APPENDIX F

REVISED FISH HABITAT OFFSET / COMPENSATION PLAN

Revised Fisheries Act, Paragraph 35(2)(b) Authorization Offset Plan and MDMER Schedule 2 Fish Habitat Compensation Plan

Springpole Gold Project

First Mining Gold Corp.

CA-EI-ONS2104

Prepared by:
WSP Canada Inc.

October 2024

Fisheries Act, Paragraph 35(2)(b) Authorization Offset Plan and MDMER Schedule 2 Fish Habitat Compensation Plan Springpole Gold Project

Red Lake District, Northwest Ontario
Project #CA-EI-ONS2104

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EXECUTIVE SUMMARY

First Mining Gold Corp. proposes to develop an open pit gold and silver mine with supporting facilities known as the Springpole Gold Project (Project). The Project is located in a remote area of northwestern Ontario, approximately 110 kilometres (km) northeast of the Municipality of Red Lake and 145 km north of the Municipality of Sioux Lookout.

An environmental assessment pursuant to the *Canadian Environmental Assessment Act, 2012* (SC 2012, c. 19, s. 52) and the Ontario *Environmental Assessment Act* (RSO 1990, c. E.18) is required to be completed for the Project. This report is one of a series of Technical Support Documents prepared by WSP Canada Inc. on behalf of First Mining Gold Corp. to support the predicted environmental effects of the Project.

Efforts have been made to design the Project to minimize encroaching on fish habitat. As a result of the location of the ore body and the presence of numerous lakes and small waterbodies in the area, avoidance of fish habitat while developing and operating the Project is not feasible. In this case, and similar to most other mining projects in Canada, the Project will meet the requirements of the *Fisheries Act* (RSC 1985, c. F-14), where fish frequented watercourses and waterbodies that are overprinted or otherwise potentially impacted by proposed mine-related infrastructure require the development and implementation of a Fish Habitat Offset and Compensation Plan (FHOCP) to offset or compensate consistent with *Fisheries Act* regulations and policies. This revised FHOCP has been updated from the version submitted during the draft EIS/EA submission and is provided with the intent to be further reviewed and discussed with government, Indigenous communities and the public before finalization. Although the proposed measures have been refined and advanced in this document and demonstrate the ability of the Project to meet regulatory requirements, it is expected that additional or alternative measures of offsetting and habitat compensation may be evaluated and made part of the final FHOCP to be submitted during permitting.

Approximately 213 hectares (ha) of fish habitat is conservatively anticipated to be impacted and require either a Schedule 2 listing per Section 27.1(1) of the Metal and Diamond Mining Effluent Regulations (MDMER; SOR/2002-222) or authorization under Paragraphs 34.4(2)(b) and 35(2)(b) of the *Fisheries Act*. This represents a reduction in overall predicted impacts to fish habitat of around 15 ha from the initial draft FHOCP due to additional engineering and analysis of the Project. To counterbalance the impacts, offsetting and compensation candidate measures are proposed that include up to approximately 575 ha of new, reclaimed, restored or enhanced habitat for the Project. Although not all of the measures are needed to offset the impacts, the intent of advancing all of the candidate measures in the FHOCP is to provide confidence that appropriate and sufficient offsetting and compensation measures are available to mitigate the impacts. The final selection of measures will be based on additional feedback received during the review of the final EIS/EA and potential conditions of approval prior to finalizing the FHOCP during permitting of the Project. The majority of fish habitat impacted (73%; 156 ha) is related to the controlled dewatering and development of the open pit within a small of a portion of the north basin of Springpole Lake. Of the total 213.2 ha of affected fish habitat, it is anticipated that only approximately 39.46 ha will be permanently removed through overprinting by facilities such as the co-disposal facility (CDF) and Central Water Storage Pond (CWSP). The remaining areas including unnamed lakes L-1 and L16 and the dewatered portion of the north basin of Springpole Lake, road crossings, and water intakes and discharges will be disrupted, or altered, but are proposed to be reclaimed or restored to productive fish habitat functions at closure.

Development of the open pit and the extent of the dewatered area has been minimized through the evaluation of various dike locations resulting in the ability to limit the temporary reduction in surface area of Springpole Lake to 6%. This represents approximately 1% of the overall larger lake complex (Birch Lake, Seagrave Lake and Springpole Lake) surrounding the Project. This is considered a moderate fisheries impact when compared to other similar Canadian mines with lake interactions, including the Meadowbank Mine, Gahcho Kué Mine and Diavik Mine, all of which have previously required and implemented permanent and temporary lake habitat offsetting at an equivalent or greater scale than proposed for this Project.

A summary of the small waterbodies that will require listing on Schedule 2 of the MDMER is provided in Table E-1, and those waterbodies predicted to require offsetting due to Harmful Alteration, Disruption or Destruction (HADD) (*Fisheries Act* Paragraph 35 Authorization) are listed in Table E-2. A combined summary of the anticipated Schedule 2 waterbodies and Paragraph 35 waterbodies is provided in Table E-3.

The fisheries offset and compensation candidate measures currently proposed for the Project were developed in consideration of the *Policy for Applying Measures to Offset Adverse Effects on Fish and Fish Habitat Under the Fisheries Act* (DFO 2019b) and its guiding principles:

1. Measures to offset should support fisheries management objectives and give priority to the restoration of degraded fish habitat.
2. Benefits from measures to offset should balance the adverse effects resulting from the works, undertakings or activities.
3. Measures to offset should provide additional benefits to the ecosystem.
4. Measures to offset should generate self-sustaining benefits over the long term.

The measures were also developed in consideration of the Cat Lake First Nation and Slate Falls Nation land use objectives including the following presented in the *Guidelines for Mineral Sector Projects Best Management Practices* (Cat Lake First Nation and Slate Falls Nation 2011):

- Respect the environment in which you work.
- Refrain from unnecessarily disturbing the natural environment.
- Restore the natural setting of areas where you have worked.

The draft FHOCP further considers the provincial Fisheries Management Plan for Fisheries Management Zone 4 (MNR 2014), the zone in northwestern Ontario where the proposed Project is located.

The FHOCP’s overarching strategy incorporates the mine development sequence to restore, reclaim, expand and enhance fish habitat and proposes the study and potential reintroduction of historically present fish (e.g., Lake Sturgeon) that have been diminished over time. Since the draft EIS/EA was submitted, the Project team and provincial Ministry of Mines (MINES) have collaborated to advance the option to reclaim the abandoned South Bay Mine as an additional candidate offsetting and compensation measure.

This strategy is consistent with the Project’s objectives of restoring habitat while reducing impacts to terrestrial landscapes and Species at Risk such as Caribou (Boreal population) and Wolverine. The strategy also recognizes and respects that the Project area is already predominantly characterized by extensive and numerous waterbodies and that new lakes may not be feasible or a preferred use of the landscape.

Based on mine planning and design having considered the importance of fish habitat, some of the offset and compensation candidate measures could be implemented concurrently with the start of the Project, including the study of Lake Sturgeon, reclamation of the South Bay Mine and overbuilding the two dikes to construct new spawning shoals and rearing habitat for Lake Trout and Lake Whitefish.

One of the larger offset and compensation measures proposed will be the reclamation of the open pit basin including the establishment of a new high quality lake basin in Springpole Lake after mining ceases. The proposed strategy will require a time lag (approximately 17 years) between the impact to fish habitat and the restored basin being available to fish. The proposed benefits of the measure will, however, extend in perpetuity and there are sufficient earlier onset compensation measures proposed to accommodate this time lag.

In total, there is up to 575 ha of combined new, restored, reclaimed and enhanced habitat proposed to offset and compensate for the approximately 213.2 ha of impacted habitat of the Project. The currently proposed candidate offset and compensation measures to be implemented for the Project are as follows:

- Overbuild and integrate spawning shoals along the active lake-facing embankments of the dikes to replace Lake Trout and Lake Whitefish spawning opportunities lost within the dewatered basin.
- Coordinate with the provincial government (MINES) to implement the reclamation of the abandoned South Bay Mine.
- Implement the investigation and study of Lake Sturgeon, in addition to the baseline studies, in the Birch River and Cat River system and consider measures to reinstate or augment the population.
- Place coarse wood structure (e.g., root wads, log piles) along Springpole Lake shorelines currently lacking structural diversity.
- Construct a new large embayment (46 ha fish habitat development area) to the east of the dewatered area to be functional at closure.
- Enhance the open pit basin (dewatered) area for selected key species (determined during engagement and consultation) by modifying cover, structure and substrates to improve habitat suitability where appropriate.
- Contour the north end of the main open pit and the Phase 1 pit and optimize fish habitat structures, substrates and depth for selected key species as determined during engagement and consultation.
- Restore flow to unnamed lake L-1 on completion of mining and filling of the dewatered basin.

A summary of the areas of habitat described above are provided in Table E-4.

Although not considered an offset measure or included in the habitat balance of the Plan, the CWSP (unnamed lake L-2) will be reclaimed in post closure once it is no longer needed for water management, consistent with the intention of restoring the land.

The FHOCP has been developed based on the current Project design and assessment of impacts to fish and fish habitat. The FHOCP will be updated following the EA process and a final combined fisheries offset and compensation plan that will facilitate eventual MDMER Schedule 2 waterbody listings and *Fisheries Act* Paragraph 35 Authorizations will be provided for permitting.

Table E-1: Summary of Fish Habitat Impacts to Schedule 2 Waterbodies

Impact Segment ID	Waterbody	Mine feature	Length (m)	Wetted Width (m)	Predicted HADD Area (m^2)	Predicted HADD Area (ha)
IS-D	L-3	CDF	N/A	N/A	16,1838.4	16.2
IS-E	S-16	CDF	492.9	0.5	246.4	0.02
IS-L	L-4	CDF	N/A	N/A	10,254.2	1.03
IS-M	S-17	CDF	102.8	0.5	51.4	0.01
IS-Q	L-17	CDF	N/A	N/A	7,228.08	0.72
IS-R	S-18	CDF	56.2	0.5	28.1	0.003
IS-U	L-18	CDF	N/A	N/A	21,003.5	2.100
IS-Y	L-5	CDF	N/A	N/A	21,359.0	2.1
IS-AG	L-2	CWSP	N/A	N/A	115,631.1	11.6
IS-AH	L-2	CWSP	N/A	N/A	339.8	0.03
				Schedule 2 Total	**337,980**	**33.8**

Note:
m = metre; m^2 = square metre; N/A = not applicable.

Table E-2: Summary of Predicted Paragraph 35 HADD to Fish and Fish Habitat

Impact Segment ID	Name / Location Description	Mine Feature	Length (m)	Wetted Width (m)	Predicted HADD Area (m^2)	Predicted HADD Area (ha)
IS-AW	Birch Lake	Fresh water intake	N/A	N/A	112.5	0.01
IS-BJ	Birch Lake	Overpressure (blast)	N/A	N/A	14,000	1.40
IS-A	Inflow to L-16	Flow reduction	161.2	0.5	80.6	0.01
IS-B	Inflow to L-16	Flow reduction	N/A	N/A	7311.8	0.73
IS-C	Inflow to L-16	Flow reduction	59.4	0.5	29.7	0.003
IS-AA	Inflow to L-2	Plant site	122.8	0.5	61.4	0.01
IS-AB	Inflow to L-2	Plant site	43.5	0.5	21.8	0.002
IS-AC	Inflow to L-2	Haul road	65.7	0.5	32.8	0.003
IS-AD	Inflow to L-2	Flow reduction	141.4	0.5	70.7	0.01
IS-AE	Inflow to L-2	Flow reduction	43.4	0.8	32.5	0.003
IS-AF	Inflow to L-2	Haul road	39.6	0.8	29.7	0.003
IS-AI	Inflow to L-2	Phase 1 pit	245.9	0.5	122.9	0.01
IS-AJ	Inflow to Springpole Lake	Flow reduction	11.7	0.5	5.8	0.001
IS-AN	Inflow to Springpole Lake	Fish habitat development area / High-mid grade ore stockpile	362.2	0.5	181.1	0.02
IS-AT	L-1	Flow reduction	10.4	0.5	5.2	0.001
IS-AY	L-1	Flow reduction	N/A	N/A	18602.4	1.86
IS-AZ	L-1	Flow reduction	N/A	N/A	69666.3	6.97
IS-BA	L-16	Flow reduction	N/A	N/A	59479.3	5.95
IS-BH	L-17	CDF - embankment	N/A	N/A	1944.6	0.19
IS-BI	L-18	CDF - embankment	N/A	N/A	28735.4	2.87
IS-BG	L-5	CDF - embankment	N/A	N/A	25077.4	2.51
IS-Z	L-5-OUT	Haul road	296.5	0.8	222.4	0.02
IS-AU	Outflow from L-1	Flow reduction	81.3	0.5	40.7	0.004
IS-AV	Outflow from L-1	Flow reduction	N/A	N/A	1,482.2	0.15
IS-BB	Outflow from L-16	Flow reduction	35.5	0.5	17.7	0.002
IS-BD	Outflow from L-19	Flow reduction	619.2	0.5	309.6	0.03
IS-BE	Outflow from L-19	Flow reduction	168.4	1.2	202.1	0.02
IS-F	S-16	Flow reduction	208.0	0.5	104.0	0.01
IS-G	S-16	Flow reduction	N/A	N/A	2,384.9	0.24
IS-H	S-16	Flow reduction	204.2	0.5	102.1	0.01
IS-I	S-16	Flow reduction	188.3	1.0	188.3	0.02
IS-J	S-16	Flow reduction	N/A	N/A	4,282.4	0.43
IS-K	S-16	Flow reduction	118.7	0.5	59.3	0.01
IS-AR	S-16	CDF embankment / access road / ditch	289.4	0.5	144.7	0.01
IS-N	S-17	Flow reduction	191.1	0.5	95.5	0.01
IS-BF	S-17	CDF embankment / access road / ditch	278.2	0.5	139.1	0.01

Table E-2: Summary of Predicted Paragraph 35 HADD to Fish and Fish Habitat

Impact Segment ID	Name / Location Description	Mine Feature	Length (m)	Wetted Width (m)	Predicted HADD Area (m^2)	Predicted HADD Area (ha)
IS-AS	S-18	CDF embankment	362.1	0.5	181.0	0.02
IS-S	S-19	CDF embankment / access road / ditch	464.9	0.5	232.5	0.02
IS-O	S-21	CDF embankment / Access road / ditch	112.7	0.5	56.4	0.01
IS-P	S-21	Flow reduction	315.9	0.5	158.0	0.02
IS-T	S-22	CDF embankment / Access road / ditch	42.1	0.5	21.1	0.002
IS-X	S-22	Flow reduction	334.4	0.5	167.2	0.02
IS-V	S-23	CDF embankment / access road / ditch	92.8	0.5	46.4	0.005
IS-W	S-23	Flow reduction	257.5	0.5	128.8	0.01
IS-AK	Springpole Lake	Dewatering	N/A	N/A	15,270.8	1.53
IS-AL	Springpole Lake	Dewatering	N/A	N/A	4,792.5	0.48
IS-AM	Springpole Lake	Main open pit	N/A	N/A	711,238.7	71.12
IS-AO	Springpole Lake	Dewatering	N/A	N/A	826,287.9	82.63
IS-AX	Springpole Lake	Effluent discharge	N/A	N/A	50.0	0.005
IS-AP	UNX03	Water crossing	40	0.5	20	0.002
IS-AQ	Unnamed watercourse	Water crossing	20	0.5	10	0.001
				Paragraph 35 Predicted HADD Total	**1,794,040**	**179.40**

Note:
m = metre; m^2 = square metre; N/A = not applicable.

Table E-3: Summary of Combined Schedule 2 Waterbodies and Predicted Paragraph 35 HADD

Impact Type	Predicted HADD Area (m^2)	Predicted HADD Area (ha)
Schedule 2 total	337,980	33.8
Paragraph 35 total	1,794,040	179.40
Combined Schedule 2 and Paragraph 35 total	2,132,020	213.2

Note:
m^2 = square metre.

Table E-4: Summary of Fish Habitat Offset and Compensation Measures

Proposed Offset / Compensation Measure	Type of Offset Measure (1)	Approximate Offset Measure Area or Area Equivalent (ha)	Project Phase of Implementation(3) and/or Duration
Overbuilding of dikes and development of new spawning and rearing shoals in Springpole Lake	Habitat restoration and enhancement	10	Construction
South Bay Mine – Reclamation of impacted lakes	Habitat restoration and enhancement	87	Operations
Lake Sturgeon Program – Stage 1, Lake Sturgeon Research Program	Complementary measure	25 (2a)	Construction through closure
Lake Sturgeon Program – Stage 2, Population Support – reintroduction of Lake Sturgeon in selected previously inhabited waters	Biological manipulations	200 (2b)	Construction through closure
Fish habitat development area – new fish habitat area excavated east of the dewatered basin	Habitat creation	46	Closure
Reclaimed and enhanced dewatered area	Habitat restoration and enhancement	82.6	Closure
Restoration of flows to unnamed lake L-1	Habitat restoration and enhancement	9	Closure
Phase 1 pit backfill and recontour	Habitat creation	9	Closure
Backfilling and contouring of north end of open pit	Habitat creation	2.14	Closure
Reclaimed main open pit area (pelagic habitat)	Habitat restoration and enhancement	120	Closure
Total potential area of new, reclaimed or enhanced fish habitat		Up to 590.7	Varies

Notes:

(1) Grouped per *Fish and Fish Habitat Protection Policy* Statement (DFO 2019a).

(2a) Lake Sturgeon research program to better define the current status of Lake Sturgeon in the Project area and possible sources of population decline. Considered a complementary measure and area equivalent calculated as 10 percent (%) of the offset area required.

(2b) Reintroduction and restoration efforts for Lake Sturgeon in select previously inhabited lakes. Credit calculated as 2% of a targeted 10,000 ha lake area including lakes such as Cat Lake, Springpole Lake, Birch Lake and Seagrave Lake.

(3) The temporal boundaries for the Project phases are defined as follows:

- Construction Phase: Years -3 to -1, representing the construction period for the Project.
- Operations Phase: Years 1 to 10, with the first year potentially representing a partial year as the Project transitions from construction into operations.
- Closure Phase:
  - Active Closure: Preliminary timing of Years 11 to 15, when final decommissioning and the majority of active reclamation activities are carried out; and
  - Post-closure: Years 16+, corresponding to primarily the monitoring period for the Project but also when the filled open pit basin will be reconnected to Springpole Lake.

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°	degree
BsM	Broadscale monitoring
CCME	Canadian Council of Ministers of the Environment
CDF	Co-disposal facility
CPUE	Catch per unit effort
DFO	Fisheries and Oceans Canada
EA	Environmental assessment
EIS	Environmental impact statement
FHOCP	Fish Habitat Offset and Compensation Plan
FMG	First Mining Gold Corp.
FMZ	Fisheries Management Zone
Ha	Hectares
HADD	Harmful Alteration, Disruption or Destruction
IAAC	Impact Assessment Agency of Canada
km	Kilometres
km^2	Square kilometres
kPa	Kilopascal
kV	Kilovolt
m	Metre
m^2	Square metres
m^3	Cubic metres
m^3/d	Cubic metres per day
MDMER	Metal and Diamond Mining Effluent Regulations
mg/L	Milligrams per litre
MINES	Ontario Ministry of Mines
mm/s	Millimetres per second
MNR	Ontario Ministry of Natural Resources
Mt	Million tonnes
NAD	North American datum
MNR	Ontario Ministry of Natural Resources
P_{peak}	Peak pressure
PPV	Peak particle velocity
Project	Springpole Gold Project
ToR	Terms of Reference
UTM	Universal Transverse Mercator
Wood	Wood Environment & Infrastructure Americas, a division of Wood Canada Limited
WSP	Water storage pond

1.0 INTRODUCTION

First Mining Gold Corp. proposes to develop, operate and eventually decommission and close an open pit gold and silver mine and ore process plant with supporting facilities known as the Springpole Gold Project (Project). The Project is located in a remote area of northwestern Ontario, approximately 110 kilometres (km) northeast of the Municipality of Red Lake and 145 km north of the Municipality of Sioux Lookout (Figure 1-1).

An environmental assessment (EA) pursuant to the Canadian Environmental Assessment Act, 2012 (SC 2012, c. 19, s. 52) and the Ontario Environmental Assessment Act (RSO 1990, c. E.18) is required to be completed for the Project. This report is one of a series of Technical Support Documents prepared by WSP Canada Inc. on behalf of First Mining Gold Corp. to describe the predicted environmental effects of the Project.

1.1 Purpose and Objective of the Report

An initial draft Fish Habitat Offset and Compensation Plan (FHOCP) document was prepared as part of the draft Environmental Impact Statement / Environmental Assessment (EIS/EA) for consultation. Subsequent consultation effort (Section 1.4) with regulators, Indigenous communities and the public, in addition to Project optimizations, has resulted in revisions to the FHOCP. Revisions include calculated effects on fish and fish habitat, mitigation measures, proposed offseting and compensation measures, and proposed monitoring activities, all of which have been documented in this revised FHOCP.

This FHOCP includes the detailed assessment of potential impacts to fish and fish habitat, as well as several candidate offset and compensation measures than can be implemented to counterbalance and mitigate the impacts. All of the proposed offset and compensation measures are feasible and have been vetted for consistency with the Fisheries and Oceans Canada (DFO 2019b) offsetting policy; however, not all of the presented measures may be required in the final FHOCP. The intent of presenting more offset and compensation measures than required is to provide confidence that appropriate and sufficient measures are available to counterbalance predicted impacts.

The FHOCP remains a draft for the final EIS/EA in recognition that additional consultation, optimizations and refinments will continue to be made. Prior to the completion of permitting and approvals for the Project, the FHOCP will be finallized.

1.2 Project Overview

The Project is proposed to be mined as an open pit. To allow the development and safe operation of the open pit mine, dikes will be established to facilitate safe and controlled dewatering of the open pit basin. Ore from the open pit will be processed in an onsite process plant at approximately 30,000 tonnes per day. Mine rock and tailings resulting from the processing of ore will be stored in a co-disposal facility (CDF).

The main components of the Project are as follows and as shown in Figure 1-1, Figure 1-2 and Figure 1-3:

- Open pit;
- Dikes (cofferdams) (west dike and east dike);
- CDF for mine rock and tailings (north cell and south cell);
- Surficial soils stockpile;
- Ore stockpiles;
- Process plant or process plant complex;
- Buildings and supporting infrastructure;

- Water management and treatment facilities;
- Fish habitat development area;
- Accommodations complex;
- Aggregate operation(s);
- Transmission line; and
- Mine access road and co-located airstrip.

