during construction to exclude water from an area in which work is being executed.
Coldwater habitat	Habitat for fish having a water temperature preference of 10 to 18ºC.
Coleoptera	Beetles.

Conductivity	Numerical expression of a water's ability to conduct an electric current; the conductivity of water is dependent on its ionic concentrations and temperature.
Coolwater habitat	Habitat for fish having a water temperature preference of 18 to 25°C.
Coregonidae (coregonid)	Family of soft-finned fishes comprising the freshwater whitefishes.
Cottidae (cottid)	Sculpin family.
Crest gate (Control gate)	The gate that controls water flow into a hydroelectric dam.
Crustacea (crustaceans)	Crustaceans form a very large group of arthropods including crabs, lobsters, crayfish, shrimp and krill.
Cyprinidae (cyprinid)	Minnow or carp family.
Dam	A concrete or earthen barrier constructed across a river and designed to control water flow or create a reservoir.
Diatoms	Unicellular algae, usually microscopic, that are characterized by having a cell wall of silica.
Diptera	True flies.
Draft tube	The flared passage leading vertically from a turbine to its tailrace.
Drawdown	The release of water from a reservoir for power generation, flood mitigation, irrigation or other water management activity.
Dyke	Embankment against flooding.
Endangered	A species facing imminent extirpation (no longer existing in the wild in Canada, but occurring elsewhere) or extinction (no longer exists).
Ephemeroptera	Mayfly nymphs.
Epilithic	Attached to rocks.
Epipelic	Associated with (attached to) bottom sediments in waterbodies.
Epiphytic	Attached to vegetation, e.g., larger filamentous algae, mosses and aquatic macrophytes.
EPT Index	A measure of the diversity of the relatively more sensitive benthic macroinvertebrate groups, Ephemeroptera, Plecoptera and Trichoptera based on the sum of all taxa within these three orders.
Ericaceous	Plants belonging to the Heath (Ericaceae) family; require acidic soil with pH less than 7.
Extirpation	Elimination of a species in the wild of a particular area (e.g., Ontario), but occurring elsewhere.
Family	A category used in the classification of organisms that consists of one or several similar or closely related genera.

Feldspar	A group of common aluminum silicate minerals that contains potassium, sodium or calcium; the most important group of rock-forming minerals, making up about 60% of the rocks of the earth's crust.
Fen	Peatland with water table at or just above the surface and with very slow internal drainage by seepage; more nutrient-rich than bogs; sometimes occurs as a floating mat; vegetation consists of sedges, mosses, shrubs and sometimes a sparse tree layer.
Forebay	The part of a dam's reservoir that is immediately upstream from the powerhouse.
Freshet	High flows caused by snow melt, runoff, heavy rains and/or high inflows.
Fulvic acids	Yellow to yellow-brown humic substances that are soluble in water under all pH conditions.
Gastropoda (gastropods)	Snails.
Generator	A machine that changes water power, steam power, or other kinds of mechanical energy into electricity.
Genus	A group of animals and plants having common structural characteristics distinct from those of all other groups and usually containing several species.
Geotechnical	Concerned with the physical properties of soil, rock and groundwater usually in relation to the design, construction and operation of engineered works.
Gneiss	A coarse-grained metamorphic rock commonly composed of quartz and feldspar, with lesser amounts of mica.
Granite	Medium to coarse grained igneous rock that is rich in quartz and potassium feldspar.
Habitat	The environment in which the life needs of a plant or animal is supplied.
Hardness	Related to a water's capability to produce lather from soap (the harder the water, the more difficult it is to lather soap), principally determined by the sum of calcium and magnesium.
Head	The difference in elevation between the water surface at the intake and tailrace.
Headpond	The reservoir from which the hydroelectric facility draws water flow for generation.
Headwater	The section of a river or stream with the highest elevation above sea level.
Hemiptera	True bugs.
Herb (Herbaceous)	A non-woody vascular plant.

Humic acids	A mixture of various dark-coloured organic acids that are the principal components of humic substances which are the major organic constituents of soil, peat and many upland streams.
Hydraulic	Of water conveyed through a pipe or channel.
Hyporheic	After burial.
Igneous	Rocks formed from the solidification of molten magma either beneath (intrusive igneous rock) or at (extrusive igneous rock) the earth’s surface.
Insecta	Insects.
Ion	An atom that is either negatively or positively charged.
Intake	A structure which regulates the flow of water into a water-conveying conduit.
Lacustrine	Of lakes.
Lentic	Slow flowing or still water, e.g., in ponds and lakes.
Lithification	Process by which sediments are consolidated into sedimentary rock.
Littoral	The shoreward region of a body of water.
Lotic	Flowing water, e.g., in streams and rivers.
Magma	Molten or fluid material generated from rock deep within the earth that may force its way upward into the crust (as igneous rock) or onto the surface (as lava).
Megaloptera	Alderflies, dobsonflies and fishflies.
Metamorphic	A rock that forms from the recrystallization of igneous, sedimentary or other metamorphic rocks through pressure increase, temperature rise, or chemical alteration.
Mica	Silicate mineral that exhibits a platy crystal structure and perfect cleavage.
Mollusca	Molluscs (snails and clams).
Moraine	A landform generally composed of till and created by glacial action.
Muskeg	A term describing a type of landscape, environment, vegetation and deposit; peatland and organic terrain are equivalent terms generally referring to northern landscapes characterized by a wet environment and vegetation (e.g., Black Spruce) botanically classified as mire (subdivided into bogs and fens).
Nematoda (nematodes)	A phylum of pseudocoelomate (lacking a true coelum) invertebrates comprising the roundworms, characterized by a smooth narrow cylindrical unsegmented body tapered at both ends.
Odonata	Dragonflies and damselflies.

Oligochaeta (oligochaetes)	Worms.
Oligotrophic	Waters with a small supply of nutrients and therefore a small organic production.
Order	A category used in the classification of organisms that consists of one or several similar or closely related organisms.
Organic	Soils that have developed from accumulations of organic materials such as grasses, reeds, rushes, sedges, mosses and ferns.
Overburden	The soil, rock and other material which lie on top of the underlying mineral or other deposit, e.g., bedrock.
Peaking	Generating stations that are normally operated only to provide power during maximum load periods.
Peat	Partly decomposed plant material; refers to soils containing >30% organic matter by weight.
Pelecypoda	Bivalva; clams.
Periphyton	The organisms, collectively, that live attached to rocks, gravel, aquatic vegetation and other substrate.
pH	Indicates the balance between the acids and bases in water and is a measure of the hydrogen ion concentration in solution.
Photosynthesis	The process which takes place in green plants by which simple sugars are manufactured from CO_2, water and mineral nutrients with the aid of chlorophyll within the plant cells in the presence of light.
Phylum	A major division of the animal kingdom containing classes of animals.
Physoclistic	With swim bladder isolated from the oesophagus.
Physostomic	With swim bladder connected to the oesophagus by an open duct.
Pier	As part of a hydroelectric station, an abutment extending from the station, either upstream or downstream, and lending foundation support and directionality to water passed through the structure.
Piscivorous (piscivores)	Fish-feeding.
Planform	A body of water's outline or morphology as viewed from above.
Planktivorous (planktivores)	Plankton-feeding.
Plankton	Minute organisms that drift or float passively with the current of a lake.
Plecoptera	Stonefly nymphs.

Pneumatic	Involving the mechanic properties associated with air or other gas pressure.
Potamoplankton	Drift plankton (associated with flowing water, i.e., streams and rivers).
Powerhouse	A primary part of a hydroelectric facility where the turbines and generators are housed and where power is produced by falling water rotating the turbine blades.
Quartz	A mineral: an oxide of silicon which is abundant and widespread occurring as an important constituent in many igneous, sedimentary and metamorphic rocks.
Reservoir	A body of water collected and stored in an artificial lake behind a dam.
Riparian	Of or on a watercourse bank.
Rotifera (rotifers)	Small, usually microscopic, pseudocoelomate (lacking a true coelum) unsegmented animals, with a ciliated region, the corona, at the anterior end, comprising the zooplankton community in waterbodies.
Runner	An enclosed water wheel that transforms the static and kinetic energy of the water into useful work.
Run-of-the-river	Passing all flows as they come.
Secchi disc	Circular disc used to measure transparency in lakes; the depth at which the pattern on the disc is no longer visible is taken as a measure of the transparency of the water.
Sedimentary	Rock formed by the deposition, alteration and/or compression and lithification of weathered rock debris, chemical precipitates, or organic sediments.
Shannon-Weiner Diversity Index	A measure of the number of species and individuals present at a given location as well as the distribution of those individuals among the various species.
Sluice	An open channel designed to divert excess water which could be within the structure of a hydroelectric dam or separate of the main dam (see spillway).
Sluice gate	Gate used to regulate the flow of water through an opening usually used to pass water over or around dams.
Special Concern	A species of special concern because of characteristics that make it particularly sensitive to human activities or natural events.
Species	A group of closely related individuals which can and normally do interbreed to produce fertile offspring.
Sphagnum	A genus containing the species of moss responsible for the production of peat – common within bog wetlands.