As a result of the proposed Project development, there will be unavoidable impacts to fish and fish habitat. Efforts have been made to design the Project to minimize encroaching on fish habitat, and opportunities to avoid and mitigate impacts have been evaluated and will be implemented where appropriate. However, given the location of the ore body and the presence of numerous lakes and small waterbodies in the area, avoidance of fish habitat is not feasible. In this case, and similar to most other mining projects in Canada, the Project will meet the requirements of the *Fisheries Act* (RSC 1985, c. F-14), where fish bearing watercourses that are overprinted or otherwise potentially impacted by proposed mine-related infrastructure require the development and implementation of a FHOCP. The impacts are considered as either Harmful Alteration, Disruption or Destruction (HADD) per Paragraph 35 of the *Fisheries Act* or resulting in waterbodies requiring listing on Schedule 2 of the Metal and Diamond Mine Effluent Regulations (MDMER; SOR/2002-222). In both cases, the respective legislation will require offsetting or compensation consistent with *Fisheries Act* regulations and policies.

1.3 Phases and Schedule

The Project is expected to be developed over a two to three-year construction period. A mine life of approximately 10 years is anticipated based on the extensive work carried out to define the Springpole ore body. Progressive reclamation will be carried out during operations, and final decommissioning and closure of the site will follow once operations cease. The primary decommissioning and closure period (i.e., active closure) will be followed by a period of post-closure environmental monitoring.

The phases are briefly described in Sections 1.3.1 to 1.3.3. The timing of works specifically associated with fish and fish habitat are listed in Table 1-1 and referenced to the years of Project development.

1.3.1 Construction Phase

Construction will begin once the EIS/EA process is complete and initial permits / approvals are received. The timeframe to complete the construction of the surface infrastructure to start mining and processing activities is approximately three years. This phase includes almost all infrastructure development such as the main site footprint, the mine access road and co-located airstrip and transmission line, and as such would be the period when most fisheries impacts are expected to occur. To allow flexibility in the presented schedule, the construction phase is shown as Year -3 to -1 in Table 1-1, with the operations phase beginning Year 1. In some cases, impacts are shown to extend over phases, such as the CDF where the facility will be built as a starter configuration and expanded to full size during operation. Similarly, pit dewatering effects are expected to occur gradually over the life of the Project through flow reductions to adjacent waterbodies.

1.3.2 Operations Phase

The operations phase is anticipated to last 10 years and will include the operation of the mine including advancing the open pit, use of the CDF, development and consumption of ore stockpiles, and treated effluent discharge to Springpole Lake. Progressive reclamation is also expected to occur during this time as practicable, as well as some of the proposed restoration and enhancements in the pit and open pit basin.

1.3.3 Decommissioning / Closure Phase

The decommissioning and closure phase is anticipated to include an active decommissioning and closure phase and a post-closure maintenance and monitoring phase:

- **Active Closure:** Preliminary timing of Years 11 through 15, when final decommissioning and the majority of active reclamation activities are carried out including the filling of the reclaimed open pit basin; and
- **Post-closure:** Years 16+, corresponding to the monitoring period for the Project but also when the filled open pit basin will be reconnected to Springpole Lake.

1.4 Influence of Consultation with Indigenous Communities, Government and the Public

During preparation of this revised FHOCP, FMG provided opportunities for early engagement with Indigenous communities, DFO and the public. This revised FHOCP is part of the final EIS/EA documentation and is intentionally left as draft with the intent that it be further reviewed and discussed with regulators, Indigenous communities and the public to share ideas and consider feedback in a meaningful manner before finalization. The initial draft FHOCP review was facilitated through the draft EIS/EA document review process and targeted meetings / workshops that promoted engagement and discussion on the proposed offsetting and compensation measures. Key engagement on the previous and current draft of this FHOCP included the following:

- Follow-up meetings and presentation to regulators and Indigenous communities (including SFN, MON and NWOMC) to review and clarify responses to comments received with respect to baseline data, effects assessment and mitigation measures;
- Meeting / workshop with DFO in September 2023 to discuss the proposed fish and fish habitat impacts and offset / compensation measures for the Project;
- Workshop with the Northwestern Ontario Métis Community (NWOMC) in September 2023 to discuss the proposed fish and fish habitat impacts and offset / compensation measures for the Project;
- Technic
- al briefing to the Impact Assessment Agency of Canada (IAAC) and federal agencies on fish and fish habitat – Springpole Gold Project in September 2023;
- Workshop with the Mishkeegogamang Ojibway Nation (MON) in December 2023 to discuss the proposed fish and fish habitat impacts and offset/ compensation measures for the Project;
- Presentation to the Ontario Ministry of Natural Resources (MNR) in December 2023 to review the proposed fish and fish habitat impacts and offset / compensation measures for the Project (for information only); and
- Workshop with the Slate Falls Nation (SFN) in January 2024 to discuss the proposed fish and fish habitat impacts and offset/ compensation measures for the Project.

Consultation has been ongoing for several years prior to and throughout the EA process, and will continue with Indigenous communities, government agencies and the public through the life of the Project. Section 2 of the final EIS/EA provides more detail on the extensive consultation process. The Record of Consultation (Appendix D of the final EIS/EA) includes detailed comments received, and responses provided, during the development of the final EIS/EA.

A review of the comments and responses on the draft EIS/EA and subsequent engagements has benefited this FHOCP through the identification of several topics where additional information and clarification was needed. Feedback received through consultation has been addressed through direct responses (in writing and follow-up meetings) and in the final EIS/EA, as appropriate. A summary of key comments that influenced the assessment for fish and fish habitat between the draft and final EIS/EA is provided below.

Baseline Investigations

The MNR requested that a broadscale monitoring (BsM) study be conducted to determine the status of the fish community in Springpole Lake. A full BsM program was completed on Springpole Lake following standardized provincial protocols (Appendix O-4 of the final EIS/EA) but was modified to address the request from the MNR to reduce the number of deep-water net sets in the 12- to 35-metre (m) strata and to increase the number of net sets in the 1 to 12 m strata.

DFO; the Ministry of the Environment, Conservation and Parks; the MNR; Cat Lake First Nation (CLFN); Lac Seul First Nation (LSFN); and SFN requested additional baseline data to support the effects assessment. A full lake, provincial standard BsM study was completed in 2022 (Appendix O of the final EIS/EA). The BsM was used to calibrate a full lake, hydroacoustic fish community study that was also completed in 2022. Lower trophic level (i.e., chlorophyll a, phytoplankton and zooplankton) studies (multi-year and multi-season) were completed throughout Springpole Lake and at adjacent comparable locations in Birch Lake. Reviewers also requested additional habitat data for the nearshore areas of Birch Lake adjacent to the Project. Supplemental habitat characterization of adjacent Birch Lake was completed in 2022. This is information is summarized in Section 6.10.2 of the final EIS/EA.

The MNR, DFO, CLFN, LSFN, SFN and MON requested clarification regarding statements that Lake Sturgeon are absent from Springpole Lake or are in extremely low abundance within the Birch River / Cat River system. A full lake, BsM and hydroacoustic survey was completed in Springpole Lake in 2022 (Appendix O of the final EIS/EA). Targeted large mesh river index netting (RIN) in Springpole Lake coupled with a two-season (i.e., spring and summer) environmental DNA (eDNA metabarcoding) sampling program in Springpole Lake, Birch Lake and regional stations (Cat River) was completed in 2022. Additional targeted eDNA quantitative polymerase chain reaction sampling of historical observations and spawning areas was completed within Springpole Lake, Cat River, Lake St. Joseph outflow, Birch Lake and Birch River in 2023. This information is summarized in Section 6.10.2 of the final EIS/EA.

DFO, CLFN and LSFN requested that additional spawning area analysis be extended to include other parts of Springpole Lake (outside of the north basin of Springpole Lake). Additional analysis of potential spawning areas was completed (Appendix O of the final EIS/EA) with additional ground truthing to extend the delineated areas of potential spawning areas for Northern Pike, Lake Trout and Lake Whitefish.

Effects Assessment

The MNR, DFO, CLFN, LSFN, MON and SFN requested clarification on potential effects on the food web / primary productivity. Detailed investigations and studies (Appendix O of the final EIS/EA) have been completed for the Project and provide comparison of lower trophic data and fish community data for Springpole Lake and the adjacent Birch Lake sufficient to assess the potential effects of the isolated open pit basin. Results show comparable primary resources in the six deep water sample stations in Springpole Lake and two stations in Birch Lake, and a high degree of similarity between the three most northern stations in the north basin of Springpole Lake (Basins NB01, NB02 and NB03).

The CLFN, LSFN, SFN, the NWOMC, DFO and Environment and Climate Change Canada requested more information about potential effects on Springpole Lake and Birch Lake from blasting effects. Further, DFO requested more stringent blasting criteria be used in the effects analysis. A revised blasting assessment (Appendix H-4 of the final EIS/EA) was completed using more conservative (i.e., larger) charges and the more stringent blasting criteria for fish to conservatively identify additional areas of potential effects as discussed in Section 6.10.6 of the final EIS/EA and Section 5.2.2 of this FHOCP.

The IAAC and DFO requested more information about potential effects on Birch Lake from groundwater drawdown. Aquatic investigations were completed along the south shore of Birch Lake in 2022 to better describe lake conditions adjacent to the Project (Appendix O-3 of the final EIS/EA). Additional groundwater modelling (Appendix L-2 of the final EIS/EA) has been completed to support the final EIS/EA and shows the area of drawdown into the nearshore areas of Birch Lake to assess habitats potentially affected.

The MNR, DFO, MON, SFN and the NWOMC requested additional information on how the isolation of the open pit basin and removal of fish from the isolated areas would occur. Additional detail of the isolation procedure including methods, timing and other mitigation measures has been added to Section 5.2.3 of this FHOCP and Section 6.10.6 of the final EIS/EA. Detailed discussion on controlled dewatering rates and procedure for the isolated basin has been added to Section 5.2.2 and Section 5.2.3 of this FHOCP. Additional description of the fish removal (mitigation) is also provided, including a strategy suggested by DFO where isolation of the basin during the spring may reduce the number of Lake Trout and Walleye entrained in the basin.

Mitigation, Offsetting and Compensation

The MNR and DFO requested further details on how the reclaimed open pit basin will provide habitat similar to existing conditions for Lake Trout and Lake Whitefish and, where possible, examples of similar reclamation activities. Additional examples of successful fisheries established in former open pits are provided in Section 8 of this FHOCP along with more detailed plans for the fish habitat development area and reclaimed basin. Drawings and descriptions of the grading and surface treatments, including habitat features, have been added to Attachment E of this FHOCP.

IAAC, CLFN, LSFN and SFN requested additional evaluation of the isolated basin compared to the rest of Springpole Lake and how the remaining area will support the fish community during the life of the mine. IAAC also requested that additional consideration be given to the status of Lake Trout in Springpole Lake and assessment of the sustainability of Lake Trout populations through the life of mine and post-closure resulting from removal and alteration of habitat. Additional fisheries and aquatic data were collected for all of Springpole Lake and the proposed open pit basin during 2022. The 2022 program included a full lake BsM program, ongoing lower trophic level studies, a lake-wide hydroacoustic fish community survey, and multiple eDNA metabarcoding surveys (Appendix O of the final EIS/EA). The additional data, in combination with previously collected aquatic data, increase the confidence that most of Springpole Lake will remain capable of sustaining all species and all life functions present and that Lake Trout and the resources they depend on are well distributed in the north basin and not reliant only on the portion that will be isolated.

IAAC, DFO, the MNR, CLFN, LSFN, MON, SFN and the NWOMC asked for more details about Lake Sturgeon reintroduction measures and additional documentation and data to describe species absence and the likely cause of Lake Sturgeon absence. In response, this measure has been revised to a two-step measure: 1) collect additional data and information and 2) implement reintroduction / enhancement measures. This revised measure has been added to Section 6.10.6 of the final EIS/EA and Section 8.1.3 of this FHOCP.

IAAC requested that suitable habitat for Lake Sturgeon in the area be identified and characterized. Birch Lake, Springpole Lake and other surrounding lakes are large, with numerous embayments, deep water refugia and large connecting rivers that are favourable habitats for Lake Sturgeon. These lakes have a mixture of relatively shallow and deeper water habitats, with the connecting rivers providing the needed habitat requirements for Lake Sturgeon. Several historical spawning locations have been identified between Lake St. Joseph and Cat Lake (Cat Lake / Slate Falls / MNRF n.d.). Excluding the dams at Lake St. Joseph, there are no known major works within the waterbodies upstream of Lake St. Joseph that would have changed the physical habitats of the upstream waterbodies that historically supported a healthy Lake Sturgeon population.

The MNR, MON and the NWOMC requested additional rationale for the strategic stocking and micro-hatchery measure, as well as assurance that it would not unbalance natural communities. Several comments from Indigenous communities and government agencies indicated a lack of support for this measure, and as a result, it has been removed from the preferred offsetting and compensation measures detailed in this FHOCP as a means of maintaining the general fish community during operations. Comments from the CLFN and LSFN did identify stocking as a proven method to restore Lake Trout numbers and requested that a Lake Sturgeon restocking program occur as part of the Project regardless of the results from western science data collection. For this reason, stocking of selected species may still become part of the methods used in the final FHOCP.

IAAC, DFO, the Ministry of the Environment, Conservation and Parks, and MON requested additional information on how the potential time lag between the effect and the implementation of offset measures is addressed, considering that a large proportion of the offsetting and compensation relies on the reclamation of the open pit basin. Through discussion with DFO and the MNR, fish biomass as a measure of productivity will be used as the effects prediction and the measure of offsetting success to allow consistent and readily made revisions to the total effect and total required offsets should a delay in reclamation occur. This is included in Section 4.2 of this FHOCP.

Engagement with CLFN, SFN and LSFN, as well as with MON, has shared an understanding of historical Lake Sturgeon presence in area waters and the cultural value placed on the species. The discussions have contributed ideas to the proposed measure of reintroducing and restoring Lake Sturgeon into waterbodies locally that were previously inhabited.

1.5 Guidance Documents

The fisheries offset and compensation candidate measures currently proposed for the Project were developed in consideration of the *Policy for Applying Measures to Offset Adverse Effects on Fish and Fish Habitat Under the Fisheries Act* (DFO 2019b) and its guiding principles:

1. Measures to offset should support fisheries management objectives and give priority to the restoration of degraded fish habitat.
2. Benefits from measures to offset should balance the adverse effects resulting from the works, undertakings or activities.
3. Measures to offset should provide additional benefits to the ecosystem.
4. Measures to offset should generate self-sustaining benefits over the long term.

The measures were also developed in consideration of the CLFN and SFN land use objectives including the following presented in the *Guidelines for Mineral Sector Projects Best Management Practices* (Cat Lake First Nation and Slate Falls Nation 2011):

- Respect the environment in which you work;
- Refrain from unnecessarily disturbing the natural environment; and
- Restore the natural setting of areas where you have worked.

This revised FHOCP further considers the provincial Fisheries Management Plan for Fisheries Management Zone 4 (FMZ 4) (MNR 2014), the zone in northwestern Ontario where the proposed Project is located.

The assessment of effects on fish and fish habitat, development of offsetting / compensation measures and the preparation of this FHOCP were informed by guidance provided in the documents listed in Table 1-2. Guidance documents include federal, provincial and community-derived guidance.

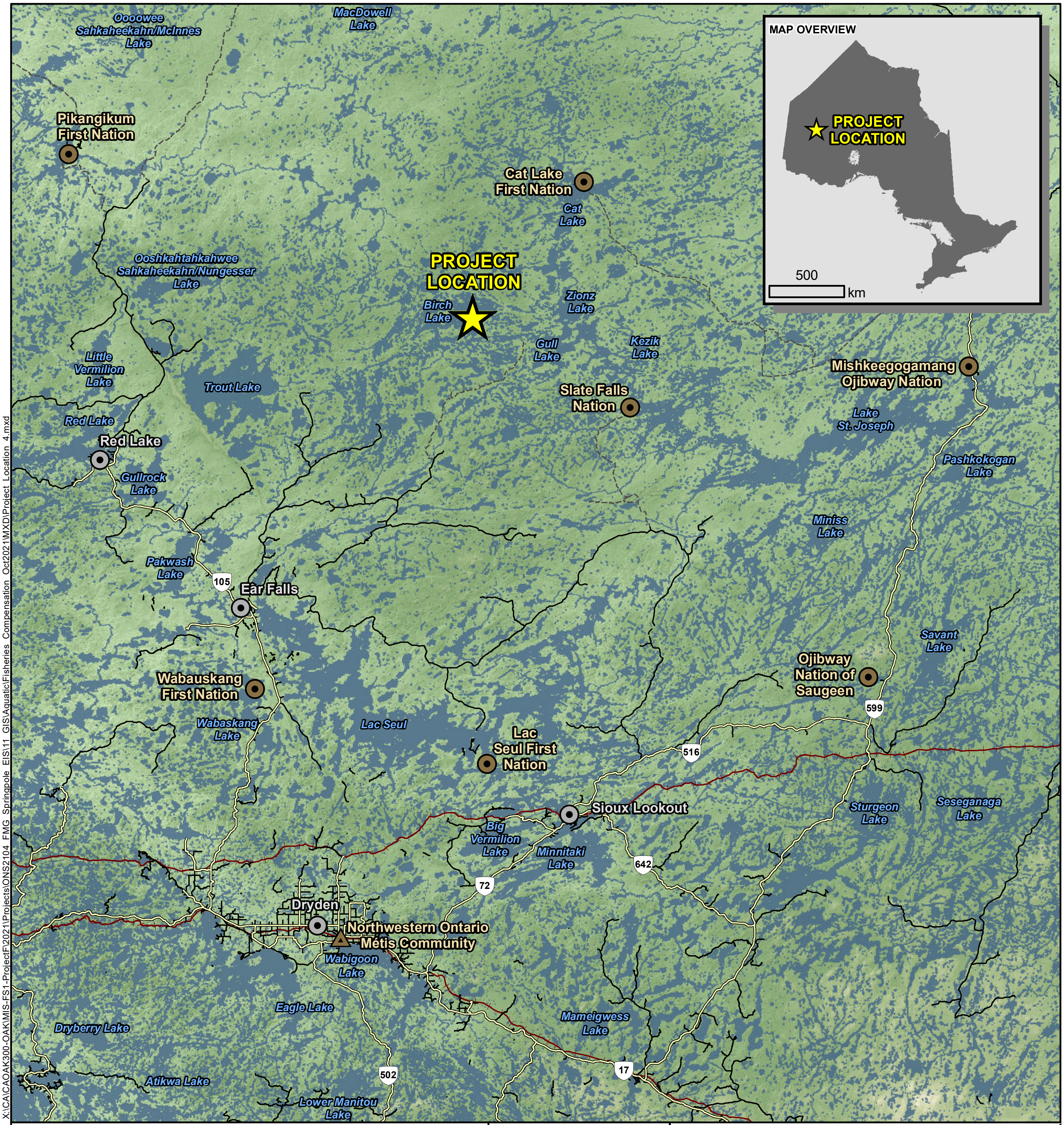
Table 1-1: Conceptual Schedule of Project Work, Undertaking or Activity and Offsets

Works or Offset Component Affecting Fish Habitat	Impact or Offset(1)	Early Start(2) (year)	Late Completion(2) (year)
Dike construction and dewatering of portion of north basin of Springpole Lake and flow reductions to various waterbodies	Impact	-3	-1
Road crossings, airstrip, plant site and water storage pond (CWSP; various small lakes and creeks)	Impact	-3	1
CDF overprinting of L-3, L-4, L-5, L-6, L-17, L-18, S-18, S-19, S-21, S-16, S-17 and L-6-out	Impact	-3	2
CDF – downstream flow reductions (L-16, S-16, S-17, L-5-Out, S-19, S-21, S-22 and S-23)	Impact	-3	2
Plant site impacts (L-2, L-1, Springpole Lake southeast arm discharge structure and Birch Lake intake structure)	Impact	-3	1
Other flow reductions (L-1, and L-16)	Impact	-1	15
Overbuilding and integration of spawning shoals on dikes in Springpole Lake	Offset / compensation	-2	2
Coarse wood structure (Springpole Lake shorelines)	Offset / compensation	-2	1
Lake Sturgeon reintroduction / restoration program	Offset / compensation	-2	20
South Bay Mine reclamation	Offset / compensation	1	10
Recontoured north end of main open pit and Phase 1 pit	Offset / compensation	7	10
New fish habitat development area excavated east of the dewatered open pit basin	Offset / compensation	10	15
Restoration of flow to L-1	Offset / compensation	10	15

Notes:
(1) Detailed description of impacts or offsets are provided in Sections 5.0, 6.0 and 8.0 of this document.
(2) Construction is Year -3 to -1, operations commence Year 1 and continue through Year 10, and closure is Year 11 onward.

Table 1-2: Guidance Documents for Impacts Determination and Offsetting

Document / Guidance	Purpose / Use
Schedule 1 of Authorizations Concerning Fish and Fish Habitat Protection Regulations (SOR/2019-286)	Schedule 1 describes the information and documents to be provided in the offset plan and application documents for *Fisheries Act* Authorizations.
Applicant's Guide Supporting the Authorizations Concerning Fish and Fish Habitat Protection Regulations 2019 (DFO 2019c)	This guide provides guidance for seeking an authorization for the purpose of Paragraphs 34.4(2)(b) and 35(2)(b) of the *Fisheries Act* with guidance on how to develop and submit an application in accordance with the regulations
Fish and Fish Habitat Protection Policy Statement (DFO 2019a)	This document is used to confirm compliance and consistency with DFO in the application of fish habitat protection provisions of the *Fisheries Act*.
Standards and codes of practice (DFO 2024a)	These documents are used to guide the planning and construction of works near water to avoid and mitigate harmful effects on fish and fish habitat.
Policy for Applying Measures to Offset Adverse Effects on Fish and Fish Habitat Under the *Fisheries Act* (DFO 2019b)	This document provides guidance on undertaking effective measures to offset impacts to fish habitat, consistent with the fish and fish habitat protection provisions of the *Fisheries Act*; includes guiding principles.
Pathways of Effects (DFO 2024b)	Diagrams are provided for common land based and in-water activities that show cause–effect relationships that are known to exist, and the mechanisms by which stressors ultimately lead to effects on the aquatic environment.
Cat Lake – Slate Falls Community Based Land Use Plan "Niigaan Bimaadiziwin" A Future Life (Cat Lake First Nation et al. 2011)	Guiding principles and statements setting out land use areas, identifying desired and compatible land uses, and providing strategic direction for the manner in which activities will take place.
Fisheries Management Olan (Fisheries Management Zone; FMZ 4) (MNR 2014)	This management plan identifies issues that are key to resource sustainability within FMZ 4, establishes management objectives for the major species and fisheries, and recommends actions and strategies to achieve these objectives.
MNR Application Review and Land Disposition Process Appendix A – Crown Land Disposition and Lake Trout Lakes (MNR 2008)	Policy PL 4.02.01 provides direction regarding land disposition process and considerations with specific reference to Lake Trout lakes.
General Fish-out Protocol for Lakes and Impoundments in the Northwest Territories and Nunavut (Tyson et al. 2011)	This protocol provides guidance and lessons learned from partial and whole lake fish-out programs.
Factsheet: Culvert Installations, Department of Fisheries and Oceans (DFO 1995)	This document provides relevant guidance on culvert design and installation considerations for crossings.



LEGEND

- Project Location
- Town
- First Nation Reserve
- Northwestern Ontario Métis Community
- Highway
- Secondary Road
- Resource / Winter Road
- Railway

0 12.5 25 50 75 100 Kilometres

NOTES:
- Topographic information extracted from LIO, MNRF.

Datum: NAD83
Projection: UTM Zone 15N

N W E S

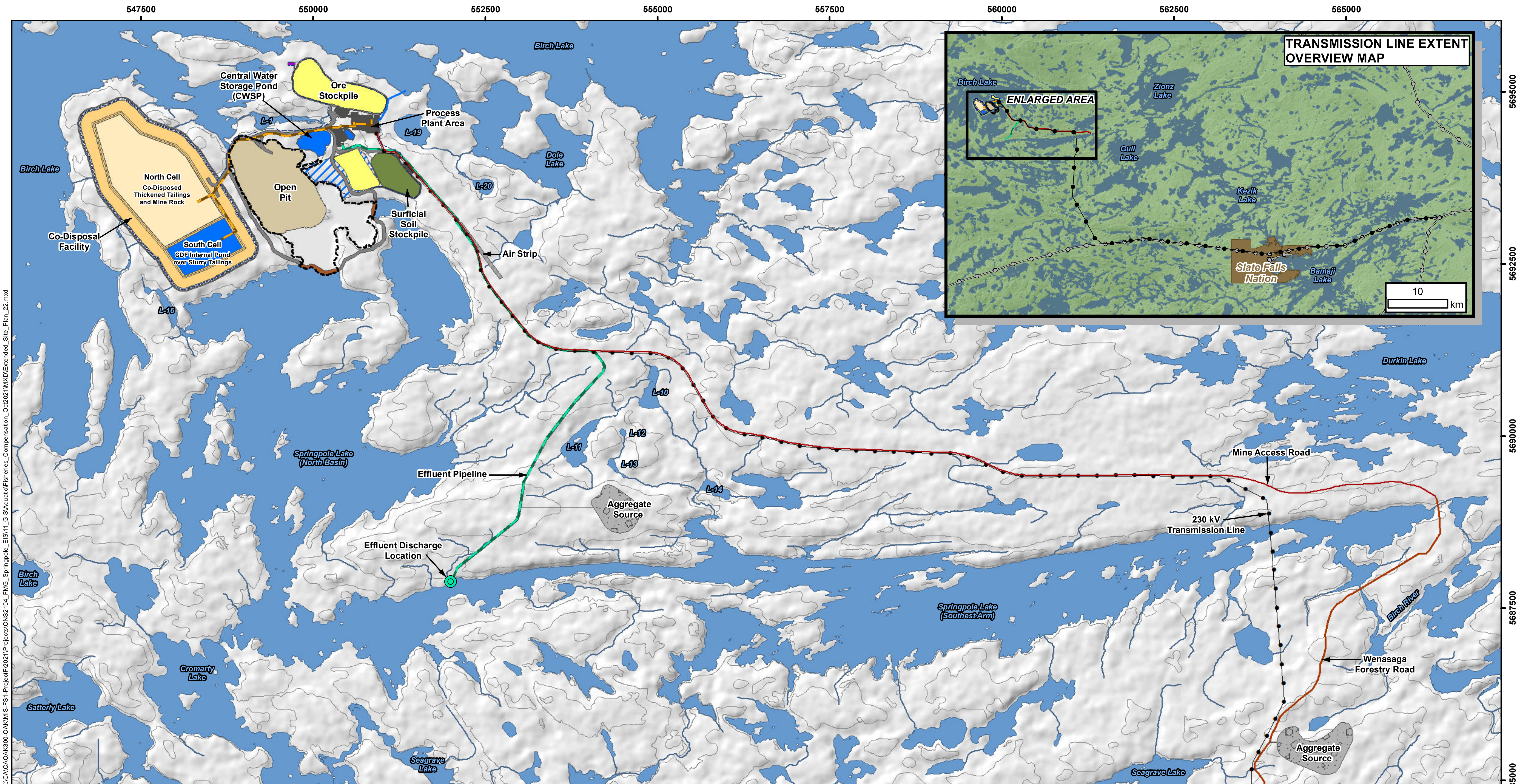
FIRST MINING GOLD

wsp

SPRINGPOLE GOLD PROJECT

Project Location

PROJECT N°: ONS2104	**FIGURE: 1-1**
SCALE: 1:1,500,000	DATE: September 2024



LEGEND

- Aggregate Source
- Existing Road
- Watercourse
- Waterbody
- Existing Transmission Line
- Contour (10 m intervals)

Proposed Mine Feature

- Open Pit
- Open Pit Basin
- Ore Stockpile
- Surficial Soil Stockpile
- Co-Disposal Facility
- Co-Disposed Thickened Tailings and Mine Rock
- Process Plant Area
- Dike
- Pond
- Haul / Access Road
- Explosives Storage
- Air Strip
- Mine Access Road
- Seepage / Runoff Collection System
- 230 kV Transmission Line
- Fresh Water Intake Pipeline
- Tailings Pipeline Corridor
- Effluent Discharge Pipeline
- Fish Habitat Development Area
- Effluent Discharge Location

0 1 2 4 6 8 10 Kilometres

NOTES:
- Topographic information extracted from LIO, MNRF.
- Proposed site plan provided by Ausenco, drawing number 104496-GX-03000-31344-003, Rev 1. 26 June 2023 and modified by WSP July 2023.
- 230 kV transmission line provided by First Mining Gold, April 2024.

Datum: NAD83
Projection: UTM Zone 15N

FIRST MINING GOLD

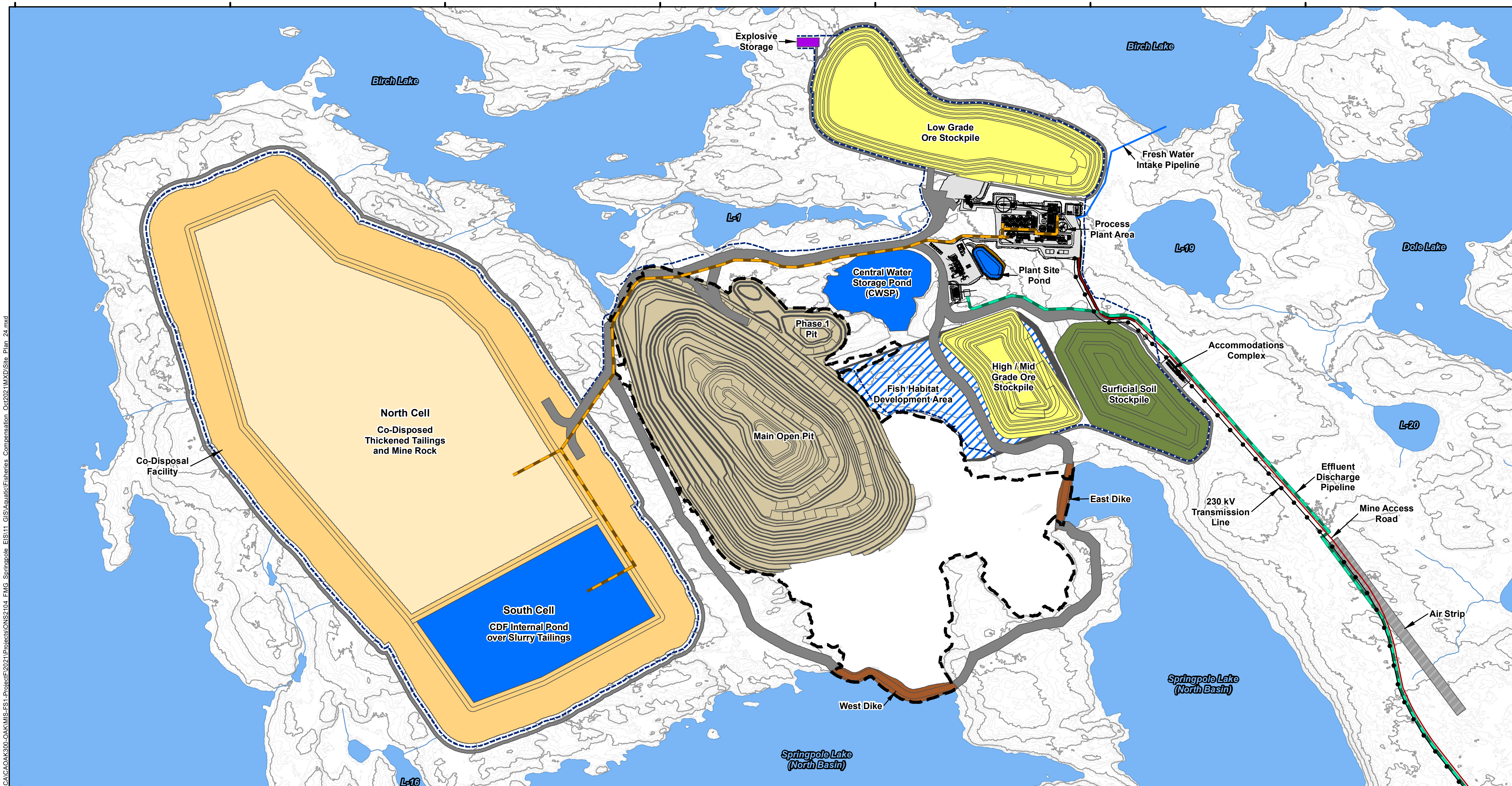
WSP

SPRINGPOLE GOLD PROJECT

EIS / EA Extended Site Plan

PROJECT Nº: ONS2104 | **FIGURE: 1-2**

SCALE: 1:52,000 | DATE: September 2024



LEGEND

- Watercourse
- Waterbody
- Major Contours (5 m interval)
- Minor Contours (1 m interval)

Proposed Mine Features

- Open Pit
- Open Pit Basin
- Ore Stockpile
- Surficial Soil Stockpile
- Co-Disposal Facility
- Co-Disposed Thickened Tailings and Mine Rock
- Process Plant Area
- Dike
- Pond
- Haul / Access Road
- Explosives Storage
- Air Strip
- Mine Access Road
- Seepage / Runoff Collection System
- 230 kV Transmission Line
- Fresh Water Intake Pipeline
- Effluent Discharge Pipeline
- Tailings Pipeline Corridor
- Fish Habitat Development Area

0 0.5 1 2 3 4 5 Kilometres

NOTES:
- Contours extracted from 2020 LiDAR survey.
- Proposed site plan provided by Ausenco, drawing number 104496-GX-03000-31344-003, Rev 1. 26 June 2023 and modified by WSP July 2023.
- 230 kV transmission line provided by First Mining Gold, April 2024.

Datum: NAD83
Projection: UTM Zone 15N

FIRST MINING GOLD

wsp

SPRINGPOLE GOLD PROJECT

EIS / EA Site Plan

PROJECT N°: ONS2104	**FIGURE: 1-3**
SCALE: 1:17,000	DATE: September 2024

2.0 PROJECT CONTACT INFORMATION

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Mr. Lines is an authorized representative for FMG and will be the signing authority for the *Fisheries Act* Authorization Application, on behalf of FMG.

3.0 LOCATION OF PROPOSED PROJECT

The Project is located approximately 110 km northeast of the Municipality of Red Lake. The Town of Ear Falls is 105 km to the southwest and the Municipality of Sioux Lookout is situated 145 km southeast of the property as shown in Figure 1-1. The Universal Transverse Mercator (UTM) coordinates for the general Project are UTM 549,183 N and 5,693,578 E (North American Datum [NAD] 83 Zone 15).

There are several waterbodies (i.e., lakes, small ponds and creeks) affected by the Project where HADD of (i.e., impacts to) fish and fish habitat would occur or may require that fish frequented waterbodies be listed on Schedule 2 of the MDMER. These waterbody locations are shown in Figure 3-1 and Figure 3-2, and are summarized in Table 3-1 and Table 3-2 for Schedule 2 and Paragraph 35 waterbodies, respectively. Waterbodies have been delineated into impact segments (IS) in Figure 3-1 and Figure 3-2 to better identify and summarize areas as in some cases only portions of a waterbody will be altered. Additional descriptions of the anticipated Project effects on fish and fish habitat are provided in Section 5.0 of this document.

Table 3-1: Coordinates of MDMER Schedule 2 Waterbodies Affected by Project

Impact Segment ID (1)	Name/ Location Description	Mine Feature or Effect (2)	Waterbody (3)		Watercourse Limits (4)			
			Centroid Coordinates		Upstream		Downstream	
			E	N	E	N	E	N
IS-D	L-3	CDF	547878	5693481	N/A	N/A	N/A	N/A
IS-E	S-16	CDF	N/A	N/A	547617	5693612	547333	5693346
IS-L	L-4	CDF	547762	5693061	N/A	N/A	N/A	N/A
IS-M	S-17	CDF	N/A	N/A	547710	5693052	547618	5693015
IS-Q	L-17	CDF	547679	5694272	N/A	N/A	N/A	N/A
IS-R	S-18	CDF	N/A	N/A	547635	5694321	547591	5694355
IS-U	L-18	CDF	547183	5694606	N/A	N/A	N/A	N/A
IS-Y	L-5	CDF	548828	5692896	N/A	N/A	N/A	N/A
IS-AG	L-2	CWSP	550036	5694283	N/A	N/A	N/A	N/A
IS-AH	L-2	CWSP	550248	5694449	N/A	N/A	N/A	N/A

Notes:
Schedule 2 waterbodies are those expected to require listing on Schedule 2 of the MDMER.
Coordinates are in UTM NAD 83, Zone 15; E – Easting; N – Northing.
(1) Impact Segment ID corresponds to delineated areas shown in Figure 3-1 and Figure 3-2.
(2) Mine feature or effect is either the feature that overprints and area (e.g., CDF) or the effect caused by a feature if the waterbody is not overprinted (e.g., flow reduction).
(3) Waterbody centroid is the approximate centremost point of the waterbody (lake / pond) portion affected by the Project.
(4) Watercourse limits are the approximate upstream and downstream point of the watercourse (creek / stream / river) portion affected by the Project.
N/A = not applicable.

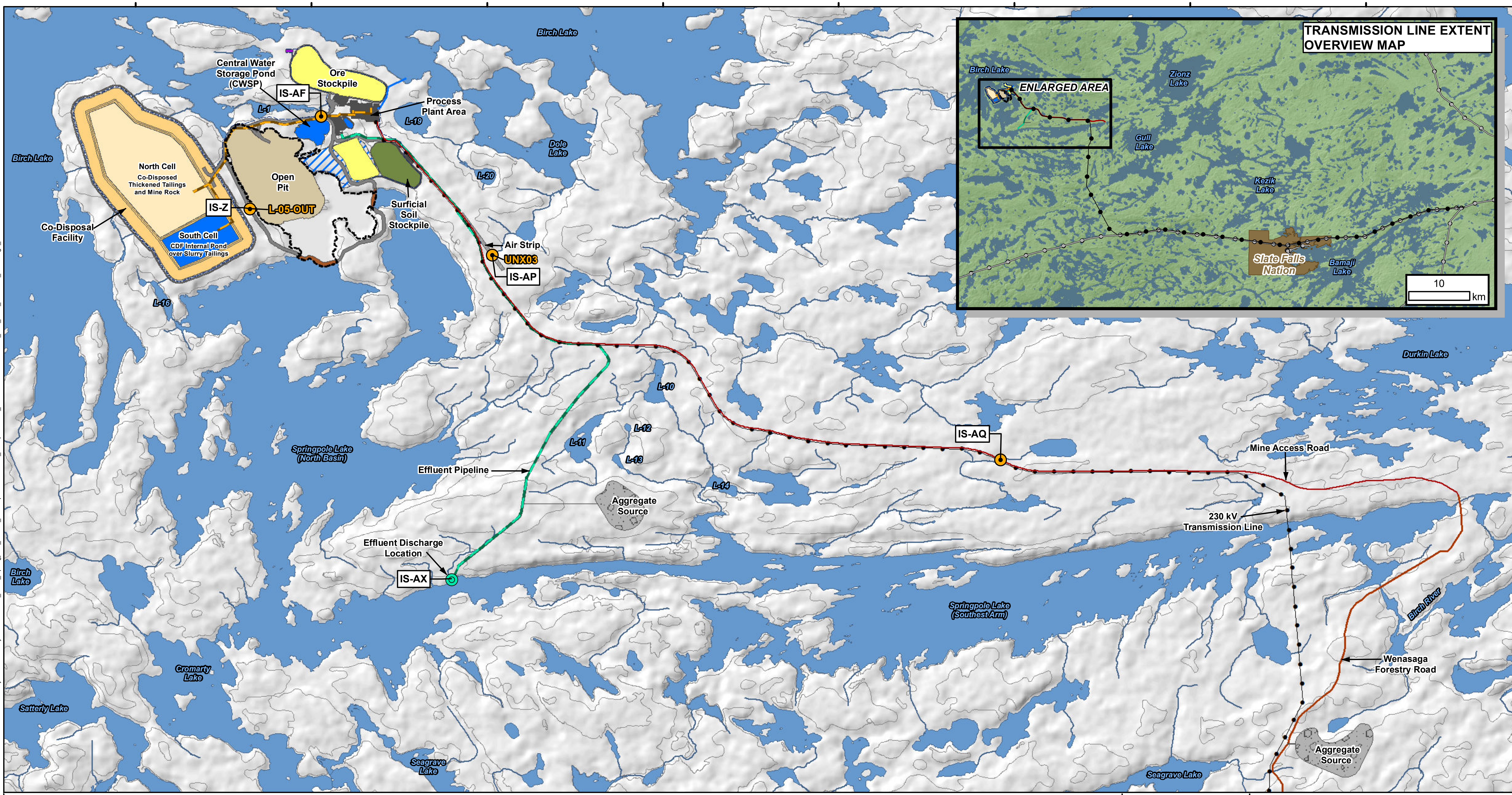
Table 3-2: Coordinates of Paragraph 35 Waterbodies Affected by Project

Impact Segment ID (1)	Name / Location Description	Mine Feature or Effect (2)	Waterbody (3) Centroid Coordinates		Watercourse Limits (4) Upstream Coordinates		Watercourse Limits (4) Downstream Coordinates	
			E	N	E	N	E	N
IS-AW	Birch Lake	Fresh water intake	551353	5695021	N/A	N/A	N/A	N/A
IS-BJ	Birch Lake	Overpressure (blast)	547293	5694691	N/A	N/A	N/A	N/A
IS-A	Inflow to L-16	Flow reduction	N/A	N/A	547524	5692315	547556	5692161
IS-B	Inflow to L-16	Flow reduction	547598	5692118	N/A	N/A	N/A	N/A
IS-C	Inflow to L-16	Flow reduction	N/A	N/A	547653	5692117	547710	5692116
IS-AA	Inflow to L-2	Plant site	N/A	N/A	550430	5694761	550309	5694744
IS-AB	Inflow to L-2	Plant site	N/A	N/A	550309	5694744	550268	5694730
IS-AC	Inflow to L-2	Haul road	N/A	N/A	550268	5694730	550230	5694678
IS-AD	Inflow to L-2	Flow reduction	N/A	N/A	550230	5694678	550116	5694605
IS-AE	Inflow to L-2	Flow reduction	N/A	N/A	550160	5694536	550144	5694497
IS-AF	Inflow to L-2	Haul road	N/A	N/A	550144	5694497	550128	5694461
IS-AI	Inflow to L-2	Phase 1 pit	N/A	N/A	549587	5694125	549822	5694175
IS-AJ	Inflow to Springpole Lake	Flow reduction	N/A	N/A	550081	5694028	550083	5694016
IS-AN	Inflow to Springpole Lake	Fish habitat development area / high-mid grade ore Stockpile	N/A	N/A	550729	5693618	550437	5693420
IS-AT	L-1	Flow reduction	N/A	N/A	549677	5694616	549688	5694615
IS-AY	L-1	Flow reduction	549854	5694608	N/A	N/A	N/A	N/A
IS-AZ	L-1	Flow reduction	549347	5694593	N/A	N/A	N/A	N/A
IS-BA	L-16	Flow reduction	547895	5691870	N/A	N/A	N/A	N/A
IS-BH	L-17	CDF – embankment	547683	5694332	N/A	N/A	N/A	N/A
IS-BI	L-18	CDF – embankment	547293	5694691	N/A	N/A	N/A	N/A
IS-BC	L-19	CDF – embankment	551439	5694458	N/A	N/A	N/A	N/A
IS-BG	L-5	CDF – embankment	548927	5692961	N/A	N/A	N/A	N/A
IS-Z	L-5-OUT	Haul road	N/A	N/A	549005	5693066	549251	5693186
IS-AU	Outflow from L-1	Flow reduction	N/A	N/A	550052	5694590	550121	5694553
IS-AV	Outflow from L-1	Flow reduction	550135	5694565	N/A	N/A	N/A	N/A
IS-BB	Outflow from L-16	Flow reduction	N/A	N/A	548030	5691600	548055	5691575
IS-BD	Outflow from L-19	Flow reduction	N/A	N/A	551576	5694206	552142	5694073
IS-BE	Outflow from L-19	Flow reduction	N/A	N/A	552142	5694073	552286	5694129
IS-F	S-16	Flow reduction	N/A	N/A	547197	5693120	547181	5692929
IS-G	S-16	Flow reduction	547192	5692936	N/A	N/A	N/A	N/A
IS-H	S-16	Flow reduction	N/A	N/A	547206	5692906	547299	5692732
IS-I	S-16	Flow reduction	N/A	N/A	547299	5692732	547340	5692559
IS-J	S-16	Flow reduction	547324	5692502	N/A	N/A	N/A	N/A
IS-K	S-16	Flow reduction	N/A	N/A	547293	5692455	547206	5692390
IS-N	S-17	Flow reduction	N/A	N/A	547471	5692811	547299	5692732
IS-AR	S-16	CDF embankment/ access road / ditch	N/A	N/A	547333	5693346	547197	5693120
IS-BF	S-17	CDF embankment/ access road / ditch	N/A	N/A	547618	5693015	547471	5692811
IS-AS	S-18	CDF embankment	N/A	N/A	547591	5694355	547359	5694591