Spillway	A passageway located near or at the top of a dam through which excess water is released or "spilled" past the dam without going through the turbine(s); as a safety valve for the dam, the spillwall must be capable of discharging major floods without damaging the dam while maintaining the reservoir level below some predetermined maximum level.
Stop log	A gate (sometimes made from squared lumber) which can be placed into an opening to shut off or regulate the flow of water.
Subfamily	Taxonomic category of related organisms ranking between family and genus.
Swamp	Wooded mineral wetland or peatland.
Tailrace	A channel through which the water flows away from a hydroelectric plant following its discharge from the turbine(s).
Tailwater	The water from a generating station after it has passed through the turbine.
Tannins	Large polyphenolic compounds that form strong complexes with proteins and other macromolecules.
Till	Material derived from bedrock and overlying unconsolidated material and deposited directly by glacial ice with its characteristics dependent upon the source rock.
Threatened	A species likely to become endangered if limiting factors are not reversed.
Total dissolved solids	An index of the amount of dissolved substances in a water.
Total Kjeldahl nitrogen	Measure of both ammonia and organic nitrogen.
Total organic carbon	Composed of both dissolved and particulate organic carbon, with the bulk comprised of humic substances and partly degraded plant and animal materials.
Total suspended solids	Measure of particle weight obtained by separating particles from a water sample using a filter.
Trash rack	Bar screen with larger space openings installed to prevent logs, stumps and other larger solids from penetrating the intake.
Trichoptera	Caddisfly larvae.
Trophic	Level of organization in the food chain, e.g., producers, herbivores, carnivores.
Turbidity	A measure of the suspended particles such as silt, clay, organic matter, plankton and microscopic organisms in water which are usually held in suspension by turbulent flow or Brownian movement.

Turbine	A mechanism in an electrical generation facility which converts the kinetic and potential energy of water (in the case of hydroelectric turbines) into mechanical energy which is then used to drive a generator converting mechanical to electrical energy.
Vascular	Made up of vessels or ducts for conveying water.
Warmwater biota	Having a water temperature preference of 25°C or higher.
Weir	A dam in the river to stop and raise the water.
Young-of-the-year	Fish that hatched during the year when caught.
Zooplankton	That portion of the plankton consisting of animals, usually minute crustaceans and other small multicellular and single-cell animals.

APPENDIX A

Fish and Fish Habitat Investigations for the Proposed Re-Development of the Calabogie GS, Madawaska River

Fish and Fish Habitat Investigations for the Proposed Redevelopment of the Calabogie GS, Madawaska River.

2016 and 2017

Submitted to:

Ontario Power Generation Inc.
&00 University Avenue
Toronto, Ontario, M5G 1X6

October 25, 2017.

C. PORTT and ASSOCIATES
56 Waterloo Avenue
Guelph, Ontario, N1H 3H5
cportt@sentex.net

Table of Contents

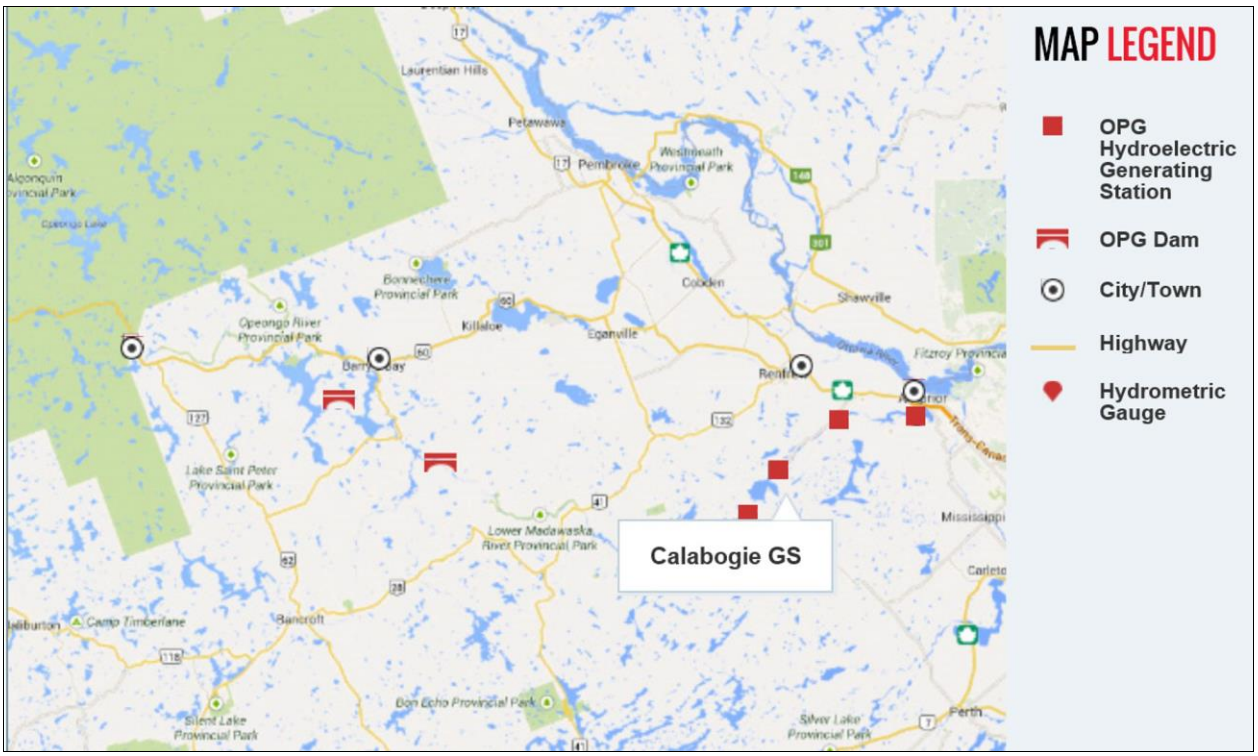
List of Tables

List of Figures

1 Introduction

C. Portt and Associates was retained by Ontario Power Generation Inc. (OPG) in 2016 to conduct an initial habitat and fish community investigation at the Calabogie generating station (GS) on the Madawaska River, approximately 80 km west-southwest of Ottawa, Ontario (Figure 1-1), in support of the proposed hydroelectric redevelopment of this site. In 2017, OPG retained Arcadis Canada Inc. to conduct the overall Environmental Assessment and permitting process for the redevelopment of the Calabogie GS, with C. Portt and Associates as a subcontractor to Arcadis Canada Inc. to undertake the fisheries component. This document presents the results of the background information review, and the 2016 and 2017 field investigations.

Figure 1-1. Location of the Calabogie GS.



Source: http://www.opg.com/generating-power/hydro/ottawa-st-lawrence/river-systems/Pages/madawaska-river.aspx

2 Background Information

2.1 Generating Station Operation

The existing GS went into service in 1917 with an installed capacity of 5 megawatts using two generating units with a maximum flow of 65.6 m^3/s and utilizing a head of 8.2 m (MNR and OPG, 2009). It is the third in a series of five generating stations operated by Ontario Power Generation along the Madawaska River, which is a tributary of the Ottawa River. The total discharge capacity at the Calabogie GS is 950 m^3/s (MNR and OPG, 2009).

Calabogie Lake is situated approximately 1 km upstream of the Calabogie GS. Water from Calabogie Lake has three possible paths downstream: the North Channel, which is one of the original natural river channels; the South Channel Sluiceway and spill channel, and; the GS (Figure 2-1). Figure 2-2 illustrates the general habitat and flow conditions in the vicinity of the GS.

Figure 2-1. Madawaska River in the vicinity of the Calabogie GS.

Figure 2-2. Oblique aerial photograph showing the GS and adjacent sluiceway.

Fish cannot move upstream through the Calabogie GS and associated sluiceways, and the 21.4 km downstream reach ends at the Stewartville hydroelectric station that also blocks the upstream movement of fish. Though fish populations in the reach between the Calabogie GS and the Stewartville GS are essentially isolated, occasionally a few fish must move or are carried downstream through the Calabogie GS or sluiceways from Calabogie Lake (upstream) and, similarly, some fish will occasionally move out of the reach through the Stewartville GS or sluices.

Past concerns regarding the impact of the OPG operating regime upon spring spawning through this area have been addressed by the implementation of seasonal total river flow regime constraints from April 1 to the long weekend in May, to facilitate Walleye and Northern Pike spawning. Furthermore, a minimum year-round flow, and an enhanced minimum flow during Walleye spawning, is maintained in the North Channel (MNR, 2008).

2.2 Fish Community

A fairly diverse community of fish is known to exist in the vicinity of the Calabogie GS (Table 2-1). Three of the species are considered at-risk (see Section 2.3). The part of the Madawaska River between the Calabogie GS and the Stewartville GS is managed as a coolwater fishery (MNR, 2008), with Northern Pike, Smallmouth Bass, Largemouth Bass, Walleye, Rock Bass, Pumpkinseed, Yellow Perch, White Sucker, and Redhorses (Table 2-1). No fall-spawning fishes are known to spawn downstream of the Calabogie GS, though Cisco (a member of the Whitefish subfamily and a fall-spawner) occurs upstream in Calabogie Lake (Table 2-1). Of those fish listed in Table 2-1 that occur downstream of the Calabogie

GS, only Lake Sturgeon, White Sucker, River Redhorse, Shorthead Redhorse, Common Shiner, Walleye and Logperch could potentially utilize habitat in the flowing water associated with the tailrace or the spillway of the GS for spawning, but potentially suitable spawning habitat is also present downstream of the GS in the Madawaska River. Sturgeon has not been known from this portion of the Madawaska River for many years (Kirby Punt, Management Biologist, MNRF. Pers. comm. September 9, 2016). Walleye and White Sucker may have marginally overlapping spawning periods and spawning areas in the early spring, where they both utilize coarse substrates in shallow flowing water. River Redhorse and Shorthead Redhorse spawn over somewhat smaller substrates (i.e. gravel) later in the spring. Logperch and Common Shiner are both common small-bodied fishes that likely occur and spawn in suitable habitats in the Madawaska River downstream between the Calabogie GS and the Stewartville GS. The remaining species, including Northern Pike, Smallmouth Bass, Largemouth Bass, Yellow Perch, etc., are not dependent upon the flowing water habitat associated with the GS for any particular life-stage.

Table 2-1. Fish species found in the vicinity of the Calabogie GS (MNR, 2008).

Common Name (*Scientific name*)	**Upstream of Calabogie to Barrett Chute**	**Downstream of Calabogie to Stewartville**
Lake Sturgeon (*Acipenser fulvescens*)		x
Splake (*Salvelinus namaycush* x *Salvelinus fontinalis*)	x	
Cisco (*Coregonus artedi*)	x	
Northern Pike (*Esox lucius*)	x	x
White Sucker (*Catostomus commersonii*)	x	x
River Redhorse (*Moxostoma carinatum*)	x	x
Shorthead Redhorse (*Moxostoma macrolepidotum*)	x	x
Fallfish (*Semotilus corporalis*)	x	
Northern Redbelly Dace (*Chrosomus eos*)	x	
Golden Shiner (*Notemigonus crysoleucas*)	x	x
Bluntnose Minnow (*Pimephales notatus*)	x	x
Common Shiner (*Luxilus cornutus*)		x
Spottail Shiner (*Notropis hudsonius*)		x
Brown Bullhead (*Ameiurus nebulosus*)	x	
Channel Catfish (*Ictalurus punctatus*)	x	
American Eel (*Anguilla rostrata*)	x	
Banded Killifish (*Fundulus diaphanus*)		x
Trout-Perch (*Percopsis omiscomaycus*)	x	
Smallmouth Bass (*Micropterus dolomieu*)	x	x
Largemouth Bass (*Micropterus salmoides*)	x	x
Rock Bass (*Ambloplites rupestris*)	x	x
Pumpkinseed (*Lepomis gibbosus*)	x	x
Walleye (*Sander vitreus*)	x	x
Yellow Perch (*Perca flavescens*)	x	x
Logperch (*Percina caprodes*)		x
Johnny Darter (*Etheostoma nigrum*)		x

Note: During this study, Channel Catfish were observed downstream of the Calabogie GS; Mimic Shiner (*Notropis volucellus*) and Iowa Darter (*Etheostoma exile*) were captured downstream of the Calabogie GS; and Longnose Dace (*Rhinichthys cataractae*) and Stonecat (*Noturus flavus*) were captured in the North Channel.

2.3 Species-At-Risk

2.3.1 Endangered Species Act

Species that are listed under the Province of Ontario's *Endangered Species Act* (ESA) are categorised as:

- Extirpated: lives somewhere in the world, and at one time lived in the wild in Ontario, but no longer lives in the wild in Ontario.
- Endangered: lives in the wild in Ontario but is facing imminent extinction or extirpation.
- Threatened: lives in the wild in Ontario, is not endangered, but is likely to become endangered if steps are not taken to address factors threatening it.
- Special concern: lives in the wild in Ontario, is not Endangered or Threatened, but may become Threatened or Endangered due to a combination of biological characteristics and identified threats.

Those that are extirpated, endangered, or threatened are protected under the ESA from being harmed or harassed. Species classed as Special Concern are not included in this protection. Those listed as Endangered or Threatened will also have their general habitat protected. General habitat is an area on which a species depends, directly or indirectly, to carry out its life processes. This includes places that are used by the species as dens, nests, hibernacula or other residences. It doesn't include areas where the species once lived or where it may be reintroduced in the future (https://www.ontario.ca/page/how-species-risk-are-protected).

2.3.2 Species-At-Risk Act

Under federal *Species at Risk Act* (SARA), similar to the ESA, species-at-risk are classed as being either Extirpated, Endangered, Threatened, or a Special Concern. SARA contains prohibitions against the killing, harming, harassing, capturing, taking, possessing, collecting, buying, selling or trading of individuals of Endangered, Threatened and Extirpated species listed in Schedule 1 of the *Act*. The *Act* also contains a prohibition against the damage or destruction of their residences (e.g. nest or den). These prohibitions do not apply to a species listed as Special Concern. A management plan must be prepared for Special Concern species and their habitat (https://www.registrelep-sararegistry.gc.ca/default.asp?lang=En&n=71BBC38E-1).

2.3.3 Lake Sturgeon

Lake Sturgeon is listed as Threatened under the ESA, but is not listed at this time under the SARA. In 1879, a commercial Lake Sturgeon fishery harvested fish from the Madawaska and Bonnechère rivers, and from lakes in Lanark and Renfrew counties, but Lake Sturgeon no longer exist in these waterbodies, and the chances of re-establishment are remote due to fragmentation and barriers (COSEWIC, 2006a). MNRF does not believe Lake Sturgeon currently occur in the vicinity of the Calabogie GS, but may be found in downstream reaches (Kirby Punt, MNRF Management Biologist, Pembroke District. Pers. Comm. October 29, 2015).

2.3.4 American Eel

American Eel is listed as Endangered under the ESA, but is not listed at this time under the SARA. Recent dramatic declines in American Eel abundance have occurred in the Ottawa River (COSEWIC, 2012). COSEWIC (2012) reported that eel were now only being found in low numbers below the last dam in the Ottawa River (Carillon Dam), suggesting that they may be close to extirpation there. However, while MNRF does not believe American Eel currently occur in the vicinity of the Calabogie GS, more recent sampling by the MNRF has found some eel in the Ottawa River and in the tailwater of the Arnprior GS (Kirby Punt, MNRF Management Biologist, Pembroke District. Pers. Comm. April 26, 2017).

2.3.5 River Redhorse

River Redhorse has been found in recent years in the vicinity of the Calabogie GS. This species is listed as Special Concern under the ESA and as Special Concern on Schedule 1 of SARA.

Adult River Redhorse have been reported from both rivers and lakes, but it relies on rivers for spawning (DFO, 2016). The River Redhorse is primarily an inhabitant of the deeper portions of moderate to large rivers, where the water is relatively clear and fast flowing, substrates are clean stones, rubble, and bedrock, and where siltation is at a minimum (Trautman 1981; Parker, 1988; Smith, 1979). Like most *Moxostoma* species, it is reportedly intolerant of turbidity, siltation, and pollution (Trautman, 1981; Smith, 1979; Parker and McKee, 1984).

Parker (1988) reported that River Redhorse is not often captured in sluggish environments with an abundance of macrophytes and/or soft sediments such as sand and silt. However, young-of-the-year in the Richelieu River, Quebec, are found along vegetated shores with substrates of silt, clay and sand, at an average depth of 1.5 m (3 m maximum), and age 1+ specimens are found in greater abundance in vegetated areas in the early spring (COSEWIC, 2006b). Jenkins and Burkhead (1993) reports that adults apparently avoid the shallow portions of pools, but young and small juveniles often are found there and in backwaters. Yoder and Beaumier (1986) reported that in the Sandusky River the highest numbers of River Redhorse were found in habitats with moderate to swift current, riffle/run structure, and convoluted bedrock, boulder, rubble, and gravel substrates. Similar habitat attributes are present in the Mississippi River, Ontario, where they were captured in fast-flowing pools in a 300 m long chute and in the plunge-pool of a waterfall (Parker and McKee, 1984).

Spawning of River Redhorse reportedly occurs at water temperatures of 18-24.3°C, over gravel or gravel/cobble/rubble shoals at depths of 0.2-1.2 m, and where water velocity is 0.6-1.0 m/s (Jenkins and Burkhead, 1993; Becker, 1983). However, in northern populations spawning is known to occur at water temperatures of 17-20°C (COSEWIC, 2006b). At a location on the Trent River in Ontario, River Redhorse were captured and observed in aggregations over a shallow shoal, in spawning condition (*i.e.* runny milt or eggs) on June 3 and 11, 2002, when water temperature was 16 and 17°C respectively (Scott Reid, personal communication), and some of the females were spent on June 11, 2002. At this same Trent River location on June 4, 2009, when water temperature was 16.1°C, a spawning aggregation of approximately 8-10 River Redhorse were observed within a small area of distinct habitat, less than 1 m deep with substrates of gravel, cobble and some sand (G. Coker, personal observation).

3 Field Investigations

3.1 Methods

3.1.1 Walleye Spawning Observations

Walleye spawning surveys were conducted by C. Portt and Associates staff on April 27 and 28, 2016 (G. Coker; J. Reid), and on April 25 and 26, 2017 (G. Coker). OPG staff provided on-site safety and logistical support. Additional field observations of water temperature and river flow during early April were provided by OPG staff to aid in determining the timing for the field investigations.