Table 3-2: Coordinates of Paragraph 35 Waterbodies Affected by Project

Impact Segment ID (1)	Name / Location Description	Mine Feature or Effect (2)	Waterbody (3) Centroid Coordinates		Watercourse Limits (4) Upstream Coordinates		Watercourse Limits (4) Downstream Coordinates	
			E	N	E	N	E	N
IS-S	S-19	CDF embankment/ access road / ditch	N/A	N/A	547779	5694500	547371	5694673
IS-O	S-21	CDF embankment/ access road / ditch	N/A	N/A	546911	5693761	546800	5693749
IS-P	S-21	Flow reduction	N/A	N/A	546800	5693749	546499	5693671
IS-T	S-22	CDF embankment/ access road / ditch	N/A	N/A	547948	5694454	547982	5694479
IS-X	S-22	Flow reduction	N/A	N/A	547982	5694479	548289	5694583
IS-V	S-23	CDF embankment/ access road / ditch	N/A	N/A	547404	5694752	547483	5694768
IS-W	S-23	Flow Reduction	N/A	N/A	547483	5694768	547716	5694836
IS-AK	Springpole Lake	Dewatering	549909	5693926	N/A	N/A	N/A	N/A
IS-AL	Springpole Lake	Dewatering	548835	5693864	N/A	N/A	N/A	N/A
IS-AM	Springpole Lake	Main open pit	549576	5693468	N/A	N/A	N/A	N/A
IS-AO	Springpole Lake	Dewatering	550300	5693096	N/A	N/A	N/A	N/A
IS-AX	Springpole Lake	Effluent discharge	551998	5687892	N/A	N/A	N/A	N/A
IS-AP	UNX03	Airstrip	552573	5692509	N/A	N/A	N/A	N/A
IS-AQ	Unnamed Watercourse	Mine access road	559803	5689598	N/A	N/A	N/A	N/A

Notes:
Paragraph 35 waterbodies are those expected to require Authorization or review under Paragraphs 34.4(2)(b) and 35(2)(b) of the *Fisheries Act*.
Coordinates are in UTM NAD 83, Zone 15, Zone 15; E – Easting; N – Northing.
(1) Impact Segment ID corresponds to delineated areas shown in Figure 3-1 and Figure 3-2.
(2) Mine feature or effect is either the feature that overprints and area (e.g., CDF embankment) or the effect caused by a feature if the waterbody is not overprinted (e.g., flow reduction).
(3) Waterbody centroid is the approximate centremost point of the waterbody (lake / pond) portion affected by the Project.
(4) Watercourse limits is the approximate upstream and downstream point of the watercourse (creek / stream / river) portion affected by the Project.
N/A = not applicable



LEGEND

- Aggregate Source
- Existing Road
- Watercourse
- Waterbody
- Existing Transmission Line
- Contour (10 m intervals)

Proposed Mine Feature

- Open Pit
- Open Pit Basin
- Ore Stockpile
- Surficial Soil Stockpile
- Co-Disposal Facility
- Co-Disposed Thickened Tailings and Mine Rock
- Process Plant Area
- Dike
- Pond
- Haul / Access Road
- Explosives Storage
- Air Strip
- Mine Access Road
- Seepage / Runoff Collection System
- 230 kV Transmission Line
- Fresh Water Intake Pipeline
- Tailings Pipeline Corridor
- Effluent Discharge Pipeline
- Fish Habitat Development Area
- Effluent Discharge Location (Labelled with Impact ID)
- Potential Watercourse Crossing (Labelled with Crossing Name and Impact Segment ID)
- NAME - Crossing Name
- IS-ID - Impact Segment ID

0 1 2 4 6 8 10 Kilometres

NOTES:
- Topographic information extracted from LIO, MNRF.
- Proposed site plan provided by Ausenco, drawing number 104496-GX-03000-31344-003, Rev 1. 26 June 2023 and modified by WSP July 2023.
- 230 kV transmission line provided by First Mining Gold, April 2024.

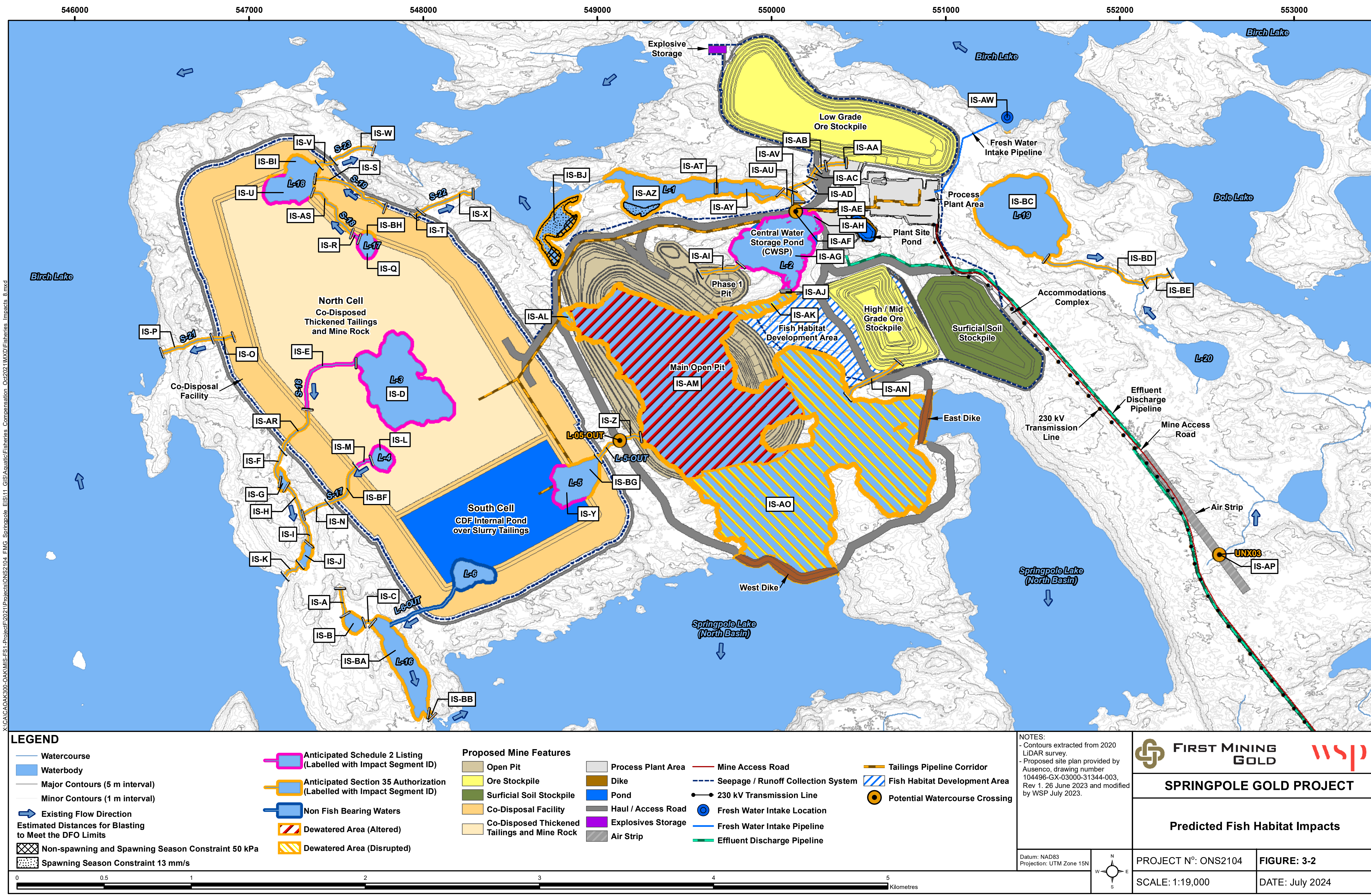
Datum: NAD83
Projection: UTM Zone 15N

FIRST MINING GOLD | WSP

SPRINGPOLE GOLD PROJECT

Extended Site Plan with Potential Watercourse Crossings

PROJECT Nº: ONS2104	FIGURE: 3-1
SCALE: 1:52,000	DATE: September 2024



546000
547000
548000
549000
550000
551000
552000
553000
5695000
5694000
5693000
5692000
Birch Lake
Dole Lake
Springpole Lake (North Basin)
Explosive Storage
Low Grade Ore Stockpile
Fresh Water Intake Pipeline
Process Plant Area
Plant Site Pond
Central Water Storage Pond (CWSP)
Phase 1 Pit
Main Open Pit
Fish Habitat Development Area
High / Mid Grade Ore Stockpile
Surficial Soil Stockpile
Accommodations Complex
Effluent Discharge Pipeline
230 kV Transmission Line
Mine Access Road
Air Strip
East Dike
West Dike
North Cell
Co-Disposed Thickened Tailings and Mine Rock
South Cell
CDF Internal Pond over Slurry Tailings
Co-Disposal Facility
L-1
L-2
L-3
L-4
L-5
L-6
L-16
L-17
L-18
L-19
L-20
L-05-OUT
L-5-OUT
L-6-OUT
UNX03
S-16
S-17
S-18
S-19
S-21
S-22
S-23
IS-A
IS-B
IS-BA
IS-BB
IS-C
IS-D
IS-E
IS-F
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IS-AJ
IS-AK
IS-AL
IS-AM
IS-AN
IS-AO
IS-AP
IS-AR
IS-AS
IS-AT
IS-AU
IS-AV
IS-AW
IS-AY
IS-AZ
IS-BC
IS-BD
IS-BE
IS-BF
IS-BG
IS-BH
IS-BI
IS-BJ
LEGEND
Watercourse
Waterbody
Major Contours (5 m interval)
Minor Contours (1 m interval)
Existing Flow Direction
Estimated Distances for Blasting to Meet the DFO Limits
Non-spawning and Spawning Season Constraint 50 kPa
Spawning Season Constraint 13 mm/s
Anticipated Schedule 2 Listing (Labelled with Impact Segment ID)
Anticipated Section 35 Authorization (Labelled with Impact Segment ID)
Non Fish Bearing Waters
Dewatered Area (Altered)
Dewatered Area (Disrupted)
Proposed Mine Features
Open Pit
Ore Stockpile
Surficial Soil Stockpile
Co-Disposal Facility
Co-Disposed Thickened Tailings and Mine Rock
Process Plant Area
Dike
Pond
Haul / Access Road
Explosives Storage
Air Strip
Mine Access Road
Seepage / Runoff Collection System
230 kV Transmission Line
Fresh Water Intake Location
Fresh Water Intake Pipeline
Effluent Discharge Pipeline
Tailings Pipeline Corridor
Fish Habitat Development Area
Potential Watercourse Crossing
NOTES:
- Contours extracted from 2020 LiDAR survey.
- Proposed site plan provided by Ausenco, drawing number 104496-GX-03000-31344-003, Rev 1. 26 June 2023 and modified by WSP July 2023.
Datum: NAD83
Projection: UTM Zone 15N
0 0.5 1 2 3 4 5 Kilometres
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wsp
SPRINGPOLE GOLD PROJECT
Predicted Fish Habitat Impacts
PROJECT N°: ONS2104
FIGURE: 3-2
SCALE: 1:19,000
DATE: July 2024

4.0 BACKGROUND AND ENVIRONMENTAL SETTING

4.1 Context

Detailed fisheries and fish habitat studies have been undertaken at the Project site and surrounding area since 2011 and include multiple years and multiple seasons of investigation. Studies were designed and completed based on the level of site engineering and planning available at the time. The collected data are sufficient to accurately define species presence and relative abundance by waterbody. In response to comments received by regulators and Indigenous communities, focused efforts have been made to collect and analyze data within Springpole Lake to demonstrate the similarities and comparability of individual basins and similarities to Birch Lake. For example, following comments received on the draft EIS/EA, additional comprehensive sampling was conducted in 2022, including a full BsM program on Springpole Lake, as well as a hydroacoustic fish community survey. Also, in response to comments, additional habitat mapping was completed in Birch Lake, and lower trophic community sampling was continued through 2022 into 2023. This focus increases the certainty of predictions regarding the temporary isolation of a small portion of the north basin of Springpole Lake and provides a strong foundation to support this FHOCP and future monitoring.

A summary of the waterbodies considered to be potentially affected by the Project are provided in Section 4.2 to Section 4.5. Observed and inferred fish communities are summarized in Table 4-1. Habitat descriptions by habitat type are provided in Table 4-2 and delineated in Figure 4-2.

Watercourses and waterbodies as presented are from provincial integrated hydrology mapping and Land Information Ontario datasets. It should be noted than many of the watercourses delineated in the figures as habitat Type D are artifacts based on the computer interpretations during development of the provincial mapping. These virtual segments reflect land topography and drainage directions but based on ground truthing frequently do not represent actual channels or fish habitat. For consistency and to be conservative, the provincial base mapping has been retained unless site-specific analysis has demonstrated the absence of a watercourse. Most of these Type D drainages, particularly their upper reaches, are not frequented by fish. Fish abundance by waterbody and waterbody type is provided in Table 4-3.

Additional detailed fisheries investigations completed for the Project are available in the following Project documents:

- *Existing Conditions Report. Fish Community and Habitat* (FMG and Portt 2018);
- *2019-2020 Aquatic Resources Assessment*, Springpole Gold Project (Wood 2021);
- *2021 Aquatic Resources Baseline Report*, Springpole Gold Project (Wood 2022b);
- *2022 Springpole Lake Hydroacoustic Survey Report* (Milne 2023); and
- *2023 Aquatic Resources Baseline Report, Springpole Gold Project* (WSP 2024a).

To aid in the efficient use of these documents, a chronological summary of the data collected in each study, and where to locate figures and tables within the specific documentation, is provided in Attachment A of this FHOCP.

The abbreviated waterbody summaries below provide a description of the general habitat conditions and the observed fish community based on the completed baseline reports listed above. Where appropriate, additional ongoing investigations will be incorporated into the final version this FHOCP.

Studies conducted to date at the site include the following:

- A full BsM program on Springpole Lake, as well as a hydroacoustic fish community survey;
- Detailed aquatic habitat investigations of site waterbodies including bathymetry, substrates, aquatic vegetation, water quality and sediment quality;
- Comprehensive lower trophic and food web sampling including chlorophyll a, phytoplankton, zooplankton and benthic invertebrates;
- Detailed fish community sampling including large bodied and small bodied species (data include species composition, richness and abundance);
- Fish tissue studies (large bodied and small bodied fish);
- Spawning surveys in Springpole Lake for Walleye, Lake Trout, Northern Pike and Lake Whitefish;
- Telemetry studies to track seasonal fish movement (Walleye n=15 and Lake Trout n=67); and
- Detailed netting programs and eDNA sampling to confirm the presence or absence of Lake Sturgeon in Springpole Lake.

The baseline data collection provides an informative baseline condition on which to determine watercourse sensitivities and offsetting / compensation measures.

4.2 Springpole Lake

Springpole Lake has a total surface area of 2,556.8 ha, an average depth of 6.3 m and a maximum depth of 35.1 m. The lake is composed of a large oval north basin (4.5 km wide and 6.5 km long) and a 17.7 km long narrow southeast arm. There are six deep water basins (greater than 12 m in depth) within the lake (five in the north basin and one in the southeast arm) that have maximum depths of 20 to 35.1 m. The deep basins have been shown to provide summer habitat for Lake Trout and other cool and coldwater species. To date the majority of sampling in Springpole Lake has been focused on the north basin as the area most proximal to and likely to be influenced by the Project. Ongoing investigations are continuing to further evaluate the deep water basins and the southeast arm of the lake.

The nearshore substrate composition consists largely of exposed bedrock and boulders, whereas areas near tributary inflows and sheltered embayments consist of soft fine-grained sediments. Lake bottom within the shallow embayments supports submerged macrophytes, including watermilfoil and pondweed, and floating macrophytes, such as water lily. The emergent macrophyte community along the shorelines, where present, is dominated by sedges and rushes, as well as localized areas with water horsetail, cattail and Sweet Flag. Vegetation in the upland zones includes mainly mixed forest dominated by Black Spruce and Tamarack, while vegetation within the riparian zone includes woody shrub species such as Alder and herbaceous species. Additional detailed descriptions of the substrates and macrophyte presence are provided in FMG and Portt (2018).

Fish sampling has been completed over multiple seasons and years and included a diversity of sampling techniques, such as minnow traps (baited gee style) seine nets, electrofishing, trap nets (hoop / fyke) and gill nets. In response to comments received on the draft EIS/EA, additional comprehensive fish sampling was conducted following provincial protocols, including a BsM program and modified RIN program to target Lake Sturgeon during the spring migration period. Springpole Lake provides habitat for a diverse fish community, including 8 sportfish species (Burbot, Cisco, Lake Trout, Lake Whitefish, Northern Pike, Rock Bass, Walleye and Yellow Perch) and 18 forage and baitfish species (Table 4-1). Lake Sturgeon have not been captured in Springpole Lake or adjacent waterbodies but they are included in Table 4-1 as a historically present, but depleted, species. Additional studies targeting Lake Sturgeon are proposed as part of this FHOCP.

Additional detailed descriptions of fish presence and fish habitat, water quality, sediment, primary productivity and physicochemical conditions can be found in FMG and Portt (2018) and Wood (2021a,b, 2022b).

Fish Health and Recruitment Biomass

The BsM data collected within Springpole Lake have been used to assess fish health using condition factor (k; Williams 2000) where a k<0.6 indicates a poor condition fish and k>1 a good condition fish. Statistical comparisons by fish species using these BsM data from Springpole Lake can be a standardized monitoring metric for comparison to other Northern Ontario lakes, as well as future BsM events within Springpole Lake. Attachment B of this FHOCP provides statistical condition factor comparisons between the Springpole Lake and Birch Lake BsM data showing differences for many species are not statistically significant. Of particular importance are sportfish valued by Indigenous communities such as Lake Trout, Northern Pike and Walleye, all of which show similar condition between lakes. Lake Whitefish from Birch Lake had a greater mean condition factor than Springpole Lake, and future baseline monitoring planned prior to construction will provide additional confidence in this result.

Similarly, the BsM data were used to assess the recruitment biomass, by species, in these lakes, which is another standardized metric for monitoring change in fish populations. Attachment B of this FHOCP provides statistical recruitment biomass comparisons between the Springpole Lake and Birch Lake BsM data, and indicates that differences for most species are not statistically significant. Also like the condition factor results, the valued sportfish also have similar recruitment biomass between lakes. Lake Whitefish from Birch Lake had a greater mean recruitment biomass than Springpole Lake, which aligns with the condition factor results. Future baseline monitoring will provide additional confidence in this result.

Lake Sturgeon

Lake Sturgeon have not been captured in Springpole Lake or adjacent waterbodies as part of the Project fisheries sampling, including targeted Lake Sturgeon netting and eDNA work, or through BsM programs in Birch Lake by conducted by the MNR. Given the absence of Lake Sturgeon, a specific Lake Sturgeon netting program was implemented during the 2022 field season to assess presence in Springpole Lake, specifically the southeast arm along the flow path between the Cromarty Lake inflow (Birch River) and outflow of Springpole Lake (Figure 3-1). The assessment used a modified RIN protocol for the capture of Lake Sturgeon, including extra-large RIN nets with stretched mesh sizes of 204, 230, 255 and 306 millimetres (mm; 8, 9, 10 and 12 inches) (Jones and Yunker 2009). Net sets were conducted in spring, as opposed to the standard July 1 to October 1 RIN assessment, to target Lake Sturgeon during the spring migration period as they travel to spawning locations. Concurrent with the RIN netting, eDNA sampling was conducted in the same flow path, and at several of the same sites immediately prior to netting. Samples were submitted for metabarcoding analysis. No nets or eDNA samples captured or detected Lake Sturgeon DNA.

A second Lake Sturgeon–specific eDNA sampling event was undertaken in spring 2023 during their spring migration period. This sampling event targeted likely spawning locations identified through aerial surveys and local community knowledge, including noted historical spawning grounds (provided by the MNR) and deeper water locations in Springpole and Birch Lake to coincide with potential post-spawn movement and residency patterns. Samples were run through a quantitative polymerase chain reaction test using Lake Sturgeon–specific assays by a qualified external laboratory. No Lake Sturgeon were observed during sampling via float plane when flying over potential spawning locations, and no Lake Sturgeon DNA was detected in any samples.

Notwithstanding their absence in sampling efforts, the Lake Sturgeon population that would have been in the Project area are part of the Southern Hudson Bay – James Bay population, which are listed as special concern under the federal *Species at Risk Act* (SC 2002. c. 29) and the provincial *Endangered Species Act, 2007* (SO 2007, c. 6). Further, this population has been noted as being valued by local Indigenous communities, and Lake Sturgeon have been identified as a species that occurred historically in the Birch Lake watershed. Lake Sturgeon have been observed in adjacent waters by anecdotal records provided by the MNR as recently as 1997 and documented as likely present through traditional knowledge (Cat Lake / Slate Falls / MNRF n.d.) and a MON (2023) workshop.

Spawning Surveys

Spawning surveys were conducted in the north basin for four sportfish species: Lake Trout (fall 2012 to 2014); Northern Pike (spring 2013, 2015 and 2017); Walleye (spring 2015, 2017); and Lake Whitefish (fall 2012). No Walleye were observed during the spring surveys, and telemetry data determined that tagged Walleye emigrated from Springpole Lake and moved upstream into the Birch River during the early spring to spawn. Results of the spawning surveys for Lake Trout, Lake Whitefish and Northern Pike (Figure 4-1; Table 4-4) indicate some spawning areas occur within the area to be impacted by the Project. Additional surveys in 2021 and subsequent geographic information system analysis (Wood 2022b) have identified additional potential Lake Trout and Lake Whitefish spawning shoals in the southeast arm.