The study area was examined during daylight hours on the first day of each survey in order to identify safety hazards, access routes, river conditions and potential Walleye spawning habitat. Water temperature was measured using a Checktemp °C by Hanna Instruments, which has a specified accuracy of ±0.2°C. A Garmin GPSmap 76CSx Global Positioning System (GPS) unit was used to locate and identify key features. Digital photographs were taken at selected locations. After nightfall, a powerful spotlight (1.5 million candlepower) was used from shore to search for Walleye, which are differentiated from other fishes primarily by the light reflected by the *tapetum lucidum* of their eyes, as well as the white tip of the lower caudal lobe. White Sucker spawn in similar habitats and at similar time periods as Walleye, and are often observed along with spawning Walleye.

Spawning observations were conducted at four locations in the North Channel (Figure 3-1: Areas 1 to 4) in 2016, covering many of the faster-flowing sections. In 2017 the number of locations in the North Channel were reduced due to unsuitable spawning habitat (Area 3), or safety concerns related to access and high flows (the downstream half of Area 2). Spawning observations were also made in parts of the South Channel in 2016 and 2017, downstream of the South Channel Sluiceway (Figure 3-1: Areas 5 to 7), and in the tailrace of the GS (Figure 3-1: Area 8). In 2016 reference spawning observations were conducted at Cherry Point Park (Figure 3-1: Area 9), as well as in the tailrace of Barrett Chute which is the next GS upstream of Calabogie Lake (Area 10: not identified in any figures), and in Constance Creek, a tributary of Calabogie Lake, between the lake and the first road bridge (Area 11: not shown in any figures). In 2017, reference spawning observations were conducted at Barrett Chute and Constance Creek.

Walleye normally spawn at temperatures of 6.7 to 8.9°C over boulder to coarse gravel (Scott and Crossman, 1973), generally in water less than 1.2 m deep (Smith, 1985), and in velocities from 0.3-1.0 m/s (McMahon *et al*, 1984). Interpretation of the graphs in Gillenwater *et al*. (2006), indicate that water velocity is optimal for Walleye spawning at 0.3 to 0.95 m/s, and marginal below 0.3 m/s or between 0.95 and 1.2 m/s. They have been known to spawn at temperatures as low as around 2ºC (Coad *et al*. 1995; Holm *et al.* 2009), and as high as 17.2ºC (Becker, 1983). Male Walleye arrive on the spawning grounds first (Scott and Crossman, 1973).

3.1.2 River Redhorse Spawning Investigation

Investigations for River Redhorse spawning were conducted by C. Portt and Associates staff (G. Coker, J. Reid) on May 29 and June 10, 11, and 12, 2017 (ref. Section 2.3.5 for River Redhorse spawning habitat and conditions). Water temperature was measured several times each field day using a Checktemp °C by

Hanna Instruments, which has a specified accuracy of ±0.2°C. A temperature logger (HOBO Water Temp Pro v2. Onset Corp., accuracy of ±0.21°C) was deployed from May 30 to June 11, in a shaded location in the Calabogie GS tailrace at a depth of 0.5 m, and recorded the water temperature at 15 minute intervals.

Visual observations were made from the surface where the water was shallow and visibility allowed, but most of the area was investigated using an Aqua-Vu 740c underwater colour video system deployed from a boat. Flow conditions in the GS tailrace, below the spillway, and at Cherry Point were such that video observations were only feasible while travelling with the current, and therefore the video camera was deployed from the boat at the upstream end of the area, and observation and video capture occurred while the boat drifted downstream. Multiple boat passes were made with the underwater video camera on May 29 and June 10-12, 2017, within the GS tailrace and in the lower portion of the spillway, downstream to near the safety boom (Figure 3-1). On June 10-12, 2017, the video signal was recorded on a laptop computer using Pinnacle Studio for Dazzle software (Corel Corporation) via a Dazzle Video Capture USB v1.0 interface, so it could be reviewed later to positively identify fish and make more accurate counts of fish observed. At the downstream end of the North Channel and at Cherry Point, video searches were conducted on June 10 and 11, 2017, and, where appropriate, visual observations from the surface were made on May 29 and June 10-12, 2017 (Figure 3-1). On June 11, 2017, visual observations from shore or bridges were made in the North Channel at Areas 1 and 2 (Figure 3-1).

A Safari™ HD Action Camera 2.0 affixed to a steel stand was deployed on two occasions, once in the downstream portion of the spill channel on June 10, 2017, and once in the GS tailrace, approximately 40 m downstream from the powerhouse, on June 11, 2017. On each occasion video was recorded for approximately 80 minutes.

3.1.3 Habitat Investigation and Mapping

C. Portt and Associates staff (G. Coker; J. Reid) conducted habitat mapping on October 12, 2016, and on May 29, 2017. In 2016 substrate and aquatic macrophytes were characterized from the South Channel Sluiceway (which is the name applied to the actual control structure) and the GS downstream to the Safety Boom, as well as in the vicinity of Walleye spawning observation Area 4 (Figure 3-1). Bathymetry data in the vicinity of the GS were provided by OPG. In 2017 bathymetry, substrate and aquatic macrophytes were characterized in the North Channel, downstream of Walleye spawning observation Area 4, and substrate and general instream conditions were characterized in the vicinity of Walleye spawning observation Area 1 and Area 2 in the North Channel (Figure 3-1). A Humminbird 899ci HD sonar unit was used to record georeferenced standard and side-scan sonar data. Straight, parallel boat runs, orientated to best characterize the area's features, were used to record slightly overlapping side-scan images of the river bottom. Visual observations of the substrate were also made, either from the surface where the water was shallow and visibility allowed, or using an Aqua-Vu 740c underwater colour video system where the water was deeper. All visual substrate observations were georeferenced with a Garmin GPSmap76CSx GPS unit. The side-scan images were processed using ReefMaster software (ver. 1.8) to create a single georeferenced side-scan mosaic of the area of interest. A modified Wentworth (1922) scale was used to classify substrates as bedrock, hard clay (consolidated parent material), silt/soft clay (feels soft and smooth between fingers), sand (2 mm or less and feels gritty between fingers), gravel (2-64 mm), cobble (64-256 mm) and boulder (>256 mm). Substrates are often a mixture of two or more of these classes. The side-scan imagery and visual point observations were overlaid using GIS software

(QGIS version 2.8) and areas with similar substrate and macrophyte beds were identified and digitized to create a map of the substrate classes and macrophyte beds.

Figure 3-1. Locations where Walleye (delineated in red) and River Redhorse (delineated in yellow) spawning observations were conducted. The number labels identify the investigation areas for both Walleye spawning and River Redhorse spawning. In 2016, Walleye observations were conducted at all locations shown. In 2017, Walleye observations were conducted at the locations shown, except Areas 3 and 9, and the downstream portion of Area 2. River Redhorse observations were only conducted in 2017.

3.1.4 Small-bodied Fish Collections

Electrofishing and seining were conducted in shallow wadeable habitats to further characterize the fish community within the study area. The collection of young-of-the-year (YOY) fish may also be indicative of nearby spawning areas of fishes, and would help identify nursery habitat for some fish species. Electrofishing was conducted using a Model HT 2000B Mrk 5 backpack electrofisher. The sein net was constructed with a 3/16 inch (4.76 mm) mesh, and was 10 m long and 1.5 m deep.

Electrofishing

On October 12, 2016, electrofishing was conducted by C. Portt and Associates staff (G. Coker, J. Reid) along a 224 m path, roughly parallel to the shoreline adjacent to the South Channel Spillway (Figure 3-8), at settings of 250 volts and 60 hertz.

On June 10, and again on June 11, 2017, electrofishing was conducted by C. Portt and Associates staff (G. Coker, J. Reid) along a 105 m path, roughly parallel to the shoreline adjacent to the South Channel Spillway (Figure 3-8), at settings of 150 volts and 60 Hertz.

On August 16, 2017, electrofishing was conducted by C. Portt and Associates (G. Coker) and Arcadis (S. McKee) staff along a 70 m path in the shallow water between the tailrace and the spill channel (Figure 3-8); along a 60 m section of bedrock and boulder dominated riffle on the north side of the lower North Channel (Figure 3-9), and; along a 100 section of cobble/boulder/gravel riffle in the upper North Channel (Figure 3-10), all at settings of 150 volts and 60 Hertz.

The number of electroseconds was recorded on each occasion. All fish collected were identified to species, counted, and released near the point of capture.

Sein

On August 16, 2017, eight sein hauls were conducted by C. Portt and Associates (G. Coker) and Arcadis (S. McKee) staff along approximately 110 m of shoreline, adjacent to the South Channel Spillway (Figure 3-8). Most fish collected were identified to species, counted, and released near the point of capture, except that seven specimens of YOY fishes were retained for positive identification.

3.2 Results and Discussion

3.2.1 Walleye Spawning Observations

The results of the 2016 and 2017 Walleye spawning observations are summarized in Table 3-1 and Table 3-2, respectively. Numbers of Walleye observed in the vicinity of the Calabogie GS were low relative to the numbers observed at the reference site below Barrett Chute, even though only a small proportion of the potential spawning area at the reference location could be examined.