Lower Trophic Surveys

Lower trophic metrics have also been monitored during multiple seasons and throughout the 2021 to 2023 baseline study period, which provide additional ecological monitoring tools to assess potential change in fish habitat between Springpole and Birch lakes. For example, zooplankton density and biomass were statistically compared between these lakes. Differences in density for ten of eleven taxonomic orders within these lakes are not statistically significant (Attachment B of this FHOCP). Ploima (order of rotifer) densities showed a statistically significant and higher density in Springpole Lake. However, differences in zooplankton biomass for all taxonomic orders within these lakes are not statistically significant (Attachment B of this FHOCP).

Phytoplankton (microalgae) density and biomass were also statistically compared between these lakes. Phytoplankton are the primary produces and the prey items of zooplankton, as such, these are another ecological metric commonly used to measure fish habitat health. Differences in phytoplankton density and biomass for all seven taxonomic classes within Springpole and Birch lakes are not statistically significant (Attachment B of this FHOCP).

4.3 Birch Lake

Birch Lake has a total surface area of 11,623 ha, an average depth of 7.4 m and a maximum depth of 37.0 m. The lake is a complex of irregular shoreline and basins, measuring approximately 18 km wide (north to south) and 27 km long (west to east). There are deep basins present within the lake similar to those described for Springpole Lake, two of which are currently being regularly sampled for primary productivity and physicochemical parameters. The lake is generally deeper in the east portion of the lake than the west.

Fish sampling has been completed through the MNR BsM program and includes three cycles of monitoring (2009, 2014 and 2019). Detailed fish community metrics were collected using large and small mesh gill nets to characterize both the small bodied and large bodied species present in the lake. In total, 26 species of fish have been documented in Birch Lake (Figure 4-1, Table 4-4).

As noted in Section 4.2, Birch Lake has a similar fish community, with similar fish condition factors and recruitment biomass to Springpole Lake which can provide a standardized and comprehensive tool to monitor these ecological metrics of fish health. Additionally, lower trophic level baseline results regarding zooplankton and phytoplankton show that differences between Birch Lake and Springpole Lake are not statistically different and provide other ecological monitoring tools to assess potential change in fish habitat between these lakes in future.

Additional detailed descriptions of fish presence and fish habitat, water quality, sediment, primary productivity and physicochemical conditions can be found in FMG and Portt (2018) and Wood (2021a,b, 2022b).

4.4 Small Unnamed Waterbodies

Numerous small unnamed waterbodies (lake / ponds) in the vicinity of the Project were surveyed between 2012 and 2021. These waterbodies are characterized by low fish diversity and abundance, small lake size (less than 15 ha), soft organic sediments, shorelines consisting predominantly of floating vegetation mats with small outcrops of bedrock, and a high density of submergent macrophytes in shallow areas with floating macrophytes throughout the open water. The maximum waterbody depth ranges greatly from 1 to 27 m, but typical maximum depth is 5 to 7 m. Many of the small waterbodies were found to contain only small bodied fish such as Brook Stickleback, Iowa Darter, Fathead Minnow and Finescale Dace (Table 4-1). Others included larger piscivorous species such as Northern Pike and Yellow Perch, but in most cases species richness (number of species present) was low. No fish were caught in L-6 or L-4 during sampling efforts in 2012 and 2017 (Table 4-1).

Additional detailed descriptions of fish presence and fish habitat can be found in FMG and Portt (2018) and Wood (2021a,b, 2022b).

4.5 Small Tributary Watercourses

Representative unnamed watercourses (all ultimate tributaries of Springpole Lake and Birch Lake) were surveyed between 2012 and 2021. These small watercourses are often ephemeral or intermittent in flow regime; due to small drainage areas typically less than 1 square kilometre (km^2) are influenced by beaver activity; and are typically characterized by low velocity, shallow depth, soft organic sediment, and poorly to undefined channels (Table 4-2). Several of these watercourses are shown in provincial base mapping, but within reaches, or in their entirety, are diffuse flow paths suspected to be not fish frequented (Habitat D, Table 4-2). The expectation is based on observations to date that defined channels are not present and as such fish presence is not possible. Additional sampling and ground truthing are ongoing to confirm this observation, but for now the watercourses have been treated as fish habitat as a precautionary and conservative case.

Additional detailed descriptions of fish presence and fish habitat can be found in FMG and Portt (2018) and Wood (2021a,b, 2022b).

Table 4-1: Fish Species Present in Local Waterbodies

Waterbody / Watercourse	Richness	Blacknose Shiner	Bluntnose minnow	Brook Stickleback	Burbot	Cisco sp.	Common Shiner	Emerald Shiner	Fathead Minnow	Finescale Dace	Golden Shiner	Iowa Darter	Johnny Darter	Lake Chub	Lake Sturgeon	Lake Trout	Lake Whitefish	Logperch	Longnose Dace	Mimic Shiner	Mottled Sculpin	Moxostoma sp.	Ninespine Stickleback	Northern Pearl Dace	Northern Pike	Northern Redbelly Dace	Rock Bass	River Darter	Shorthead Redhorse	Slimy Sculpin	Spoonhead Sculpin	Spottail Shiner	Trout Perch	Walleye	White Sucker	Yellow Perch
Birch Lake	30	X	X	X	X	X	X	X		X		X	X	X	H	X	X	X		X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X
Springpole Lake (L-15)	26	X	X	X	X	X	X	X	X	X	X	X	X		H	X	X	X		X	X				X		X	X	X			X	X	X	X	X
Seagrave Lake	22	Xi	Xi	Xi	X	X	Xi	Xi				Xi	Xi		H	X	X	Xi		Xi	Xi				X		Xi		Xi			Xi	Xi	X	X	X
Birch River	9											X			H	Xi			X						X		X						X	Xi	Xi	X
Lake L-1	3																								X										X	X
Lake L-2	10	X						X			X													X	X				X			X	X		X	X
Lake L-3	3			X						X																X										
Lake L-4	0																																			
Lake L-5	6			X					X	X		X												X		X										
Lake L-6	0																																			
Lake L-6-Out	0																																			
Lake L-10	2																								X											X
Lake L-11	4			X								X													X											X
Lake L-12	2			X								X																								
Lake L-13	2			X								X																								
Lake L-14	2																								X											X
Lake L-16	2																								X											X
Lake L-17	1									X																										
Lake L-18	3			X						X																X										
Lake S-19	3			X					X																	X										
Stream S-7	2			X																																X
Stream S-9	13	X		X					X	X								X	X		X			X	X	X								X	X	X
Stream S-16/17	6			X								X												X	X									X	X	
Stream S-20	1									X																										
Stream S-25	0																																			
Stream S-26	2									X																									X	
Stream S-27	2	X																																		X
Stream S-28	1																		X																	
Stream S-29	1																		X																	

Notes:
Fish species presence include those caught during the baseline studies and MNR Broadscale Monitoring studies within Birch Lake.
Species presence includes baseline survey results from 2009 to 2022.
X = present; H = historical records of Lake Sturgeon presence within watershed exist (MNR personal communications) and remnant depleted population may still exist; Xi = species inferred based on adjacent waterbodies and habitat type.

Table 4-2: Key Habitat Type Criteria

Habitat Type Classification [1]		Lake / Pond			Riverine					
		Type A	**Type B**	**Type C**	**Type D**	**Type E**	**Type F**	**Type G**	**Type H**	**Type I**
General habitat attributes		• Shallow inland lake / pond habitat • Shoreline varies between extensive floating mats of herbaceous species and localized sections with boulder, cobble and/or sand	• Deep inland lake habitat • Shoreline varies between extensive floating mats of herbaceous species and localized sections with boulder, cobble and/or sand	• Large lake habitat • Shoreline mostly bedrock / boulder substrate, with some and shallow nearshore soft sediments commonly at tributary inflows	• Low lying area with diffuse pockets of standing water • Sections of complete loss of channel, can transition into muskeg drainage, overland drainage flow path or underground flow	• No floodplain with dense shrub riparian vegetation • Bedrock, boulder and cobble substrate with coarse wood debris	• Moderate beaver activity creating alternating series of pools / impoundments • Side overflow channels created during high flow and stream stage events • Abundant coarse wood debris	• Broad floodplain with extensive floating mats of herbaceous species typical of muskeg and beaver ponds / impoundments • Primarily flat morphology with occasional pools in the thalweg of meander bends and back bays of the channel	• Moderate to broad floodplain • Primarily flat morphology with occasional pools • Commonly occurring as main connecting channels between inland waterbodies	• Birch River habitat • No floodplain • Steep banks with fast flowing riffle and rapids habitat • Coarse-grained substrate across channel including boulder and cobble, as well as exposed bedrock
Permanence		Permanent	Permanent	Permanent	Ephemeral	Permanent	Permanent	Permanent	Permanent	Permanent
Characteristic morphology features	Bankfull width (m)	N/A	N/A	N/A	N/A	0.50 to 4.0 m	1.0 to 10 m	>5 m	>5 m	>10 m
	Bankfull depth (m)	Total depth <4 m	Total depth ≥4 m	Total depth ≥4 m	N/A	0.60 to 1.5 m	0.40 to 2 m	>1 m	>1 m	>0.50 m
	Channel morphology	Pool: 100%	N/A	N/A	N/A	Slow Riffle: 5% Glide: 95%	Flat: 96% Pool: 4%	Flat: 98% Pool: 2%	Flat: 98% Pool: 2%	Fast Riffle: 80% Slow Riffle: 15% Glide: 5%
Substrate composition (approximate %)		Boulder: 2% Cobble: 2% Fines: 96%	Boulder: 5% Cobble: 5% Fines: 90%	Bedrock: 60% Boulder: 20% Fines: 20%	Bedrock: 20% Boulder: 20% Fines: 60%	Bedrock: 20% Boulder: 60% Fines: 10%	Bedrock: 5% Boulder: 15% Fines: 80%	Bedrock: 5% Boulder: 15% Fines: 80%	Bedrock: 5% Boulder: 5% Fines: 90%	Cobble: 15% Bedrock: 45% Boulder: 40%
Instream cover (approximate %)		Macrophytes: 80% Rock: 5% Wood: 15%	Macrophytes: 80% Rock: 10% Wood: 10%	Macrophytes: 15% Rock: 75% Wood: 10%	Rock: 60% Wood: 40%	Bank: 15% Macrophytes: 5% Rock: 40% Wood: 40%	Bank: 5% Macrophytes: 50% Rock: 10% Wood: 25%	Bank: 5% Macrophytes: 40% Rock: 10% Wood: 45%	Bank: 15% Macrophytes: 40% Rock: 10% Wood: 35%	Rock: 80% Wood: 20%
Dominant riparian types (approximate %)		Macrophytes: 10% Grasses and sedges: 45% Shrubs: 35% Trees: 10%	Macrophytes: 10% Grasses and sedges: 45% Shrubs: 35% Trees: 10%	Grasses and sedges: 10% Shrubs: 65% Trees: 25%	Grasses and sedges: 10% Shrubs: 60% Trees: 30%	Macrophytes: 5% Grasses and sedges: 10% Shrubs: 40% Trees: 45%	Macrophytes: 15% Grasses and sedges: 70% Shrubs: 10% Trees: 5%	Macrophytes: 10% Grasses and sedges: 80% Shrubs: 5% Trees: 5%	Macrophytes: 10% Grasses and sedges: 80% Shrubs: 5% Trees: 5%	Grasses and sedges: 30% Shrubs: 60% Trees: 10%
Representative baseline habitat sampling locations (pre-2019)		L-4, L-5, L-6, L-11, L-14, S-9 pond habitat	L-1, L-2, L-3, L-10, L-12, L-13, L-16	Birch Lake, Seagrave Lake, Springpole Lake (L-15)	S-14, S-16 (upstream reach), S-17, S-25	S-9 (upper reaches), stream between L-12 and L-13, S-16 (midstream and downstream reach), S-26 (upstream reach), S-29	S-16 (midstream reach)	S-16 (midstream reach), S-26 (downstream reach), S-28, (downstream reach)	S-27	None
Representative 2019–2020 habitat sampling locations		S-9 pond habitat	None	Springpole Lake (L-15)	UNX01, UNX03, L-4-OUT, L-6-OUT, S-9 (upstream reaches), S-19, S-20 (upstream reaches), S-21, S-22 (upstream reaches)	L-5-OUT (downstream reach), S-9 (upstream reach), S-18, S-21 (downstream reach), S-22 (downstream reach)	Connecting stream between L-1 and L-2, L-5-OUT (upstream reach)	S-20 (downstream reach), S-19 (upstream reach), S-21 (downstream reach)	UNX07	Birch River (BR-KM22)
Representative 2021 habitat sampling locations		L-17, L-18, L-19, L-20	None	Birch Lake, Springpole Lake (L-15)	None	None	None	None	None	None

Notes:
(1) Habitat type classification based on baseline existing conditions surveyed by others (FMG and Portt 2018), results of the 2019 to 2021 field surveys conducted by Wood, as well as inferred habitat delineations using aerial photo interpretation that are subject to confirmation or change with additional field survey data if collected.
N/A = not applicable, as calculation or measurement unable to be assessed; < = less than; > = greater than; ≥ = greater than or equal to.

Table 4-3: Fish Productivity Metrics (CPUE) for Local Waterbodies Affected by Project

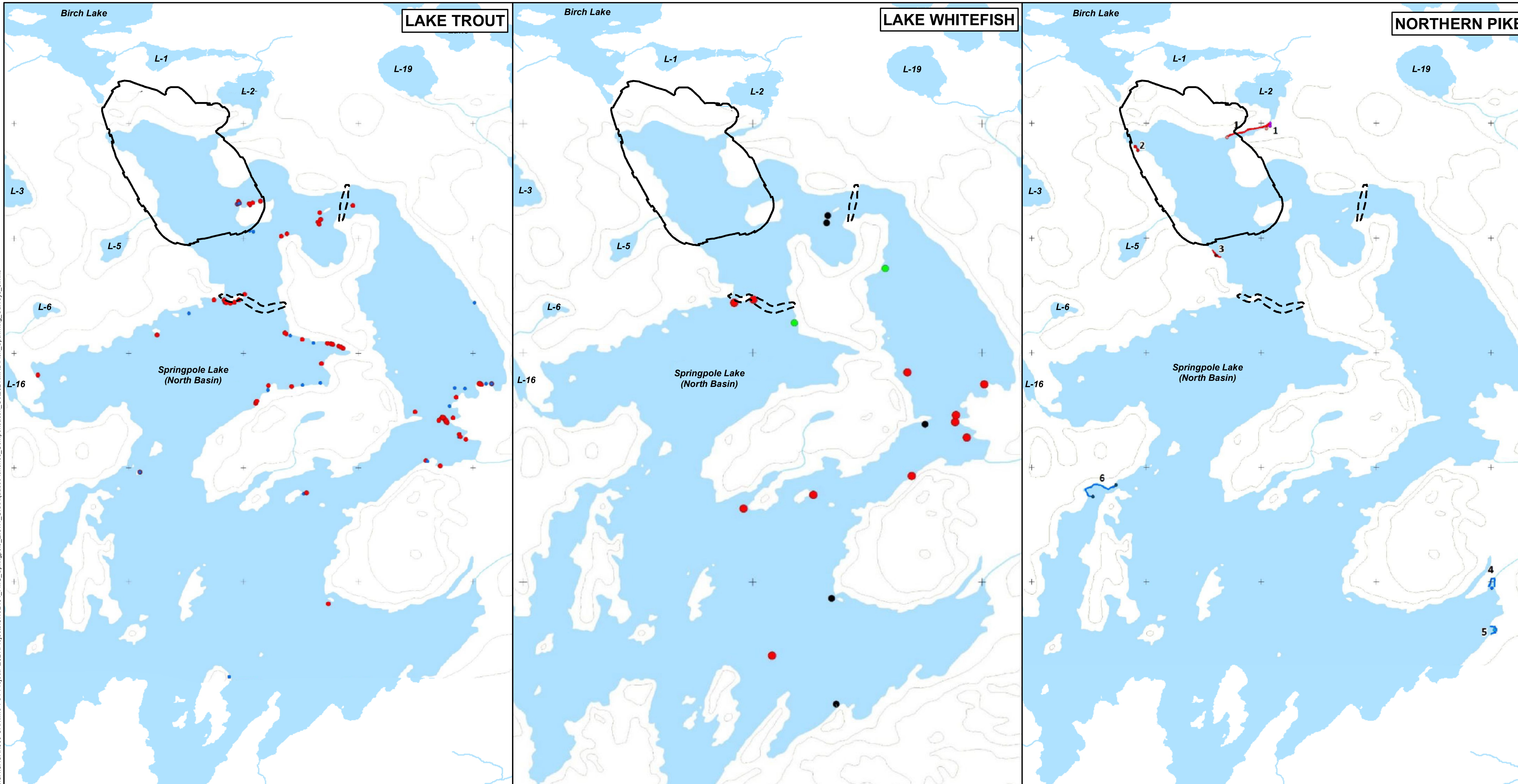
Waterbody / Watercourse	Habitat Type	Minnow Traps Mean (range)	Electrofishing Mean (range)	BsM Large Mean (range)	BsM Small Mean (range)	Gillnet Mean (range)	Seine Net Mean (range)	Hoop / Fyke Net Mean (range)
		Fish per Hour	Fish per Hour	Fish per Hour	Fish per Hour	Fish per Hour	Fish per Seine Haul	Fish per Hour
Birch Lake	Large lake	0.18	N/A	1.25 (1.02–1.57)	1.21 (0.84–1.83)	0.62	N/A	N/A
Birch River	River	0.06	N/A	N/A	N/A	0.061	N/A	N/A
L-1	Small lake	0.01	N/A	N/A	N/A	0.17	N/A	0.16 (0.01–0.31)
L-2	Small lake	0.40 (0–1.86)	N/A	N/A	N/A	0.39 (0.01–0.10)	N/A	0.49 (0–1.86)
L-3	Small lake	20.4	N/A	N/A	N/A	1.40	N/A	0.21
L-4	Small lake	0	N/A	N/A	N/A	0	N/A	N/A
L-5	Small lake	0.87 (0.09–1.86)	N/A	N/A	N/A	0.13	N/A	11.1 (9.0–13.2)
L-6	Small lake	0	N/A	N/A	N/A	0	N/A	N/A
L-10	Small lake	0.07	N/A	N/A	N/A	0.58	N/A	N/A
L-11	Small lake	0.25 (0.18–0.32)	N/A	N/A	N/A	0.56 (0.04–1.08)	N/A	N/A
L-12	Small lake	0.06	N/A	N/A	N/A	N/A	N/A	N/A
L-13	Small lake	0.09	N/A	N/A	N/A	0	N/A	N/A
L-14	Small lake	0.01	N/A	N/A	N/A	0.33	N/A	N/A
L-16	Small lake	0.01 (0–0.01)	0	N/A	N/A	0.38	0	N/A
L-17	Small lake	22.14	N/A	N/A	N/A	2.25	N/A	N/A
L-18	Small lake	2.18	N/A	N/A	N/A	N/A	N/A	N/A
L-19	Small lake	2.05	N/A	N/A	N/A	N/A	N/A	N/A
Springpole Lake (L15)	Large lake	0.08 (0.01–0.16)	N/A	1.19	N/A	0.18	411.1 (49.7–1251)	N/A
S-7	Stream	0.02	0	N/A	N/A	0.35	N/A	N/A
S-9	Stream	0.48 (0.20–0.61)	120 (0–300)	N/A	N/A	N/A	0	N/A
S-16/17	Stream	0.06	0	N/A	N/A	N/A	N/A	N/A
S-20	Stream	0	15.13	N/A	N/A	N/A	N/A	N/A
S-26	Stream	0.01	48	N/A	N/A	N/A	N/A	N/A
S-27	Stream	0.02 (0.01–0.03)	N/A	N/A	N/A	N/A	N/A	N/A
S-28	Stream	0	24	N/A	N/A	N/A	N/A	N/A
S-29	Stream	0.04	0	N/A	N/A	N/A	N/A	N/A
Average catch per unit effort (CPUE)	Large lake (n=2)	0.15	N/A	1.22	1.21	0.40	411.1	N/A
	Small lake (n=15)	2.01	0	N/A	N/A	0.10	0	N/A
	Large riverine (n=1)	0.06	N/A	N/A	N/A	0.06	N/A	2.39
	Small riverine (n=8)	0.08	29.59	N/A	N/A	N/A	0	N/A

Notes:
Average CPUE calculated by habitat type with number of waterbodies / watercourses included in the calculation represented within brackets (n=#).
Catch results include results of the baseline studies and MNR BsM studies within Birch Lake.
Gear-specific catch data include baseline survey results from 2009 to 2021.
CPUE data from early studies 2009 to 2018 assumed 24-hour minnow trapping effort where duration was not specified within the existing conditions report (FMG and Portt 2018).
Birch Lake MNR BsM effort assumed to be the average duration required by the protocol for each gear-type; 18 hours for large nets and 17 hours for small nets.
N/A = not applicable / no value.

Table 4-4: GIS-Inferred Spawning Habitat for Northern Pike, Lake Trout and Lake Whitefish

Species	Parameter	Area in Springpole Lake (ha)	Area in Dewatered Area (ha)	Percent Remaining
Northern Pike	Inferred Soft Substrate	2,229.5	107.6	95.17%
	Inferred Emergency Vegetation	31.6	0.0	100.0%
	Water Depth (0 to 2 metres)	488.3	25.7	94.74%
	Suitable Habitat (overlap of substrate, vegetation and water depth)	31.1	0.0	100.0%
Lake Trout	Inferred Hard Substrate	327.3	48.1	85.32%
	Water Depth (1 to 18 metres)	2,029.1	93.8	95.38%
	Suitable Habitat (overlap of substrate and water depth)	264.9	30.7	88.40%
Lake Whitefish	Inferred Hard Substrate	327.3	48.1	85.32%
	Water Depth (1 to 8 metres)	1,265.5	64.3	94.89%
	Suitable Habitat (overlap of substrate and water depth)	165.1	14.8	91.03%

Notes:
Springpole Lake = 2,556.8 ha
Dewatered Area = 155.8 ha



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LEGEND

- Open Pit
- Cofferdam
- Watercourse
- Waterbody

Lake Trout Observations
- Spawning Behaviour Not Observed
- Spawning Behaviour Observed

Lake Whitefish Observations
- Single Fish
- Small Group
- Small Group

Northern Pike Spawning Observation Dates
- 18/05/2015
- 19/05/2017
- 25/05/2013

NOTES:
- Proposed open pit and cofferdam provided by Ausenco, drawing number 104496-GX-03000-31344-003, Rev 1. 26 June 2023 and modified by WSP July 2023.
- Fish spawning surveys provided by Cam Portt, "Existing Conditions Report: Fish Community and Habitat", 2018.