In 2016 the water temperature on April 27 at 17:25 was 7.6°C, and on April 28 at 22:00 it was 7.3°C, which is about the mid-point of the typical temperature range for Walleye spawning. In 2017 the water temperature on April 25 at 17:24 was 6.9°C, and on April 26 at 22:22 was also 6.9°C. The presence of spawning Walleye below Barrett Chute confirmed that the timing of the field investigations in 2016 and 2017 was appropriate.

Table 3-1. Number of Walleye observed for each Area on April 27 and 28, 2016. Locations and extents for Areas 1 to 9 are provided in Figure 3-1.

Area	April 27, 2016.	April 28, 2016.
1 - North Channel	0	No observation
2 - North Channel	0	0
3 - North Channel	0	No observation
4 - North Channel	4 (large females)	0
5 - South Channel below sluiceway	0	0
6 - South Channel below sluiceway	0	0
7 - South Channel below sluiceway	0	3 (extreme downstream end)
8 - GS Tailrace	8 (near GS)	1 (downstream end)
9 - Cherry Point Park	No observation	3 (plus White Suckers)
10 - Barrett Chute	28+	No observation
11 - Constance Creek	1	No observation

Table 3-2. Number of Walleye observed for each Area on April 25 and 26, 2017. Locations and extents for Areas 1 to 9 are provided in Figure 3-1.

Area	April 25, 2017.	April 26, 2017.
1 - North Channel	0	1
2 - North Channel	1	1
3 - North Channel	No observation	No observation
4 - North Channel	1	0
5 - South Channel below sluiceway	1	0
6 - South Channel below sluiceway	0	0
7 - South Channel below sluiceway	0	0
8 - GS Tailrace	1 (near GS)	1 (near GS)
9 - Cherry Point Park	No observation	No observation
10 - Barrett Chute	No observation	25+
11 - Constance Creek	No observation	0 (White Suckers only)

In the vicinity of the Calabogie GS the North Channel appears to offer the most suitable flow velocities and water depths for Walleye spawning, but where suitable flow velocities occur in the downstream portion of this area the substrate in many places is either bedrock or boulders (Figure 3-2; Figure 3-9), and therefore would provide only limited potential spawning habitat. In the upper portion of the North Channel, from the North Channel Sluiceway to the downstream end of Walleye spawning observation Area 2 (Figure 3-1), the presence of some cobble and gravel substrates (Figure 3-10), combined with suitable water depths and flow velocities, provides better potential Walleye spawning habitat. The flatwater sections of the North Channel, though they may have suitable substrates, do not have flow velocities suitable for Walleye spawning. In 2016, one group of four large female Walleye was observed on one night in the North Channel, in Area 4 (Figure 3-1), while no Walleye were observed in Areas 1, 2 and 3. In 2017, a single Walleye was observed in each of Areas 2 and 4 during the first night of observation, and in Areas 1 and 2 during the second night of observation.

Figure 3-2. Bedrock dominated section of the North Channel. April 28, 2016.

The spill channel below the South Channel Sluiceway was passing the majority of spring flow at the time of the Walleye spawning observations in both 2016 and 2017, and the high turbulent flows (Figure 3-3) and bedrock and large boulder substrate (Figure 3-8) made this area generally unsuitable for Walleye spawning. It is possible that at the bottom of the spillway, where the flow velocity slows and the substrate contains some patches of gravel and sand, there are limited locations where Walleye may spawn; however, these locations could not be fully examined due to safety concerns. In 2016, a few individual Walleye were observed near shore at the extreme downstream end of the spillway (Figure 3-1: Area 7), but they appeared to be resting in slack-water areas. In 2017 a single Walleye was observed in Area 5 (Figure 3-1).on the first night of observation and none were observed on the second night.

Figure 3-3. Spill channel downstream of the South Channel Sluiceway. April 25, 2017.

Most of the tailrace of the Calabogie GS is considered to be deeper than typical Walleye spawning habitat, even though substrates in the tailrace might be suitable (Figure 3-8). A few areas of suitable substrate were observed in a narrow band of shallow water along the north side of the tailrace (see substrate in Figure 3-4), but the flow velocity there was too slow to be optimal for Walleye spawning at the time of the field observations. Regardless, low numbers of Walleye were observed in the tailrace in 2016 and 2017, indicating that they are attracted to it. In 2016 eight Walleye were observed in an eddy on the north side of the tailrace just downstream from the GS on April 27, and one Walleye was observed at the downstream end of the tailrace on April 28, 2016 (Table 3-1: Area 8). In 2017 only one Walleye was observed in the tailrace on each of the two nights of observation (Table 3-2: Area 8).

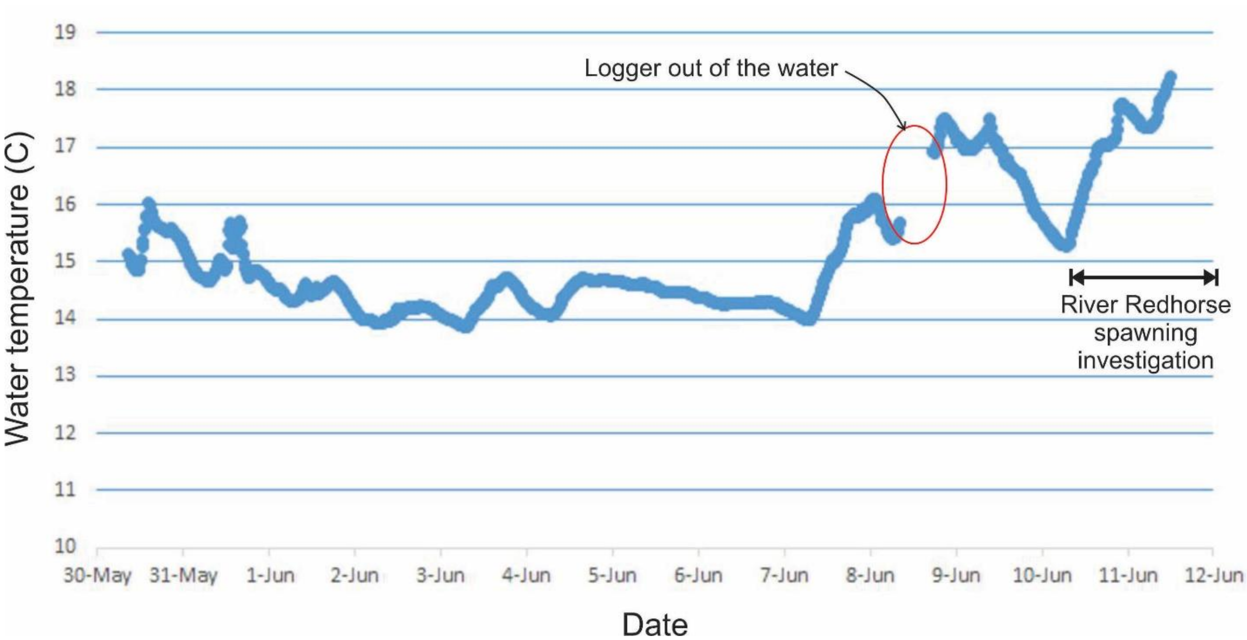
Figure 3-4. Calabogie GS tailrace. April 27, 2016. Nearshore substrate shown in foreground.

3.2.2 River Redhorse Spawning Observations

Upon arrival at the Calabogie GS on May 29, 2017, it became apparent that it was too early for River Redhorse spawning, since the water temperature was only 14.5°C, and the known spawning temperatures for other Canadian populations is a minimum of 16°C (ref. Section 2.3.5). Regardless, the area below the South Channel Spillway and within the GS tailrace were examined for spawning River Redhorse with the underwater video camera. The shallow downstream section of the North Channel was also examined from a boat, and the nearshore of Cherry Point was examined from shore, but no River Redhorse were observed.

The second attempt to observe spawning of River Redhorse was initiated on June 10, 2017, when water temperatures, measured by OPG staff, indicated that water temperature was within the known spawning range for River Redhorse. The water temperature recorded at 15 minute intervals by the temperature logger deployed in the tailrace from May 30 to June 11, 2017, illustrate the progression of water temperature leading-up to the June 10-12 field investigations (Figure 3-5).

Figure 3-5. Water temperature taken at 15 minute intervals in the Calabogie GS tailrace. May 30 - June 11, 2017.



The results of the boat-based video investigations are presented in Table 3-3. Two River Redhorse were observed using this method, but they were not part of any spawning aggregation and were likely foraging.

The action camera deployed in the outwash from the Spill Channel (Figure 3-1: Area 5) on June 10, 2017, recorded 8 minutes of useable video, in which no fish were observed, before falling over. The other deployment of the Action Camera in the tailrace (Figure 3-1: Area 8) on June 11, 2017, recorded 19 Smallmouth Bass, 5 Shorthead Redhorse, and 2 River Redhorse over 80 minutes of video. These redhorses in the tailrace appeared to be foraging in the swift current among the cobble and boulders which comprised the substrate in this portion of the tailrace.