Datum: NAD83
Projection: UTM Zone 15N

0 0.5 1 2 3 4 5 Kilometres

FIRST MINING GOLD
WSP

SPRINGPOLE GOLD PROJECT

Fish Spawning Surveys

PROJECT Nº: ONS2104
FIGURE: 4-1
SCALE: 1:32,000
DATE: September 2024

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LEGEND

- Proposed Project Feature
- Flow Direction

Habitat Types: A, B, C, D, E, F, G, H, Unclassified

0 0.25 0.5 1 1.5 2 Kilometres

NOTES:
- Aerial imagery provided by First Mining Gold, August 2020.
- Proposed site plan provided by Ausenco, drawing number 104496-GX-03000-31344-003, Rev 1. 26 June 2023 and modified by WSP July 2023.
- 230 kV transmission line provided by First Mining Gold, April 2024.

Datum: NAD83
Projection: UTM Zone 15N

FIRST MINING GOLD WSP

SPRINGPOLE GOLD PROJECT

Habitat Types

PROJECT N°: ONS2104

FIGURE: 4-2

SCALE: 1:17,000

DATE: September 2024

5.0 DESCRIPTION OF PROPOSED WORKS, UNDERTAKING OR ACTIVITY LIKELY TO AFFECT FISH AND FISH HABITAT

Despite efforts to avoid fish habitat, the Project has the potential to directly and indirectly impact waterbodies frequented by fish through works, activities and undertakings. Works, activities and undertakings such as infilling, the isolation or displacement of waterbodies, installation of water intake or discharge structures and water crossings can all directly affect fish and fish habitat. They can also indirectly impact habitat through flow alterations or water level changes to adjacent waterbodies and downstream creek sections, or with construction methods such as blasting or sedimentation.

To assess the Project interactions and potential effects on fish and fish habitat, a Pathways of Effects (PoE) analysis derived by DFO has been completed for all Project components that interact with fish habitat (Attachment C of this FHOCP). A description of the PoE analysis is provided by DFO as follows:

> *"Pathways of Effects (PoE) diagrams are used to describe development proposals in terms of the: activities that are involved, the type of cause-effect relationships that are known to exist; and the mechanisms by which stressors ultimately lead to effects in the aquatic environment.*
>
> *Each cause-and-effect relationship is represented as a line, known as a pathway, connecting the activity to a potential stressor, and a stressor to some ultimate effect on fish and fish habitat. Each pathway represents an area where mitigation measures can be applied to reduce or eliminate a potential effect. When mitigation measures cannot be applied, or cannot fully address a stressor, the remaining effect is referred to as a residual effect."* (DFO 2024b)

The PoE analysis results in a determination of whether there are residual effects on fish and fish habitat following standard and site-specific avoidance and mitigation measures. These residual effects are shown as yellow boxes in the analysis provided as Attachment C of this FHOCP. The purpose of this FHOCP is to identify and counterbalance any residual effects with offset and compensation measures. In the context of an EA, the offsetting and compensation measures are considered mitigation.

Descriptions of the Project components and their interactions with fish and fish habitat are described in Sections 5.1 to 5.5 to support the PoE analysis. The areas of impact are shown in Figure 3-1 and Figure 3-2.

Potential effects are discussed by major project component (e.g., CDF, open pit, plant site, access road and transmission line) along with avoidance and mitigation measures to avoid impacts (HADD). Residual predicted HADD and waterbodies that will require listing on Schedule 2 of the MDMER are individually and cumulatively summarized in Section 6.0 (Table 6-1, Table 6-2 and Table 6-3).

5.1 Co-disposal Facility

5.1.1 Direct Effects

The CDF is located west of the open pit and will maintain a minimum setback of 120 m from Springpole Lake and Birch Lake (Figure 3-2). The buffer will serve to mitigate potential erosion and sedimentation during construction and operation of the CDF. The facility will have a total surface area of approximately 380 ha, composed of a filtered non-acid generating filtered tailings / potentially acid generating mine rock cell (north cell, approximately 285 ha) and a slurry potentially acid generating tailings cell including a water storage component (south cell, approximately 95 ha) and surrounding dikes. The CDF height above average ground surface will be approximately 77 m to provide the required storage of mineral wastes.

The CDF will directly overprint portions of several waterbodies (L-3, L-4, L-5, L-6, L-17 and L-18) and their connecting watercourses (L-6-Out, S-16, S-17, S-18, S-19, S-21 and S-23), as shown in Figure 3-2. Of these waterbodies and watercourses, L-6 and L-6-Out have been confirmed as not fish frequented through historical sampling and are not included as areas quantified as impacted habitat. Several other waterbodies and watercourses are also suspected to be not fish frequented but are included in the current quantity estimate as a conservative measure.

This updated FHOCP reflects consultation and comments received by Environment and Climate Change Canada that clarified only the internal tailings and mine rock deposition area of the CDF will be quantified as a mineral waste deposition area requiring listing on Schedule 2 of the MDMER (Figure 3-2); while the perimeter embankments are quantified as Paragraph 35 (*Fisheries Act*) HADD impacts. While necessary to delineate these lost habitats by the respective legislations, in both cases, the waterbodies and habitats overprinted by the CDF will be permanently lost in their entirety.

5.1.2 Indirect Effects

The watercourses and waterbodies downstream of the CDF will be altered by changes in flow due to a combination of drainage area reduction and changes in groundwater contribution (WSP 2024b,c). This includes portions of waterbodies L-16, L-6-Out, L-5-Out, S-16 S-17, S-18, S-19, S-21, S-22 and S-23. Given the small watersheds of generally less than 1 km^2 (WSP 2024b; Attachment B, Table 4.2), most channels would experience a drainage area reduction of more than 30%. A conservative approach has been taken in this FHOCP to reflect uncertainties with potential impacts and possible changes to the CDF during detailed design. Accordingly, the entire areas of the impacted channels downstream of the CDF have been quantified as HADD. Although several of the waterbodies are suspected as not frequented by fish, they have also been conservatively included in the impact calculation (excluding L-6-Out, which has been determined to be not fish frequented) as a precaution.

5.1.3 Avoidance and Mitigation

One of the key objectives of the site planning efforts has been to maintain a small overall footprint for the mine including the CDF. The preferred location was selected after careful assessment of environmental, technical, social and financial factors during completion of the Mine Waste Management Alternatives Assessment (WSP 2024d), which included consideration of the overprinting of fish frequented waterbodies.

Although the CDF has been designed to make efficient use of space, the nature of the impact (overprinting) does not allow any additional mitigation for the overprinted waterbodies other than removing fish prior to construction to mitigated fish mortality.

Ditching around the CDF will collect seepage and runoff from the facility. To protect adjacent Birch Lake and Springpole Lake from potential construction impacts (i.e., suspended solids), standard measures and best management practices (such as erosion and sediment control) will be implemented as described in Section 7.0 and a 120 m buffer will be maintained between the facility and Birch Lake and Springpole Lake. Efforts to remove fish from the overprinted waterbodies will be made prior to infilling. Blasting is currently planned at the CDF location to quarry rock for construction. A blasting management plan will be prepared for the Project prior to construction, and potential effects on fish will be avoided by complying with federal blasting guidelines. Through consultation, DFO has requested that the Project exceed criteria specified by Wright and Hopky (1998) of 100 kilopascals (kPa) overpressure and follow a more stringent protection criteria of 50 kPa as described by Cott and Hanna (2005).

5.1.4 Pathway of Effects

The required size and selected location of the CDF results in residual effects (HADD) prior to offsetting, and compensation will be required. As shown in Attachment C1 of this FHOCP, there will be a permanent overprinting of fish habitat by the CDF, as well as a permanent alteration to flow to the adjacent watercourses and waterbodies. The potential for mortality to fish will be largely mitigated through fish removal efforts and staging of the works; however, some incidental mortality of fish is expected despite the fish removal efforts and is accounted for within the offset and compensation measures within this FHOCP.

5.2 Dikes, Dewatered Open Pit Basin and Open Pit

5.2.1 Direct Effects

Dikes

During the first year of the construction phase, an east and west dike (Figure 1-2) will be established to isolate a small portion of the north basin of Springpole Lake. The area isolated by the dikes is referred to as the open pit basin. The dikes themselves will have a combined length of 1,100 m with an average base width of approximately 65 m for a footprint of 7.15 ha. These dikes are essential for the safe and controlled dewatering of the pit area in advance of dewatering the open pit basin and mining operations. Similar dikes have been successfully implemented at other northern mining projects over the past 20 years including the Diavik Diamond Mine and the Gahcho Kué Diamond Mine in the Northwest Territories, the Meadowbank Gold Mine in Nunavut and the Pamour Gold Mine in Ontario.

The dikes will remain in place through operations and then be reduced to a minimum of 2 m below normal water level at closure. The remaining dike material will be contoured to provide additional spawning opportunities for species such as Lake Trout and Lake Whitefish.

Dewatered Open Pit Basin

The open pit basin including the footprint of the east and west dikes and the open pit has been calculated as 156 ha of the existing lake area. Excluding the open pit area and dike footprints, this results in an area of 77.75 ha that will be disrupted (temporarily dewatered) during operations but largely left as is. This area will be maintained in a dewatered condition through mining operations. At closure, the open pit basin will be reclaimed and reconnected to the main lake as described in Section 8.0 of this FHOCP. During operations, the open pit basin area outside of the open pit footprint is expected to undergo the following alterations:

- Portions of the open pit basin will be used to temporarily store the existing lake bed sediments for re-use in reclamation of the basin. This will temporarily alter the existing basin morphology and substrates; and
- The exposed substrates are expected to consolidate over time with the absence of water and develop some terrestrial or semi-terrestrial vegetation.

These alterations are temporary and will be accounted for in the reclamation of the basin.

Open Pit

An open pit mine is required to extract ore safely and economically for onsite processing. The pit is expected to be developed in a sequenced manner, starting with a lobe to the northeast (Phase 1 pit) before transitioning to the main open pit (Figure 3-2). The ultimate pit, using a top of pit elevation of 409 metres above mean sea level (m amsl) and a bottom elevation of 88 m amsl, will be approximately 321 m deep. The surface expression of the open pit will encompass approximately 132 ha and measure approximately 1.7 km long and 1 km wide. The open pit is proposed to have 12 m bench heights with bench widths of approximately 35 m. The ramps from surface have an approximate 10 percent (%) design gradient and will be either single or double lane width (27 to 35 m width), designed to accommodate haul truck requirements. The ultimate pit will generate about 101 million tonnes (Mt) or 38.6 million cubic metres (Mm^3) of ore, 20.4 Mt or 10.5 Mm^3 of overburden and 292 Mt or 111 Mm^3 of mine rock. The surficial layer of lake sediments will be stockpiled in the dewatered open pit basin for re-use during reclamation, with remaining overburden stockpiled in the surficial soil stockpile. Ore will be processed at the plant site, with residual tailings being deposited in the CDF. Mine rock will either be used in construction or deposited in the CDF.

The open pit will overprint an area of 71.1 ha of the existing lake. Within this footprint, the lake will be permanently altered by excavation to the ultimate depth of approximately 303 m below the normal water elevation. The sides of the excavation will be steep, with an overall angle of repose of 34 to 75 degrees (°) depending on the pit lithology such that the majority of the pit area will be deeper than the current maximum lake depth of 35.1 m.

The direct effect of constructing the dikes, isolating and dewatering the open pit basin, and establishing the open pit will result in the following impacts:

- Alteration of 71.1 ha of existing lake area for the footprint of the open pit: This area will be changed in terms of depth, substrate and water quality at depth.
- Disruption of 77.75 ha of existing lake area associated with open pit basin area surrounding the open pit footprint: This area will be isolated from the main lake for the life of mine and until the dewatered open pit basin is refilled but will remain largely unchanged from existing conditions once reconnected to the main lake. This area will undergo reclamation and habitat enhancements as discussed in Section 8.0.
- Overprinting of a small drainage reporting to L-2 (IS-AI) and a small drainage reporting to Springpole Lake (IS-AN) as shown in Figure 3-2 and Figure 4-2: Both drainages are presumed to be not fish frequented but are included in the current impact assessment as a conservative approach. The combined area of both drainages is 0.03 ha.

The combined 156 ha direct effect on Springpole Lake represents the majority (73%) of the total fisheries impacts (213.2 ha) from the Project (Section 6.0).

The 156 ha open pit area represents approximately 6.0% of the surface area of Springpole Lake (Table 5-1). The open pit basin area includes one of six deep water basins of Springpole Lake, and as such the isolated area reflects a larger percent volume (9.5%) of the total lake than percent total surface area.

The overall potential impact is considered in recognition of the larger interconnected lake complex surrounding the Project, consisting of Birch Lake, Springpole Lake and Seagrave Lake as shown in Figure 5-1. When considering the 156 ha open pit area in this broader landscape context, the affected area is approximately 1% of the larger lake complex. Considering the impact at a landscape scale is in keeping with the provincial Fisheries Management Plan for FMZ 4, which provides the following guiding principle for landscape level management: "Fisheries will be managed on a landscape scale – the FMZ scale. Individual lake management is discouraged other than in the context of water bodies specially designated by OMNR (e.g., the Specially Designated Waters of Lac Seul, Red Lake and Minnitaki Lake" (MNR 2014).

For additional context, a comparison of fisheries impacts proposed for the Project as compared to other Canadian mines with similar lake interactions is provided, including the Meadowbank Mine, Gahcho Kué Mine and Diavik Mine in Figure 5-2. All of these mines have previously required and implemented permanent and temporary lake habitat offsetting at an equivalent or greater scale than proposed for the Project.

5.2.2 Indirect Effects

Water Management

Indirect effects from the initial dewatering and continued water management within the open pit basin and the open pit will contribute to changes in groundwater and surface water contribution to other local lakes and waterbodies. Groundwater inflow to the pit is estimated to gradually increase over the life of mine to a maximum of 3,034 m^3/day at end of mine operations (WSP 2024g). Modelling of groundwater and surface water reductions to local surface waters has been completed and is discussed in Section 5.1 for the CDF, and Section 5.3 for the plant site and ore stockpile areas.

Open Pit Dewatering

In addition to water containment and control, there will be a need to dewater the open pit basin during construction. Once the open pit basin of Springpole Lake has been isolated using dikes, controlled dewatering will occur. As a base case, controlled dewatering of the open pit basin is expected to take approximately six months to complete, based on continuous (24-hour, 7-day per week) pumping at a rate that is able to maintain Springpole Lake water levels within baseline natural variation.

Average monthly inflows to Springpole Lake range from 21.3 cubic metres per second (m^3/s) in June to 5.0 m^3/s in March. The average annual water level of Springpole Lake fluxuated by more than a 1 m from June to March with a maximum natural variation of 2.1 m over the approximately 2.5-year period of record (Appendix M-1 of the final EIS/EA). Based on the data collected and analyzed to date, this provides an observed annual natural variation of 16.3 m^3/s in flow and 1.0 m in water level. The volume of the proposed open pit basin within Springpole Lake ranges is approximately 18 Mm^3, consistent with the bathymetric survey.

Controlled dewatering of the open pit basin will be completed in a manner to mitigate potential environmental impacts by managing and monitoring flow rates. The six-month timeframe has been determined based on the receiving capacity of Springpole Lake to accept an increase in flow, limited to 10% of the instantaneous natural flow through Springpole Lake consistent with DFO guidance (DFO 2013).

Table 5-2 provides the maximum dewatering rate by month (using the 10% instantaneous flow threshold), while Table 5-3 shows calculated dewatering durations for average, dry and wet years. It is recognized that instantaneous flow in the DFO guidance refers to a continuous condition, and monthly values are provided for context only. During the dewatering activities, a continuous flow monitoring station at the inlet and outlet of Springpole Lake will be used to provide a running average flow that will be used to inform the actual dewatering rate consistent with anticipated permit conditions.

The controlled dewatering process of the open pit basin, including the transfer of water back into Springpole Lake and the removal of fish, will be designed to mitigate potential environmental effects, including maintaining lake levels within natural variation. The estimated potential change in water elevation of Springpole Lake due to the development of the open pit basin would be less than 10 centimetres (cm), which is less than 10% of the observed natural annual average water level fluctuation and less than 5% of the maximum observed fluctuation of the lake water level.

During initial controlled dewatering, a barge is proposed to transfer lake water out of the open pit basin and back into Springpole Lake on the downstream side of the east dike. Dewatering will continue in this manner until the threshold concentration of total suspended solids in the discharged water is reached (15 to 30 milligrams per litre [mg/L] according to Schedule 4 of the MDMER and anticipated provincial permit limits). Once the total suspended solids threshold is reached, this water will be directed towards the CWSP for additional settling prior to discharge back to Springpole Lake. The CWSP and related infrastructure will be set up early in the process to be available to receive the total suspended solids-laden water when needed.

The CWSP was selected as the preferred location to receive this water for additional settling given its large surface area and depth, which will provide operator flexibility during development of the open pit basin. The CWSP can support a dewatering rate of up to 2.6 m^3/s, which will be sufficient for average year hydrologic conditions. The settling pond size assumes that a 5 to 10 micron (μm) particle can be settled (the smallest particle size that can be settled by sedimentation alone). Flocculant or other means may be used in the CWSP if needed to help settle suspended sediments.

Blasting

The detonation of explosives near waterbodies can produce post-detonation shock waves that result in a pressure deficit referred to as overpressure, which can cause impacts in fish (Wright and Hopky 1998). An overpressure in excess of 100 kPa can result in effects in fish. Vibrations can also harm fish eggs and larvae, and a limit of a peak particle velocity no greater than 13 $mm \bullet s^{-1}$ is allowed in a spawning bed during the period of egg incubation. The overpressure and vibration limits specified in the *Guidelines for the Use of Explosives In or Near Canadian Fisheries Waters* (Wright and Hopky 1998) are shown in Table 5-4. Subsequent work by DFO (Cott and Hanna 2005) suggested that a more conservative limit for fish habitat in waterbodies with substantial ice-cover throughout the year is 50 kPa. DFO has also confirmed, in comments received on the draft EIS/EA, that 50 kPa is a conservative limit for the fish habitat on the Project. These limits are applicable at the land-water interface (shoreline).

The use of explosives to support mine development will begin at surface level and progress quickly below grade throughout the pit development. Blast patterns vary for feed and waste to assist in mine productivity. Drilling will typically be completed with down the hole hammer drills with a 251 mm diameter bit or with smaller 140 mm diameter drills which will supplement the drilling and provide the pre-shear drilling (AGP Mining Consultants Inc. 2021).

Blast patterns and charges per delay will vary according to the rock type, conditions and proximity to the dikes and adjacent lakes. Blasting is not expected to be required at the immediate dike locations but will be required in the fish habitat development area. A blasting assessment was completed for the Project and is provided in Appendix H-4 of the final EIS/EA). The assessment shows that there is no potential for most waterbodies to be impacted by blasting operations. However, during the first year of operations there remains a potential for the blasting limits to be exceeded in nearshore areas of Birch Lake and unnamed lake L-1 at the north boundary of the open pit. It is assumed that adjustments to the charges used during spawning periods, will mitigate the potential of exceeding the 13 millimetres per second (mm/s) vibration limit. Although a detailed blasting plan will be developed prior to construction to further reduce potential impacts, we have conservatively assumed that an area of 1.4 ha may be impacted during the early blasting operations (see Figure 3-2) and have included this value in the overall HADD calculations (Section 6).

5.2.3 Avoidance and Mitigation

Location and Avoidance

The location of the ore body and the resulting open pit are fixed and cannot be relocated. The dike locations and open pit basin has been assessed for both engineering requirements and ecological effects and have been sited to minimize the isolated area while maintaining the necessary safety requirements (Knight Piésold 2021). Specific criteria considered in the selection of the dike locations included:

- Maximum dike height (safety consideration);
- Lake bed sediment type and coverage (engineering and habitat consideration);
- Distance to open pit (safety consideration);

- Dewatered lake area and volume (habitat consideration);
- Impacts to known Lake Trout and Lake Whitefish spawning locations (habitat consideration); and
- Capital cost (financial consideration).

Based on these criteria, the selected dike locations were confirmed to be the preferred locations to meet safety and engineering requirements, while minimizing habitat impacts.

Open Pit Basin Dewatering

A 10% of the instantaneous natural flow threshold has been applied as a mitigation measure and is consistent with the Fisheries and Oceans Canada (DFO) guidance document Framework for Assessing the Ecological Flow Requirements to Support Fisheries in Canada (DFO 2013). Within the framework, DFO provides a national technical guidance that cumulative flow alterations of less than 10% in amplitude of the actual (instantaneous) flow relative to a "natural flow regime" have a low probability of detectable impacts to ecosystems. By limiting the rate of dewatering and associated discharge to the downstream environment to less than 10% of the calculated instantaneous flow, the determination that the activity is not harmful to fish and fish habitat is well supported.

Blasting

Blasting residues have the potential to harm fish if not properly managed. This will be mitigated through collection of water from the Project operations and the use of onsite water management facilities, including treatment as required, prior to discharge to the environment.

A site-specific blasting plan will be completed for the Project prior to construction. Charge per delay values presented in the blasting assessment are not to be considered a fixed limit but are meant to be used by the Project team to develop a blasting plan that meets the criteria in Table 5-4, or alternate values derived in consultation with DFO.

Fish Removal

A comprehensive fish removal program is proposed to minimize the unintentional death of fish associated with dike construction and establishing the open pit basin. Although fish removals have become a common mitigation measure for projects impacting waterbodies, including large scale lake removals, each project requires individual consideration as to the best methods and preferred objectives.