An aggregation of spawning River Redhorse (Figure 3-6) was observed at the downstream end of Area 9 (Figure 3-1) on June 11 and 12, 2017, at water temperatures of 18.2-18.3°C. These fish were in a limited, somewhat protected location adjacent to a set of rapids, where complex currents result in a deposit of gravel/sand among protruding boulders. The River Redhorse were observed spawning in the gravel/sand deposit at water depths of 1-2 m, in the current. No River Redhorse were observed at any other location in the area searched by direct observation from the water surface, either from shore or from the boat, on June 11 (Figure 3-1). Areas where it was thought that habitat similar to the spawning area was present were re-examined on June 12, including the downstream portion of Area 4, areas of sand and gravel deposits on the north side of Area 5, and the downstream portions of Areas 7 and 8 (Figure 3-1). None of these locations proved to have the same habitat conditions as were observed at the spawning location in Area 9, and no spawning fish of any type were observed.

Table 3-3. Boat-based observations using an underwater video camera. June 10-12, 2017.

Area	Date	Number of passes (total time)	Fish observed
Area 4 (North Channel)	June 10	2 (17min: 3sec)	1 White Sucker 1 Smallmouth Bass 1 River Redhorse
	June 11	1 (12min: 30sec)	1 Smallmouth Bass
Area 5 (spillway north side)	June 10	6 (20min: 10sec)	9 Smallmouth Bass
	June 11	7 (19min: 10sec)	2 Smallmouth Bass
	June 12	1 (2min: 30sec)	no fish
Area 7 (spillway south side)	June 10	2 (10min: 50sec)	2 Smallmouth Bass 1 Channel Catfish
	June 11	2 (8min: 0sec)	1 Smallmouth Bass
	June 12	1 (4min: 30sec)	1 Smallmouth Bass
Area 8 (GS tailrace)	June 10	5 (24min: 40sec)	5 Smallmouth Bass 1 River Redhorse 1 Walleye 1 unidentified fish (distant)
	June 11	3 (7min: 15sec)	2 Smallmouth Bass
	June 12	1 (3min: 15sec)	no fish
Area 9 (Cherry Point)	June 10	7 (16min: 25sec)	1 Channel Catfish
	June 11	3 (9min: 30sec)	1 unidentified fish

Figure 3-6. River Redhorse in the Madawaska River at Cherry Point, resting adjacent to the spawning area. June 12, 2017.

3.2.3 Habitat Investigation and Mapping

The results of the habitat mapping are presented in Figure 3-7, Figure 3-8, Figure 3-9, and Figure 3-10. Due to the safety requirement to shut down the flow through the GS and the South Channel Sluiceway during the habitat mapping for the location shown in Figure 3-8, the sloped spillway downstream of the South Channel Sluiceway had only leakage flow, resulting in many areas of the spillway being dry and the remainder shallow (Figure 3-11, Figure 3-12 and Figure 3-13). The spillway is scoured bedrock at the upstream end, immediately downstream of the South Channel Sluiceway (Figure 3-11), changing to large boulders farther from the sluiceway (Figure 3-12), and grading to smaller boulders and cobble with a small portion of sand and gravel where the spillway ends and the velocities are lower (Figure 3-13). Figure 3-8 also illustrates the effect of flow velocity on substrate composition. Bedrock and large boulders dominate in the upper South Channel spillway where the bulk of the high river flows are passed. Areas sheltered from the flows, such as the embayment to the west of the downstream end of the South Channel spillway and the downstream end of Cross Island (Figure 2-2), have finer substrates and aquatic macrophyte beds. These different habitats will attract/support different assemblages of fish and invertebrate species.

The downstream riffle/rapids section of the North Channel (Figure 3-9) has substrates of boulder and bedrock with some cobble (Figure 3-2, Figure 3-14, and Figure 3-15). Substrate downstream of the rapids is also primarily boulders and cobble, but there are finer substrates in sheltered locations closer to shore. The upstream riffle/rapids section of the North Channel (Figure 3-10) is mainly bolder/cobble, but there is a sizeable section at the downstream end of this set of rapids, with substrates of cobble/boulder/gravel (Figure 3-16, Figure 3-17), which is the best potential Walleye and White Sucker spawning habitat in the North Channel.

Figure 3-7. Areas covered by habitat maps in Figures 3-8, 3-9, and 3-10.

Figure 3-8. Substrate, aquatic macrophytes, and river bottom elevations downstream of the Calabogie GS and associated structures. October 12, 2016. Elevations were provided by OPG. Electrofishing areas in 2016 and 2017, as well as sein netting locations in 2017, are also shown.

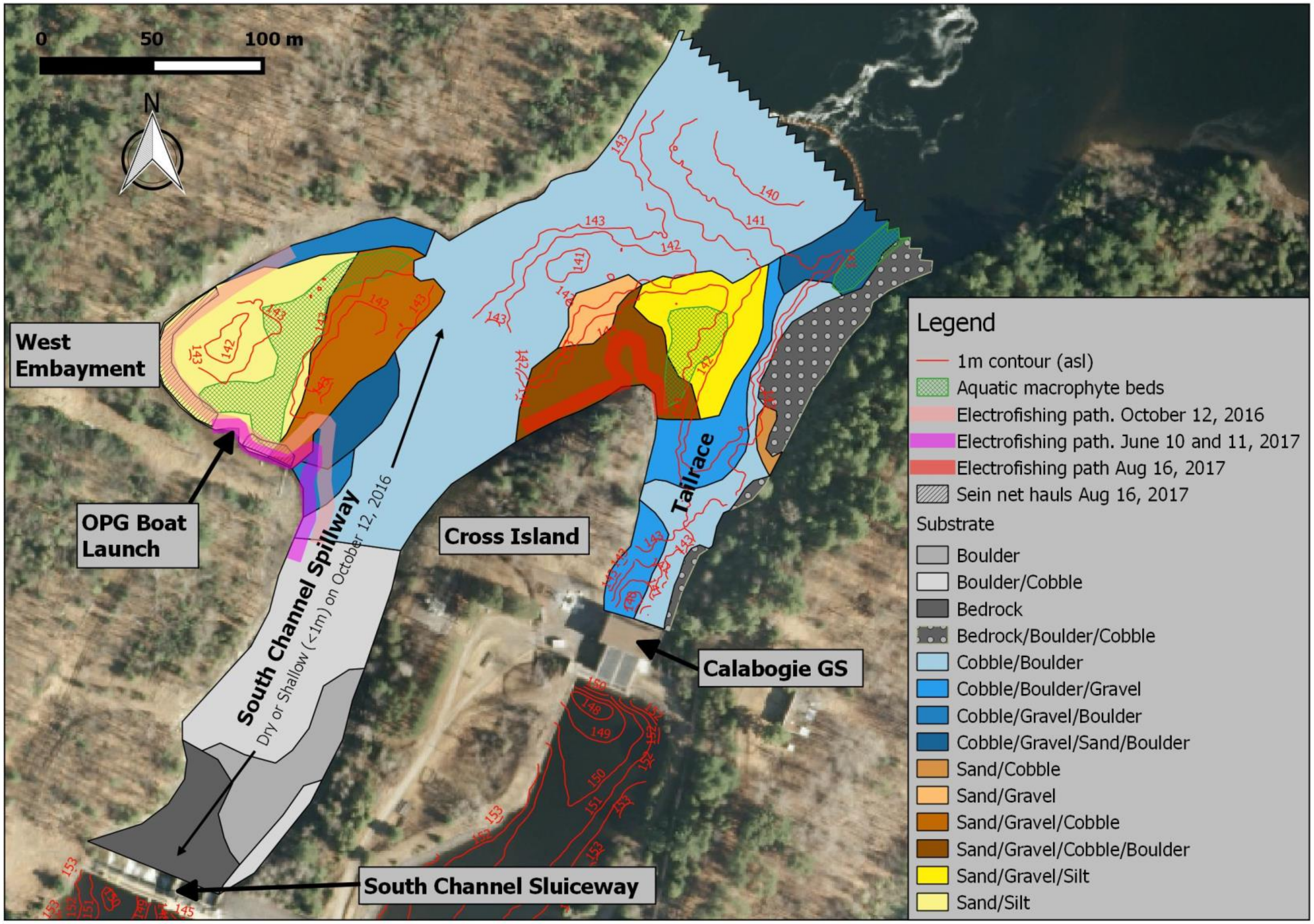


Figure 3-9. Substrate, flow condition and bathymetry in the downstream portion of the North Channel. May 29, 2017. Electrofishing location in 2017 is also shown.