The portion of Springpole Lake to be dewatered supports a diverse fish community including forage and sportfish species (Section 4.0). Several of the species such as Lake Trout and Lake Whitefish are valued species, but have habitat and seasonal characteristics that can make them less resilient to capture and relocation.

Lessons learned from other large lake fish removal efforts have suggested that a fish transfer "*is usually the least preferred method of fish disposal and should only be considered when fishes are transferred from a smaller, isolated portion of a lake to a larger main waterbody*" (Tyson et al. 2011). Although the Project meets this description (approximately 6% of the lake isolated), the detailed DFO report by Tyson et al. (2011) on Fish Out Protocol provides other potential end uses, such as community distribution as objectives to be considered. The protocol further proposes that "*the guiding principle of the fish-out program is to ensure that both the ecological data and fish specimens that are collected can be used to their fullest extent*".

Consultation and comments received from Indigenous communities and from regulators on the draft EIS/EA has shown an interest to how the fish removal could be completed to maximize its effectiveness. DFO has suggested that observed species specific seasonal movements be considered in the timing of the isolation of the open pit basin.

Fisheries in-water timing constraints are determined by provincial guidelines and based on regions and individual species. The timing constraints based on the provincial guidelines would restrict in-water works in Springpole Lake to between June 16 to August 31 (72 total days).

Telemetry data (FMG and Portt 2018) have shown that tagged Walleye and Lake Trout both use the north basin of Springpole Lake during summer months. Telemetry data show both tagged Walleye and Lake Trout used the north basin from June through October, with Lake Trout dispersing in October to the broader lake (remainder of Springpole Lake and adjacent river systems) and returning in May the following year. Walleye tend to remain in the north basin until late winter when they begin moving out of the basin towards the southeast arm of Springpole Lake and then move up the Birch River towards Cromarty Lake in April and May; returning to the north basin in June. There is an annual period of approximately late winter (February) and spring (May) when most tagged fish of both species have left the north basin into the broader lake and rivers.

Construction of the west and east dikes are expected to take approximately one year to complete. Based on previous experience, barriers such as turbidity curtains could be used to isolate the dike areas during the allowable in-water work window (June 16 through August 31).

Adhering to the current in-water construction timing window and isolating the work areas around the dike in mid-June would likely result in adult Walleye and Lake Trout trapped within the isolated north basin. These fish would need to be captured with a subsequent fish removal program. If an in-water timing constraint exemption were to be granted that would allow the initial isolation using barriers to be completed in the spring, the telemetry data indicate that most of the Walleye and Lake Trout that utilize the basin will be distributed throughout the broader lake and the number of fish trapped in the isolated basin would be reduced. However, given that the barriers and dike construction would occur prior to Lake Trout egg emergence and fry dispersal, there may be higher egg and fry mortalities experienced in the footprint of the dikes where Lake Trout have spawned.

A comprehensive fish removal plan for the isolated basin of Springpole Lake, both before and during the dewatering efforts, will be developed. Based on previous experience of the Project team with completing both whole and partial lake fish removals, capture gear would target both large and small bodied fish. If the agreed end use of fish is redistribution to the broader Springpole Lake, then gear types with lower mortality would be utilized. A quantitative depletion model would be used to monitor the success and efficiency of the removal program. The end target for fish removal will be determined in consultation with government agencies but will likely fall within the range of 70% to 85% removal for most sport fish.

The objectives and end use of the comprehensive fish removal plan will be determined through further engagement with Indigenous communities and federal and provincial regulators. The proposed offset and compensation measures proposed in Section 8.0 and summarized in Section 9.0 of this FHOCP are considered sufficient to account for the existing fish within the dewatered basin such that transferring the fish during construction should not be considered the only option.

5.2.4 Pathway of Effects

The location of the ore body results in residual effects (HADD) prior to offsetting and compensation. As shown in Attachment C2 of this FHOCP, there will be a permanent alteration of fish habitat by the open pit, as well as a disruption and alteration to the adjacent open pit basin and dike footprints. The potential for mortality to fish will be largely mitigated through fish removal efforts and staging of the works; however, some incidental mortality of fish is expected during and despite the fish removal efforts and is accounted for within the offset and compensation measures within this FHOCP.

5.3 Plant Site and Ore Stockpiles

5.3.1 Direct Effects

The plant site and ore stockpiles are located northeast and east of the open pit (Figure 3-1 and Figure 3-2). The facilities will overprint a small watercourse that reports to L-1 and L-2 as shown in Figure 3-2 as impact segments IS-AA, IS-AB and IS-AC. The feature is classified as Type D habitat (Figure 4-2) and presumed to be not fish frequented but is included in the current impact assessment as a conservative approach.

The CWSP will be developed early in mine life to manage site runoff and store surplus water. The CWSP will entirely overprint L-2 (11.5 ha). The use of L-2 for the CWSP was considered appropriate as its proximity to the open pit, and groundwater and surface water modelling indicate that it would be otherwise considerably altered by flow reductions. Although reclamation of L-2 at closure is proposed, it is not included as an offset measure and is considered a permanent HADD of fish habitat.

A water intake structure will be constructed in Birch Lake northeast of the ore stockpiles as shown in Figure 3-1. For the purpose of this revised FHOCP, it is assumed that a footprint of 0.01 ha (approximately 100 square metres [m^2]) in Birch Lake would be altered.

A water discharge structure will be constructed in the southeast arm of Springpole Lake, shown as (IS-AX) in Figure 3-1. The discharge will have a diffuser to improve mixing and has been modelled in WSP (2024f). For the purpose of this FHOCP, it is assumed that a footprint of 0.005 ha (approximately 50 m^2) in Springpole Lake would be altered.

5.3.2 Indirect Effects

Changes in flow due to a combination of drainage area reduction and changes in groundwater contribution (Wood 2021, WSP 2024f) will result in impacts to a small drainage feature that reports to L-1 and L-2 (shown in Figure 3-2 as impact segment IS-AD) and to L-1 itself. The drainage feature segment (IS-AD) is presumed to be not fish frequented but is included in the assessment as a conservative approach.

L-1 will be affected by groundwater and surface drainage area reductions in the order of -119% during operations (WSP 2024b). Although water will likely be retained in the lake, is it expected that the lake habitat (9.0 ha) would be temporarily altered during operations by the reduction in flow. L-19 (and its downstream channels) were initially considered to be impacted by a flow reduction of approximately 38% under average conditions during operations. However, further modelling has determined that the water level reduction in L-19 would only range between 0.05 and 0.06 m throughout the year. This water level difference is well within typical annual fluctuations for inland waterbodies and not considered to be harmful. The outlet from L-19 would still likely experience some disruption to flow, and to be conservative it is included in Section 6.0 as a HADD. L-16 is predicted to be permanently altered due to flow changes up to 65% during operations and 55% at closure. Although the lake may continue to retain water, the 5.9 ha area of L-16 has been included as a predicted HADD in Section 6.0 of this FHOCP.

Water taking from Birch Lake will be required during commissioning and operation of the plant site, and for fresh water for the accommodations complex. The combined water taking results in a total annual water taking from Birch Lake of 3.96 Mm^3/year (annual average rate: 0.126 m^3/s), the maximum under all modelled scenarios (WSP 2024c). The taking would be continuous during the operations phase. Birch Lake has a large watershed (approximately 762 km^2) with an estimated 100-year dry conditions annual flow rate of approximately 3.1 m^3/s (WSP 2024b). Even under this potential extreme dry flow condition, the proposed water taking from Birch Lake would be less than 5% of the flow from the lake and is not expected to result in measurable changes to lake levels or downstream water levels. Under average conditions, Birch lake provides monthly flows between 3.0 and 13.0 m^3/s, which corresponds to a water taking of between 1.0% and 4.2%. As such, the water taking from Birch Lake is not considered a HADD in Section 6.0 of this FHOCP.

5.3.3 Avoidance and Mitigation

The plant site and ore stockpile locations were selected to maintain a small footprint for the overall mine and avoid waterbodies to the extent practicable.

Ditching around the plant site and ore stockpiles will collect runoff and seepage from the facilities and direct it to the water management system. To protect the adjacent waterbodies from construction impacts (i.e., suspended solids), standard measures and best management practices such as erosion and sediment control will be implemented per Section 7.0.

Although a conservative approach has been taken with L-1 and L-16 (i.e., they are considered to be altered in their entirety), it is likely that flow reduction impacts will develop slowly as the site is constructed and the pit is dewatered. Fish are likely to be retained in both lakes or could be removed based on initial observations during construction. Fish will be removed from L-2 prior to construction and use of the CWSP.

5.3.4 Pathway of Effects

The plant site and stockpiles have been positioned to reduce the overall mine site footprint. Despite avoidance and mitigation as shown in Attachment C4a of this FHOCP, the CWSP will directly overprint L-2, while L-1 will be disrupted during the life of mining operations and the recovery of the groundwater. There will be direct impacts to Birch Lake at the immediate water intake footprint (Attachment C4b of this FHOCP), as well as in Springpole Lake from the water discharge structure (Attachment C4c of this FHOCP).

5.4 Road Crossings and Pipelines

The Project will require the development of a mine access road extending from the existing Wenasaga Road to the mine site, a distance of approximately 18 km as shown in Figure 3-1. An airstrip will be co-located with the access road just east of the mine site. There will also be a need for an access road and pipeline extending approximately 9 km south from the mine site to the southeast arm of Springpole Lake to support the effluent discharge. The draft EIS/EA alignment of the access road included up to four water crossings. Additional investigation and analysis resulted in optimizations to the route and a reduction in potential water crossings to two (Impact Segments UNX03 and IS-AQ in Figure 3-1). The currently proposed alignments has no expected crossings along the effluent discharge pipeline route and access road to the southeast arm of Springpole Lake.

The two crossings will have a length of less than 50 m (Section 6.0, Table 6-2). Although potential impacts with individual road crossings can be mitigated with best management practices, these crossings are included in Section 6.0 as impacts to account for them cumulatively.

5.4.1 Avoidance and Mitigation

Road and pipeline routes have been aligned along elevated ground in part to avoid water crossings. Further alignments may be considered and evaluated to balance aquatic impacts with sensitive terrestrial impacts (such as Species at Risk). Road crossings will use standard design measures such as structure sizing, embedment and construction methods to mitigate impacts. The structure designs will facilitate fish passage.

5.4.2 Pathway of Effects

Roads and pipelines routes have been designed to follow high ground and minimize water crossing. The structures and installation measures will incorporate fish friendly design, and installation to prevent impacts to fish passage and from sediment (Attachment C5 of this FHOCP). Isolation of the work areas and flow management will follow DFO's *Interim Code of Practice: End-of-Pipe Fish Protection Screens for Small Water Intakes in Freshwater* and *Interim Standard: In-Water Site Isolation* (DFO 2024a). The footprint of the culvert structure will result in a small habitat alteration.

5.5 Transmission Line

The draft EIS/EA originally presented a transmission line rout that crossed lands to the south of the community of Slate Falls Nation (SFN) prior to joining the existing E1C transmission line corridor. Comments received and follow-up engagement informed the Project that the route would conflict with harvesting and ceremonial areas southwest of the community, and that following the existing E1C corridor was preferred over making a new corridor around the community. This FHOCP incorporated the new alignment, which is a 94 km, 230 kilovolt (kV), overhead transmission line is proposed to tie the Project into the Wataynikaneyap 230 kV line between Dinorwic and Pickle Lake (Figure 3-1 inset). The proposed transmission line route has been established to minimize overall length while respecting input from Indigenous communities and reducing environmental effects.

The transmission line is expected to be established within a 40 m wide corridor. Additional cleared corridor width may be required at turning points, or where pole anchors are needed, such as in poor ground conditions. The transmission line is expected to be constructed primarily in the winter from temporary winter roads, avoiding sensitive periods for wildlife as much as practicable. Establishment of a permanent road within the transmission line corridor is not proposed at this time. Work including vegetation clearing may also occur during the late summer and fall on higher ground or in areas of good accessibility.

The transmission line will span approximately 43 waterbodies including small, medium and large watercourses as summarized Table 5-5. Transmission line water crossings will all be clear span with poles located above the high-water mark to avoid in-water structures and avoid HADD. Vegetation maintenance within the transmission line corridor will restrict vegetation heights, but vegetation cover is expected to remain adequate to prevent long-term ground erosion and sedimentation to waterbodies.

The transmission line and temporary winter access road / trail represent a small and localized interaction with the waterbodies, and no permanent change to banks or beds of the waterbodies. Although minor changes to riparian vegetation may occur, the small extent relative to the overall length of the channels or waterbody is not considered likely to impact habitat quality, such as temperature, cover, nutrients or food supply to an extent that would be harmful to resident fish. Accordingly, transmission line effects have not been included as predicted HADD in Section 6.0.

5.5.1 Avoidance and Mitigation

The location and routing of the transmission line was selected based on a review of effects on the both the biophysical environments and the human environment, as well as cost effectiveness and technical considerations. The transmission line construction is proposed to be completed outside of the open water wetted area at all times.

Installation will be largely completed in the winter over frozen ground, minimizing risk or soil disturbance and mobilizations. Vegetation will be cleared within the transmission line corridor and work areas, but not grubbed. To the extent practicable, vegetation clearing within riparian areas will be completed by hand to avoid ground disturbance by vehicles. Herbicides will not be used in close proximity to waterbodies during vegetation management in the corridor.

The construction access road is expected to be a winter road with ice crossings or structural crossings (e.g., temporary bridges) if required. To the extent possible, the approach provided in the *Code of Practice: Ice Bridges and Snow Fills*, *Code of Practice: Clear Span Bridges* and *Code of Practice: Temporary Fords* (DFO 2024a) will be used for the temporary access road crossings.

5.5.2 Pathway of Effects

The transmission route has been designed to reduce distance and minimize water crossing. The permanent structures will be placed above the high water mark. Temporary crossings will be required during construction and will follow best management practices to mitigate sediment and erosion impacts. As shown in Attachment C6 of this FHOCP, the potential effects of the transmission line on fish and fish habitat can be mitigated.

Table 5-1: Springpole Lake: Calculated Volumes and Surface Areas

Area	Calculated Approximate	
	Volume (m^3)	Surface Area (m^2)
Springpole Lake (entire lake)	190,000,000	25,568,000
Portion of Springpole Lake to be dewatered after dike installation	18,000,000	1,560,000
Remaining Springpole Lake area after dike installation	172,000,000	24,008,000
Percent change	-9.5%	-6.1%

Notes:
The total volume and area of Springpole Lake as well as the proposed dewatered basin was estimated using detailed bathymetry data and geographic information system computer software.
m^3 = cubic metre.

Table 5-2: Open Pit Basin Calculated Maximum Dewatering Rate

Maximum Dewatering Rate (10% of available flow) (Mm^3/month)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average year	1.8	1.4	1.3	1.9	5.6	5.5	4.2	3.0	2.8	3.0	2.8	2.3
Dry year (5th percentile flow)	1.0	0.8	0.7	1.0	3.1	3.1	2.3	1.7	1.6	1.7	1.6	1.3
Wet year (95th percentile flow)	2.9	2.2	2.2	3.1	9.1	9.0	6.9	5.0	4.6	4.9	4.6	3.7

Table 5-3: Open Pit Basin Calculated Dewatering Durations

Dewatering Schedule Scenario	Start	End	Total Duration of Dewatering Period (months)	Duration of Active Pumping (months)
Pump maximum 10% of receiver flow year-round				
Average year	Sept Year-3	May Year-2	9	9
Dry year (5th percentile flow)	Sept Year-3	Aug Year-2	12	12
Wet year (95th percentile flow)	Sept Year-3	Feb Year-2	6	6

Table 5-4: Fisheries and Oceans Canada Blasting Near Canadian Fisheries Water Limits

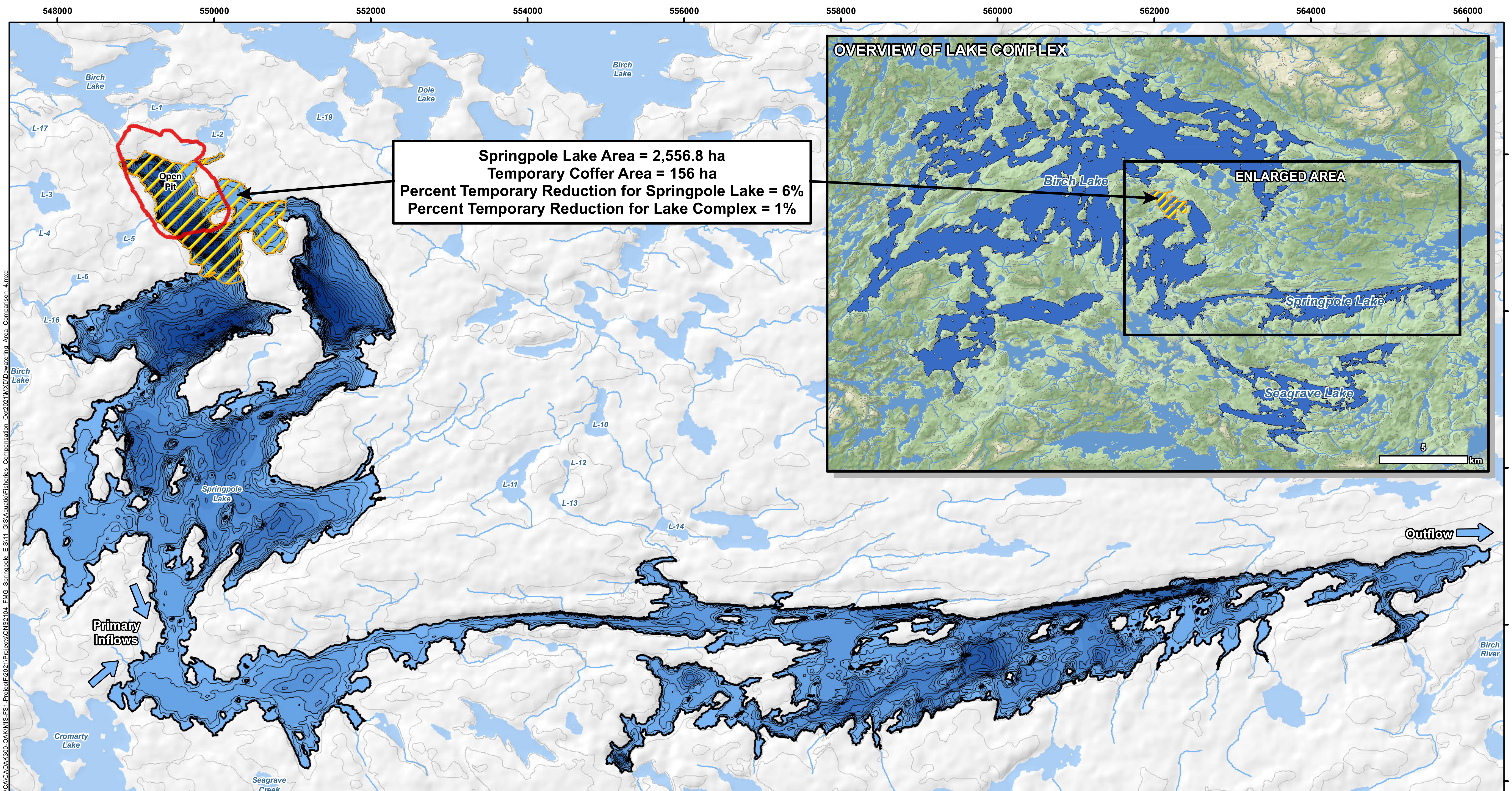
Assessment Type	Assessment Metric	Limit (Wright and Hopky 1998)	Limit (Cott and Hanna 2005)
Water-overpressure	Peak pressure (P_{peak})	≤100 kPa	≤50 kPa
Vibration(1)	Peak particle velocity (PPV)	≤13 mm/s	≤13 mm/s

Notes:
(1) The vibration limit applies with a maximum PPV level of 13 mm/s in a spawning bed during the period of egg incubation.
≤ = less than or equal to.

Table 5-5: Summary of Watercourse Size Spanned by the Transmission Line

Section of the Project Development Area	Small (<5 m)	Medium (5 to 20 m)	Large (>20 m)	Total
Mine access road	2	N/A	N/A	2
Transmission line	28	4	11	43
Total	**30**	**4**	**11**	**45**

Note:
N/A = not applicable; < = less than; > = greater than.



LEGEND

- Open Pit
- Dewatered Area (During Operation)
- Bathymetry Contours (2 m interval)
- Springpole Lake
- Waterbody
- Watercourse
- Contour (10 m intervals)

Springpole Lake Bathymetry (filled contours, metres)

0 - 2, 2 - 4, 4 - 6, 6 - 8, 8 - 10, 10 -12, 12 -14, 14 -16, 16 -18, 18 -20, 20 - 22, 22 - 24, 24 - 26, 26 - 28, 28 - 30, 30 - 32, 32 - 34, 34 - 36, 36 - 38, > 38

0 0.5 1 2 3 4 5 Kilometres

NOTES:
- Topographic information extracted from LIO, MNRF.
- Springpole Lake bathymetry provided by Story Environmental Inc, 2017/2019.
- Proposed open pit provided by Ausenco, drawing number 104496-GX-03000-31344-003, Rev 1. 26 June 2023.

Datum: NAD83
Projection: UTM Zone 15N

FIRST MINING GOLD

wsp

SPRINGPOLE GOLD PROJECT

Figure Showing Proposed Isolated Basin in Relation to Overall Springpole Lake and Surrounding Lake Complex

PROJECT N°: ONS2104

FIGURE: 5-1

SCALE: 1:46,000

DATE: August 2024

Conceptual Springpole Project *Mine*

Circa 2015. *Meadowbank Mine*

July 2019. *Gahcho Kué Mine*

2021 *Diavik Diamond Mine*

Attribute	Springpole	Meadowbank	Gahcho Kué	Diavik
Permanent Habitat Loss (ha)	34	149	159	41
Altered Habitat (ha)	71	91	84	212
Disrupted Habitat (ha)	108	254	429	-
Total (ha)	213	494	672	254
% of Host Lake Affected	Springpole (6%)	3%, 36%, >70%	Kennedy (20%)	0.45%

Note: Values are approximate based on readily available public information

LEGEND

NOTES:

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SPRINGPOLE GOLD PROJECT

Comparison of Project Fisheries Impacts with Other Similar Projects in Canada

PROJECT N°: ONS2104	**FIGURE: 5-2**
SCALE: N.T.S.	DATE: August 2024

X:\CA\CAOAK300-OAK\MIS-FS1-Project\F2021\Projects\ONS2104_FMG_Springpole_EIS\11_GIS\Aquatic\Fisheries_Compensation_Oct2021\MXD\Comparison_of_Fisheries_Impacts_to_Other_Projects_3.mxd

6.0 RESIDUAL HADD AND WATERBODIES TO BE LISTED TO MDMER SCHEDULE 2

The residual impacts to fish and fish habitat associated with the proposed Project are quantified below based on the proposed works, undertakings and activities and the subsequent pathways of effects analysis (Section 5.0; Attachment C of this FHOCP). The residual impacts from the overall Project and the deposition of a mine waste are summarized on a preliminary and conservative basis in three tables:

- Waterbodies requiring listing on Schedule 2 of the MDMER are provided in Table 6-1.
- Waterbodies predicted to result in a HADD to fish and fish habitat and requiring Authorization under Paragraph 35(2)(b) of the *Fisheries Act* are listed in Table 6-2.
- A combined summary of Schedule 2 waterbodies and predicted HADD is provided in Table 6-3.