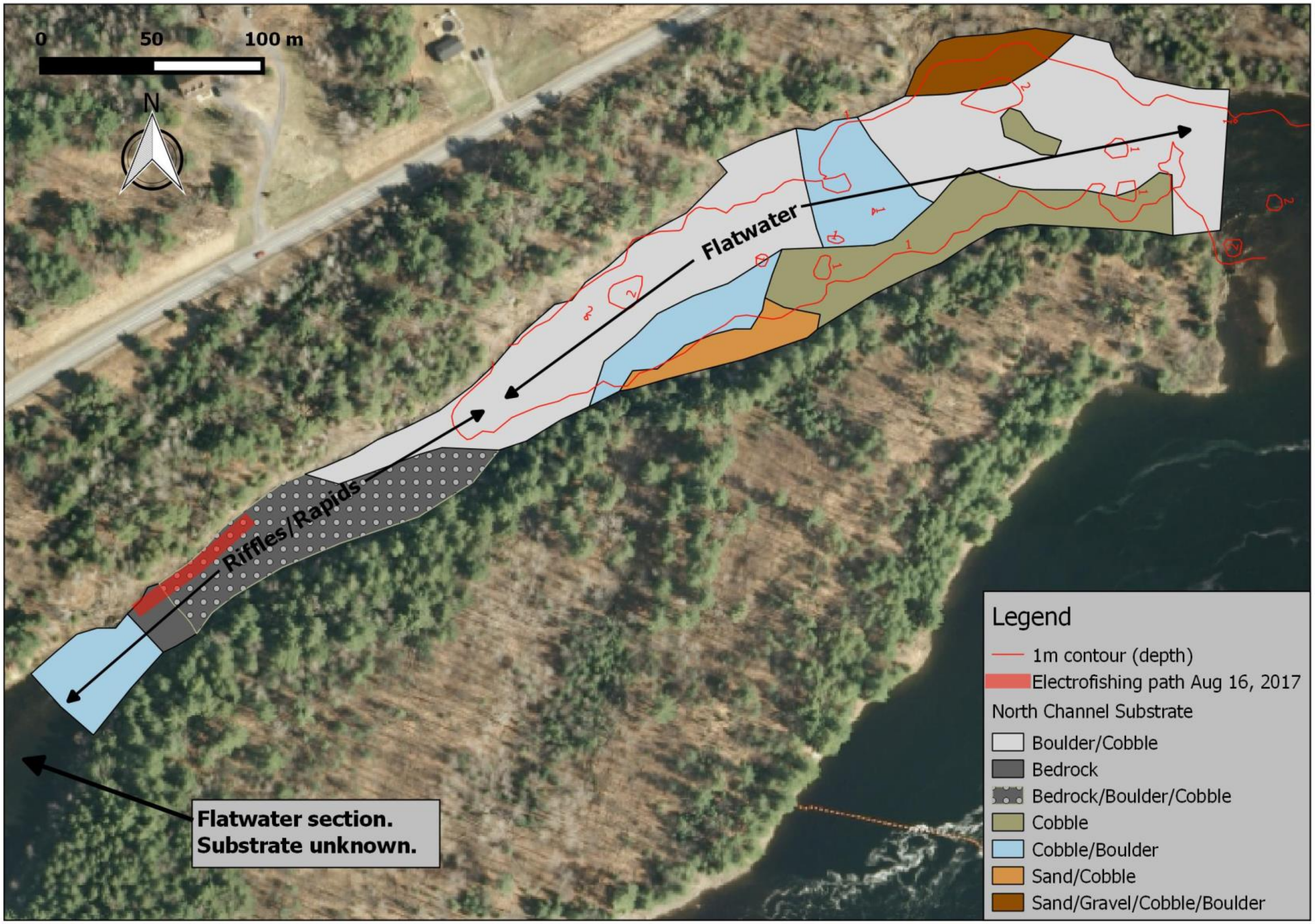


Figure 3-10. Substrate and flow condition in the upstream portion of the North Channel. Electrofishing location in 2017 is also shown.

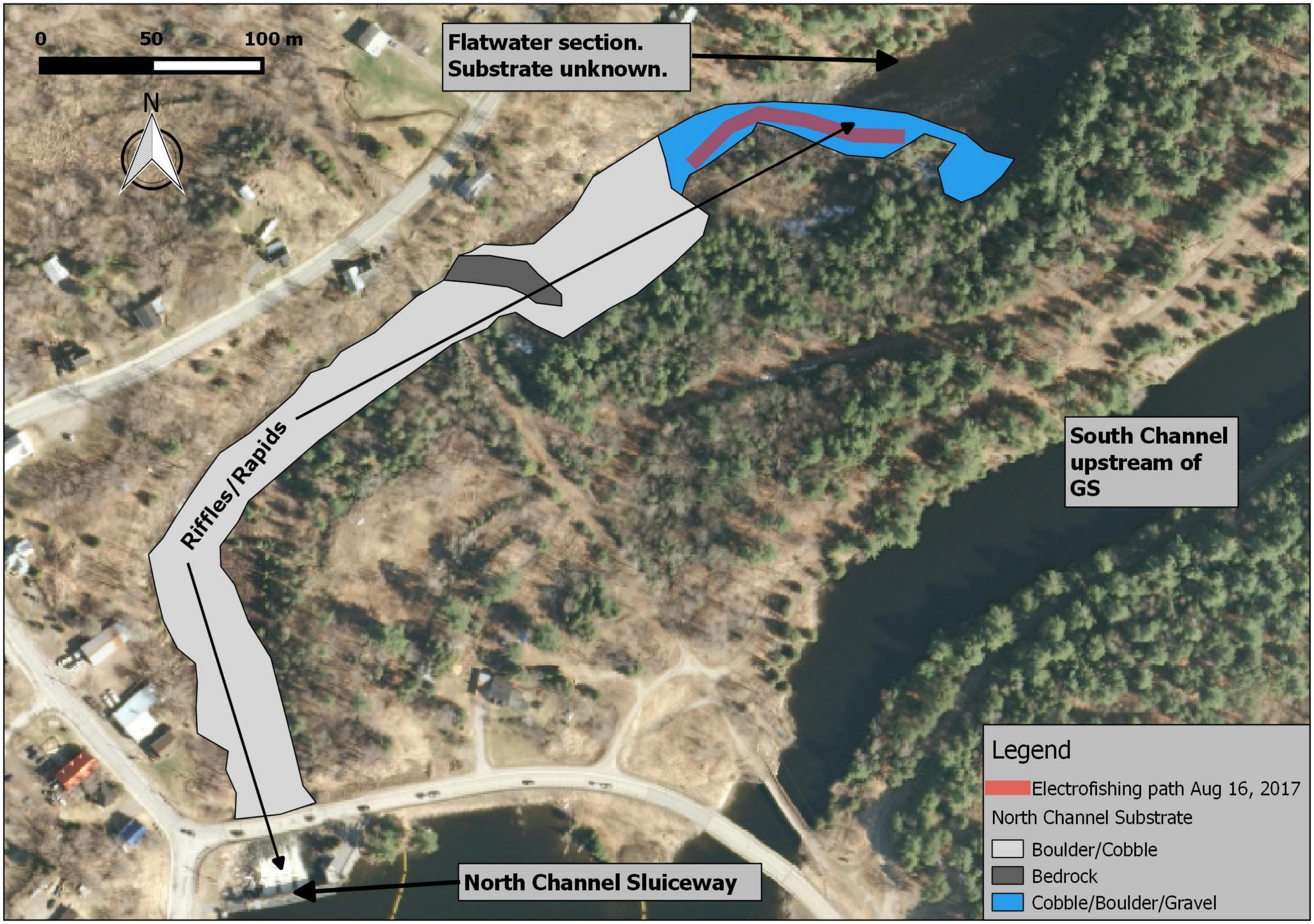


Figure 3-11. Upstream view toward the South Channel Sluiceway from within the south channel spillway. October 12, 2016.

Figure 3-12. Downstream view of the south channel spillway from same location as Figure 3-11. October 12, 2016.

Figure 3-13. Upstream view from just downstream of the south channel spillway. October 12, 2016. South Channel Sluiceway is in the background, on the right side.

Figure 3-14. Predominantly boulder, with some cobble, substrate in the downstream portion of the downstream riffles/rapids in the North Channel. June 11, 2017.

Figure 3-15. Downstream view in the upstream portion of the downstream riffles/rapids in the North Channel. October 12, 2016.

Figure 3-16. Upstream view in the downstream portion of the upstream riffle/rapids in the North Channel. June 11, 2017.

Figure 3-17. Downstream end of the upstream riffle/rapids in the North Channel. June 11, 2017.

3.2.4 Small-bodied Fish Collections

Electrofishing along a 224 m path on October 12, 2016, began at the downstream end of the South Channel Spillway, and included a cobble/gravel/sand/boulder bar, a depositional area with rooted macrophytes, a depositional shore and a rocky section of shore (Figure 3-8). Only four fish species and 21 individuals were captured during 1223 electroseconds, including 10 Logperch, 7 Johnny Darter, 2 Pumpkinseed, and 2 young-of-the-year Bluntnose Minnow (Table 3-4). This is a fairly sparse result considering the varied types of habitat sampled. The low numbers may reflect the timing of the field work in mid-October, when sampling catch typically declines, and/or the fact that flow through this area had been stopped earlier that day to allow the habitat investigations to proceed safely.

Electrofishing on June 10 and 11, 2017, occurred along a 105 m path that began at the OPG boat launch, and moved along the shore, upstream to the base of the South Channel Spillway (Figure 3-8). The same path was electrofished in the morning on both days. On June 10, four fish species were captured during 738 electroseconds, including 1 Largemouth Bass, 7 Bluntnose Minnow, 1 Logperch, and 1 Mimic Shiner (Table 3-4). Mimic Shiner has not been previously recorded from this area (Table 2-1). On June 11, no fish were captured during 484 electroseconds of effort.

Electrofishing was conducted at three different locations on August 16, 2017. One of these locations was at the downstream end of Cross Island, between the tailrace and the South Channel Spillway, where an approximately 70 m long path was electrofished over finer substrates dominated by sand and gravel (Figure 3-8). Three fish species were captured during 928 electroseconds, including 4 YOY Smallmouth Bass, 2 Rock Bass, and 4 Logperch (Table 3-4). The other two electrofishing locations on August 16, 2017, were in the North Channel (Figure 3-9 and Figure 3-10), where Rock Bass, Logperch, Smallmouth Bass juveniles, Stonecat, and Longnose Dace were captured (Table 3-4). Stonecat and Longnose Dace have not been previously recorded from this area (Table 2-1).

The eight sein net hauls conducted adjacent to the downstream end of the South Channel Spillway (Figure 3-8) captured 15 YOY Smallmouth Bass, 8 YOY Rock Bass, 3 YOY Pumpkinseed, 11 YOY Bluntnose Minnow, 5 Golden Shiner, 2 Logperch, 19 Johnny Darter, 1 Iowa Darter, and 5 YOY Yellow Perch (Table 3-4). Of these, Iowa darter has not been previously recorded from this area (Table 2-1).

The species found during these small-bodied fish collections are typical for the habitats sampled in this part of Ontario. The South Channel Spillway and Cross Island collections (Table 3-4) are typical for the shoreline areas of larger rivers, where there is a broad range in flow velocity adjacent to areas of faster water. The presence of Longnose Dace and Stonecat in the upper portion of the North Channel (Table 3-4), reflect the fast flowing rocky riffles at that location. The four Smallmouth Bass collected at that location were captured at the downstream end of the riffles in much slower velocity flow.

Table 3-4. Results of small-bodied fish collections in the vicinity of the Calabogie GS in 2016 and 2017.

	South Channel Spillway, North side. Oct. 12, 2016.	South Channel Spillway, North side. Jun. 10 and 11, 2017.	Cross Island, between the tailrace and the South Channel Spillway. Aug. 16, 2017.	North Channel, downstream portion. Aug. 16, 2017	North Channel, upstream portion. Aug. 16, 2017.	South Channel Spillway, North side. Aug. 16, 2017.
Collection method	Electrofisher	Electrofisher	Electrofisher	Electrofisher	Electrofisher	Sein
Effort	1223 s	1222 s	928 s	434 s	990 s	8 hauls
Smallmouth Bass	-	-	4 YOY	2 Juvenile	1 Juv, 3 YOY	15 YOY
Largemouth Bass	-	1	-	-	-	-
Rock Bass	-	-	2	2	-	8 YOY
Pumpkinseed	2	-	-	-	-	3 YOY
Mimic Shiner	-	1	-	-	-	-
Bluntnose Minnow	2 YOY	7	-	-	-	11 YOY
Golden Shiner	-	-	-	-	-	5
Longnose Dace	-	-	-	1 Juvenile	13	-
Logperch	10	1	4	1	-	2
Johnny Darter	7	-	-	-	-	19
Iowa Darter	-	-	-	-	-	1
Yellow Perch	-	-	-	-	-	5 YOY
Stonecat	-	-	-	-	1	-

4 Conclusions and Recommendations

4.1 Walleye

- Walleye spawning habitat in the South Channel Spillway appears to be limited due to the combination of high velocities and unsuitable substrate. However, there are small areas of potential Walleye spawning habitat immediately downstream from the South Channel Spillway, where the flow disperses and spreads, which could be suitable in some years if there was significantly less flow through the spillway than was observed in 2016 and 2017.

- Most of the habitat in the Calabogie GS tailrace is deeper than typical Walleye spawning habitat. However, there is some suitable substrate along the north side of the tailrace where water depths are shallower.

- Flow velocities and water depth are generally suitable for Walleye spawning in the North Channel, but the bedrock and boulder substrate that is present through much of the area is not suitable. Areas of suitable substrate do exist, most notably in the downstream portion of the upstream riffle/rapids (Figure 3-1: Area 2).

- There is apparently no location in the vicinity of the Calabogie GS where large numbers of spawning Walleye occur. Though low numbers of Walleye were observed at various locations, no spawning aggregations were observed, except at the upstream reference area in the Barrett Chute tailwater.

4.2 River Redhorse

- While a few individual River Redhorse were observed foraging in the GS tailrace and in the lower portion of the North Channel during the spawning period, no spawning aggregations of River Redhorse were observed, nor was any suitable spawning habitat found, in the North Channel, the South Channel Spillway, or the GS tailrace. No young-of-the-year River Redhorse were captured in the small-bodied fish collections undertaken in these areas in 2016 and 2017.

- Spawning River Redhorse were observed on June 11 and 12, 2017, on a gravel/sand shoal, in water about 1 to 2 m deep, in a backwater eddy adjacent to the rapids at Cherry Point. Water temperature was 18.2-18.3°C.

4.3 Other Fish Species

- MNRF does not believe Lake Sturgeon currently occur in the vicinity of the Calabogie GS.

- MNRF does not believe American Eel currently occur in the vicinity of the Calabogie GS, though eel have recently been found in the Ottawa River and in the tailwater of the Arnprior GS.

- No fall-spawning fishes are known to spawn in the vicinity of the Calabogie GS.

- The spawning period and spawning habitat of the White Sucker marginally overlaps those of Walleye, and it is expected that White Sucker can spawn in a number of locations in the vicinity of the Calabogie GS and downstream in the Madawaska River.

- Of the remaining fishes that are known to occur downstream of the Calabogie GS, only Shorthead Redhorse, Common Shiner and Logperch could potentially spawn in areas with the water velocities associated with the tailrace or the spillway of the GS. Suitable spawning habitat for these species also appears to be present in the North Channel and downstream of the GS in the Madawaska River.

5 References

Becker, G.C. 1983. Fishes of Wisconsin. Univ. of Wisconsin Press. Madison, Wisconsin. 1052 p.

Coad, B.W., H. Waszczuk, and I. Labignan. 1995. Encyclopedia of Canadian fishes. Canadian Museum of Nature and Canadian Sportfishing Productions Inc. 928 p.

COSEWIC. 2006a. COSEWIC assessment and update status report on the Lake Sturgeon *Acipenser fulvescens* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xi + 107 pp. (www.sararegistry.gc.ca/status/status_e.cfm).

COSEWIC. 2006b. COSEWIC assessment and update status report on the River Redhorse *Moxostoma carinatum* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 31 pp. (www.sararegistry.gc.ca/status/status_e.cfm).

COSEWIC. 2012. COSEWIC assessment and status report on the American Eel *Anguilla rostrata* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xii + 109 pp. (www.registrelep-sararegistry.gc.ca/default_e.cfm).

DFO. 2016. Management plan for the River Redhorse (*Moxostoma carinatum*) in Canada [Proposed]. Species at Risk Act Management Plan Series. Fisheries and Oceans Canada, Ottawa. v + 48 pp.

Gillenwater, D., T. Granata, and U. Zika. 2006. GIS-based modeling of spawning habitat suitability for Walleye in the Sandusky River, Ohio, and implications for dam removal and river restoration. Ecological Engineering 28 (2006): 311-323.

Holm, E., N.E. Mandrak, and M.E. Burridge. 2009. The ROM field guide to freshwater fishes of Ontario. Royal Ontario Museum, Toronto. 462 p.

Jenkins, R.E., and N.M. Burkhead. 1993. Freshwater fishes of Virginia. American Fisheries Society, Bethesda, Maryland. 1079 p.

McMahon, T.E., J.W. Terrell, and P.C. Nelson. 1984. Habitat suitability information: walleye. U.S. Dept. Int. Fish Wildl. Serv., FWS/OBS-82/10.56.

Ontario Ministry of Natural Resources (MNR). 2008. Fisheries Management in Renfrew County: A State of the Resource Report and a Focused Review of Fisheries Issues. January 2008. 101 p.

Ontario Ministry of Natural Resources and Ontario Power Generation (MNR and OPG). 2009. Madawaska River Water Management Plan. 211 p. + 8 appendices.

Parker, B.J. 1988. Updated status of the river redhorse, *Moxostoma carinatum*, in Canada. Canadian Field-Naturalist 102:140-146.

Parker, B.J., and P. McKee. 1984. Status of the river redhorse, *Moxostoma carinatum*, in Canada. Canadian Field-Naturalist 98(1):110-114.

Scott, W.B and E.J. Crossman. 1973. Freshwater fishes of Canada. Fisheries Research Board of Canada. Bulletin 183. Ottawa, Canada. 966 p.

Smith, C.L. 1985. The inland fishes of New York State. New York State Department of Environmental Conservation. 522 p.

Smith, P.W. 1979. Fishes of Illinois. University of Illinois Press. 314 p.

Trautman, M.B. 1981. The fishes of Ohio. Ohio State University Press. 782pp.

Wentworth, C.K. 1922. A scale of grade and class terms for clastic sediments. J. Geol. 30: 377-392.

Yoder, C.O. and R.A. Beaumier. 1986. The occurrence and distribution of river redhorse, *Moxostoma carinatum* and greater redhorse, *Moxostoma valenciennesi* in the Sandusky River, Ohio. Ohio Journal of Science 86:18-21.

Arcadis Canada Inc.

121 Granton Drive

Suite 12

Richmond Hill, Ontario L4B 3N4

Tel 905 764 9380

www.arcadis.com