The locations of Schedule 2 waterbodies and HADD delineated as impact segments on a preliminary basis are shown in Figure 3-1 and Figure 3-2, with coordinates provided in Table 3-1 and Table 3-2.

Most predicted residual effects on fish and fish habitat are caused from direct overprinting habitat loss (i.e., infilling, excavation or complete dewatering) of waterbodies. Additional impacts have been predicted from changes in groundwater and surface flows resulting in alterations to small watercourses or lakes. In the case of direct habitat loss, the impacted habitat is quantified as 100% of the area overprinted regardless of whether it will be restored during a subsequent Project phase. For flow reductions to small watercourses and lakes, this revised FHOCP makes the conservative assumption that 100% of the habitats are altered and considered HADD, although subsequent versions of this plan may allow for additional mitigation and avoidance. Likewise, L-1 and L-16 are within the influence of combined groundwater drawdown and surface water reduction and have been conservatively included as 100% impacted. This conservative approach will enable contemplation of a worst-case scenario, while additional mitigation measures and design options are considered during and post-EIS/EA process.

Several waterbodies are currently considered as potentially impacted in this revised FHOCP, even if they likely do not support fish at any time of the year. To be conservative, all waterbodies have been included in the impact calculation with the exception of L-6 and L-6-Out, which have been established as not fish frequented.

The current combined residual HADD and impacts to waterbodies frequented by fish associated with the Project requiring offsetting or compensation has been calculated as 213.2 ha, the majority of which is composed of the 156 ha open pit basin that will isolate a small portion of Springpole Lake during the construction and operations phases of the Project.

Table 6-1: Summary of Fish Habitat Impacts to Schedule 2 Waterbodies

Impact Segment ID	Waterbody	Mine Feature	Length (m)	Wetted Width (m)	Predicted HADD Area (m^2)	Predicted HADD Area (ha)
IS-D	L-3	CDF	N/A	N/A	161,838.4	16.2
IS-E	S-16	CDF	492.9	0.5	246.4	0.02
IS-L	L-4	CDF	N/A	N/A	10,254.2	1.03
IS-M	S-17	CDF	102.8	0.5	51.4	0.01
IS-Q	L-17	CDF	N/A	N/A	7,228.08	0.72
IS-R	S-18	CDF	56.2	0.5	28.1	0.003
IS-U	L-18	CDF	N/A	N/A	21,003.5	2.100
IS-Y	L-5	CDF	N/A	N/A	21,359.0	2.1
IS-AG	L-2	CWSP	N/A	N/A	115,631.1	11.6
IS-AH	L-2	CWSP	N/A	N/A	339.8	0.03
				Schedule 2 Total	**337,980**	**33.8**

Notes:
Anticipated impacts summarized in this table of the revised FHOCP should be considered preliminary and are subject to change with additional field data and on additional regulatory discussions / consultation.
N/A = not applicable.

Table 6-2: Summary of Predicted HADD (Paragraph 35) to Fish and Fish Habitat

Impact Segment ID	Name / Location Description	Mine Feature	Length (m)	Wetted Width (m)	Predicted HADD Area (m^2)	Predicted HADD Area (ha)
IS-AW	Birch Lake	Fresh water intake	N/A	N/A	112.5	0.01
IS-BJ	Birch Lake	Overpressure (blast)	N/A	N/A	14,000	1.40
IS-A	Inflow to L-16	Flow reduction	161.2	0.5	80.6	0.01
IS-B	Inflow to L-16	Flow reduction	N/A	N/A	7,311.8	0.73
IS-C	Inflow to L-16	Flow reduction	59.4	0.5	29.7	0.003
IS-AA	Inflow to L-2	Plant site	122.8	0.5	61.4	0.01
IS-AB	Inflow to L-2	Plant site	43.5	0.5	21.8	0.002
IS-AC	Inflow to L-2	Haul road	65.7	0.5	32.8	0.003
IS-AD	Inflow to L-2	Flow reduction	141.4	0.5	70.7	0.01
IS-AE	Inflow to L-2	Flow reduction	43.4	0.8	32.5	0.003
IS-AF	Inflow to L-2	Haul road	39.6	0.8	29.7	0.003
IS-AI	Inflow to L-2	Phase 1 pit	245.9	0.5	122.9	0.01
IS-AJ	Inflow to Springpole Lake	Flow reduction	11.7	0.5	5.8	0.001
IS-AN	Inflow to Springpole Lake	Fish habitat development area / high-mid grade ore stockpile	362.2	0.5	181.1	0.02
IS-AT	L-1	Flow reduction	10.4	0.5	5.2	0.001
IS-AY	L-1	Flow reduction	N/A	N/A	18,602.4	1.86
IS-AZ	L-1	Flow reduction	N/A	N/A	69,666.3	6.97
IS-BA	L-16	Flow reduction	N/A	N/A	59,479.3	5.95
IS-BH	L-17	CDF - embankment	N/A	N/A	1,944.6	0.19
IS-BI	L-18	CDF - embankment	N/A	N/A	28,735.4	2.87
IS-BG	L-5	CDF - embankment	N/A	N/A	25,077.4	2.51

Table 6-2: Summary of Predicted HADD (Paragraph 35) to Fish and Fish Habitat

Impact Segment ID	Name / Location Description	Mine Feature	Length (m)	Wetted Width (m)	Predicted HADD Area (m^2)	Predicted HADD Area (ha)
IS-Z	L-5-OUT	Haul road	296.5	0.8	222.4	0.02
IS-AU	Outflow from L-1	Flow reduction	81.3	0.5	40.7	0.004
IS-AV	Outflow from L-1	Flow reduction	N/A	N/A	1,482.2	0.15
IS-BB	Outflow from L-16	Flow reduction	35.5	0.5	17.7	0.002
IS-BD	Outflow from L-19	Flow reduction	619.2	0.5	309.6	0.03
IS-BE	Outflow from L-19	Flow reduction	168.4	1.2	202.1	0.02
IS-F	S-16	Flow reduction	208.0	0.5	104.0	0.01
IS-G	S-16	Flow reduction	N/A	N/A	2,384.9	0.24
IS-H	S-16	Flow reduction	204.2	0.5	102.1	0.01
IS-I	S-16	Flow reduction	188.3	1.0	188.3	0.02
IS-J	S-16	Flow reduction	N/A	N/A	4,282.4	0.43
IS-K	S-16	Flow reduction	118.7	0.5	59.3	0.01
IS-AR	S-16	CDF embankment / access road / ditch	289.4	0.5	144.7	0.01
IS-N	S-17	Flow Reduction	191.1	0.5	95.5	0.01
IS-BF	S-17	CDF embankment / access road / ditch	278.2	0.5	139.1	0.01
IS-AS	S-18	CDF embankment	362.1	0.5	181.0	0.02
IS-S	S-19	CDF embankment / access road / ditch	464.9	0.5	232.5	0.02
IS-O	S-21	CDF embankment / access road / ditch	112.7	0.5	56.4	0.01
IS-P	S-21	Flow reduction	315.9	0.5	158.0	0.02
IS-T	S-22	CDF embankment / access road / ditch	42.1	0.5	21.1	0.002
IS-X	S-22	Flow reduction	334.4	0.5	167.2	0.02
IS-V	S-23	CDF embankment / access road / ditch	92.8	0.5	46.4	0.005
IS-W	S-23	Flow reduction	257.5	0.5	128.8	0.01
IS-AK	Springpole Lake	Dewatering	N/A	N/A	15,270.8	1.53
IS-AL	Springpole Lake	Dewatering	N/A	N/A	4,792.5	0.48
IS-AM	Springpole Lake	Main open pit	N/A	N/A	711,238.7	71.12
IS-AO	Springpole Lake	Dewatering	N/A	N/A	826,287.9	82.63
IS-AX	Springpole Lake	Effluent discharge	N/A	N/A	50.0	0.005
IS-AP	UNX03	Water crossing	40	0.5	20	0.002
IS-AQ	Unnamed watercourse	Water crossing	20	0.5	10	0.001
Paragraph 35 Predicted HADD Total					**1,794,040**	**179.40**

Notes:
Anticipated impacts summarized in this table of the revised FHOCP should be considered preliminary and are subject to change with additional field data and on additional regulatory discussions / consultation.
N/A = not applicable.

Table 6-3: Summary of Combined Schedule 2 Waterbodies and Predicted HADD (Paragraph 35)

Impact Type	Predicted HADD Area (m^2)	Predicted HADD Area (ha)	Percent of Total Impact (%)
Schedule 2 total	337,980	33.8	16
Paragraph 35 total	1,794,040	179.40	84
Combined Schedule 2 and Paragraph 35 total	2,132,020	213.2	100

Note:
Anticipated impacts summarized in this table of the revised FHOCP should be considered preliminary and are subject to change with additional field data and on additional regulatory discussions / consultation.

7.0 MEASURES AND STANDARDS TO AVOID OR MITIGATE ADDITIONAL HADD TO FISH HABITAT DURING PLAN IMPLEMENTATION

7.1 Measures, Standards and Contingencies

During the construction and implementation of the FHOCP, it is important that effective measures are in place to avoid additional harm to fish and fish habitat. A combination of site-specific mitigation measures as defined in permits, approvals or EIS/EA commitments will be used to avoid or mitigate additional HADD to fish habitat during implementation of this FHOCP, along with measures described in Section 5.0, best management practices and DFO codes of practice and standards, where applicable and appropriate. Measures and standards would include but not be limited to:

- Construction water management;
- Erosion and sedimentation controls;
- Timing windows to protect sensitive life cycle periods; and
- Fish removals.

These measures are to be implemented for construction of the Project facilities and during the implementation of offset and compensation measures.

A list of typical measures, standards, codes and contingency measures that may be implemented during the Project to avoid or mitigate impacts to fish habitat, as applicable to each circumstance, are provided in Table 7-1. The measures, standards, codes and contingencies listed in Table 7-1 will be implemented and/or ready for use prior to the start of the works and maintained in a functional or prepared state until completion of the works specified in this FHOCP, as appropriate.

7.2 Monitoring and Reporting of Avoidance and Mitigation Measures

Project environmental staff (or designates) will monitor construction and implementation of the final FHOCP to confirm that the measures and standards described are implemented as proposed. Monitoring will be reported to DFO in as-constructed reports provided within 12 months of the works being completed. The as-constructed monitoring will require multiple reports to reflect some of the measures being constructed at the beginning of the Project, with others completed during operations and closure.

Documentation will be maintained to demonstrate effective implementation and function of the avoidance and mitigation measures, with summaries provided in the as-constructed report(s). These records are proposed to include the following:

- A photographic record using consistent vantage points and inspection reports will be kept to document measures and standards employed and their observed effectiveness.
- Regular environmental monitoring inspections of in-water activities will be conducted during construction so that mitigation measures, such as water management and erosion and sedimentation controls are in place, functional and maintained appropriately.
- A record will be kept of all fish removal efforts carried out, which will include the numbers of fish removed and relocation locations (consistent with permit conditions).

A detailed record will be made of any contingency measures that were implemented to prevent impacts greater than those predicted by the final EIS/EA and this FHOCP in the event that mitigation measures did not function as described, as well as the effectiveness of the contingency measure. A summary of any contingency measures will be provided in the as-constructed report.

7.3 Seasonal Construction Constraints

The waterbodies associated with the Project works, undertakings or activities reflect both coolwater and coldwater fish communities and species sensitivities. Consistent with measures to protect fish and fish habitat, the timing of in-water works should avoid restricted periods to protect fish, including their eggs, juveniles, spawning adults and/or the organisms upon which they feed (DFO 2017).

In-water works are to be avoided during the timing constraints of any given year per the *Inwater Work Timing Window Guidelines* (MNR 2013) and the *Ontario Restricted Activity Timing Windows for the Protection of Fish and Fish Habitat* (DFO 2017). Once the initial isolation of specific areas is complete, fish are removed and the risk of impacting downstream habitats is removed, this timing window would no longer apply. In the event that an exemption to the specified timing window is necessary, a request for alternate work periods will be made to the MNR and copied to DFO.

The timing constraints for each potentially affected waterbody based on the species present are summarized in Table 7-2. The table reflects the timing constraints by species or group of species as listed in the MNR (2013) guidelines.

Table 7-1: Measures and Standards, Success Criteria and Contingency Measures during Implementation

Measure or Standard	Success Criteria	Contingency
Sediment and erosion control measures associated with the work will be in place prior to substantial ground disturbance and throughout the duration of construction.	No visible sediment entering natural waterbodies as a result of ground disturbance.	Stop the work that is resulting in sediment release until effective controls are implemented. Maintain stock of erosion and sediment control supplies on site to repair, replace or supplement control measures as needed.
DFO codes of practice for applicable works, activities and undertakings including: • Code of practice: Beaver dam breaching and removal • Code of practice: Clear span bridges • Code of practice: Ice bridges and snow fills • Code of practice: Temporary fords • Code of practice: Culvert maintenance • Interim code of practice: End-of-pipe fish protection screens for small water intakes in freshwater • Interim standard: In-water site isolation	Follow codes of practice where detailed site-specific assessments / review of works, activities and undertakings have not been completed. Apply measures to protect fish and fish habitat.	Assess applicability of codes and use alternate site-specific mitigation measures or conduct detailed assessment / review of works, activities and undertakings.
Develop a blasting plan so that the use of explosives near water does not result in harm to fish per PoE guidance, unless previously identified as HADD in Authorization.	Established criteria in the blasting plan are followed and met.	Adjust blasting activity as needed to comply with the blasting plan. Any fish mortalities are to be collected, enumerated and reported to DFO.
Observe timing constraints for in-water work.	No in-water work during constraint period (Table 7-2), unless specifically exempted in permits.	Exemption from timing period may be requested from the MNR and copied to DFO.
Minimize duration of in-water work to the extent practicable.	Work carried out in continuous and efficient manner to completion.	Monitor contractor's effort and implement additional site planning as needed. Confirm materials are available to complete the construction continuously as needed.
Undertake in-water activities in isolation of open or flowing water to avoid introducing sediment into the watercourse.	Work areas are effectively isolated from open or flowing water. Follow DFO code of practice or other equivalent review and assessment. Turbidity curtains are installed and effective in isolating the work area.	Stop works that are not isolated from open or flowing water. Isolate work area, and remove fish from work area before continuing works. Maintain a sufficient supply of pumps and materials on site to isolate flows. Add multiple barriers (i.e., turbidity curtains), as needed.

Table 7-1: Measures and Standards, Success Criteria and Contingency Measures during Implementation

Measure or Standard	Success Criteria	Contingency
Stabilize shoreline or banks disturbed by any activity associated with the works.	Shorelines are mostly stable and not eroding.	Grade bank to stable slope if necessary. Use temporary or permanent bank stabilization material to stabilize banks.
Develop a detailed fish removal plan that accounts for selected end use of fish. Remove fish from areas where waterbodies are to be abandoned or isolated from the active waterbodies due to the works.	Minimize dead or stranded fish within the work areas.	If stranded or distressed fish are observed in the work area, stop work causing distress, assess the activity and continue fish removal as necessary.
Screen or use other deterrents at any pump intakes to prevent entrainment or impingement of fish per DFO code of practice or equivalent review / assessment.	No fish entrained or impinged at pump intakes.	If fish are entrained or impinged, implement corrective action by either repairing or supplementing the exclusion measure in place.
Confirm that machinery arrives on site in a clean condition and is maintained free of fluid leaks.	Machinery arrives on site in clean condition. Measures are in place to mitigate spread of invasive species.	Have an area or location on site to clean equipment to a suitable condition on arrival or as required.
Wash, refuel and service machinery and store fuel and other materials for the machinery in such a way as to prevent any deleterious substances from entering the water.	No deleterious substances entering waterbodies.	Follow site response plan that is to be implemented immediately in the event of a sediment release or spill of a deleterious substance and keep an emergency spill kit on site.

Table 7-2: Summary of In-Water Timing Constraints

		Seasonal Constraint (periods when in-water work is to be avoided)								
Work Area	**Waterbody Segments (see Figures 3-1 and 3-2)**	**None**	**Spring Spawning Species Constraints**				**Fall Spawning Species Constraints**			
		Not Fish Frequented[1]	**Walleye**	**Northern Pike**	**Lake Sturgeon**	**Other Spring Spawning Species**	**Lake Trout**	**Lake Whitefish**	**Lake Herring (Cisco)**	**Other Fall Spawning Species**
		None	**Apr 1 to Jun 20**	**Apr 1 to Jun 15**	**May 1 to Jun 30**	**Apr 1 to Jun 15**	**Sept 1 to May 31**	**Sep 15 to May 31**	**Oct 1 to May 31**	**Sep 1 to Jun 15**
CDF	S-16, S-17, S-18					●				
	S-19, S-21, S-22, S23	●								
	L-3					●				
	L-4	●								
	L-5					●				
	L-6	●								
	L-05-OUT	●								
	L-16			●		●				
	Inflow to L-16 (IS-B, IS-C)			●		●				
	Inflow to L-16 (IS-A)	●								
	L-17, L-18					●				
Plant site area	between L-1 and L-2			●		●				
	Inflow to L-2 (IS-AI)	●								
	Inflow to L-2 (IS-AD, IS-AA, IS-AB, IS-AC)	●								
	Outflow from L-2 (IS-AJ, IS-AK)			●		●				
	L-1			●		●				
	L-2			●		●				
	L-19 and outflow					●				
Fish habitat development area	Unnamed (IS-AN)	●								
Springpole Lake	Springpole Lake		●	●	●[2]	●	●	●	●	●
Birch Lake	Birch Lake		●	●	●[2]	●	●	●	●	●

Table 7-2: Summary of In-Water Timing Constraints

Work Area	Waterbody Segments (see Figures 3-1 and 3-2)	Seasonal Constraint (periods when in-water work is to be avoided)								
		None	Spring Spawning Species Constraints				Fall Spawning Species Constraints			
		Not Fish Frequented[(1)]	Walleye	Northern Pike	Lake Sturgeon	Other Spring Spawning Species	Lake Trout	Lake Whitefish	Lake Herring (Cisco)	Other Fall Spawning Species
		None	Apr 1 to Jun 20	Apr 1 to Jun 15	May 1 to Jun 30	Apr 1 to Jun 15	Sept 1 to May 31	Sep 15 to May 31	Oct 1 to May 31	Sep 1 to Jun 15
Mine site access road	UNX03 Unnamed (IS-AP)	●								
	Unnamed (IS-AQ, IS-AR, IS-AS)	●								

Notes:
(1) Many of the work area waterbodies included in HADD calculations (Section 6.0) using a conservative HADD delineation approach are considered to be not fish frequented.
(2) Lake Sturgeon have not been captured in recent years but are presumed to be present in very low abundance based on Indigenous Knowledge.
● = fish species confirmed in waterbody.

8.0 MEASURES TO OFFSET AND COMPENSATE FOR RESIDUAL HADD AND SCHEDULE 2 WATERBODIES

8.1 Description of Offsetting and Compensation Measures

This section of the FHOCP describes the currently proposed offset and compensation measures to be implemented as part of the Project to counterbalance the residual HADD (Section 6). The first draft of the FHOCP was submitted for review and consultation during the draft EIS/EA submission, and several of the proposed measures were modified, expanded upon, substituted or removed. A summary to reflect the comments received from Indigenous communities, the public and government agencies is provided in Section 1.4.

Initial engagement with the Springpole Environment Committee representing the Shared Territory Protocol Nations of CLFN, SFN and LSFN has included a request to utilize goals, objectives and information from the *Cat Lake – Slate Falls Community Based Land Use Plan* (Cat Lake First Nation et al. 2011), and associated documents such as the Cat Lake–Slate Falls *Guidelines for Mineral Sector Projects: Best Management Practices* (Cat Lake First Nation and Slate Falls Nation 2011). Specific reference to and acknowledgement of a passage in the guidelines document is as follows:

"Be aware of the three R's of exploration and practice them at every stage of your exploration program.

- *Respect the environment in which you work.*
- *Refrain from unnecessarily disturbing the natural environment.*
- *Restore the natural setting of areas where you have worked."*

Despite the avoidance and mitigation measures proposed as part of the Project (Section 5.0, Attachment C of this FHOCP), there will be a loss of fish habitat. The Project team has prepared an offsetting and compensation strategy that attempts to balance the anticipated needs and expectations of the regulatory fisheries approvals process, as well as respecting the guidance provided in the community land use planning.

The proposed fish habitat offset and compensation strategy for the estimated 213.2 ha of impacted waterbodies (Section 6.0) is focused on re-using, restoring and enhancing habitats in and around the Project site. Most notably these include the following components:

- Co-location of infrastructure to reduce the overall footprint, such as using the fish habitat development area as a quarry for construction rock;
- Repurposing the dike locations as spawning areas during construction (south side) and at closure (top and north side);
- Researching the presence and distribution of Lake Sturgeon in previously inhabited waters within or near the Cat Lake – Slate Falls Community Based Land Use Plan area with the intent of developing a recovery plan;
- Re-using, restoring and reclaiming the disrupted and altered waterbodies including the dewatered portion of the north basin of Springpole Lake, L-1 and L-16; and
- Reclaiming the abandoned South Bay Mine through cooperation with the Province.

As several of the measures occur during operations or at closure, this strategy will result a time lag between the impact to fish and fish habitat and some of the benefits from the offsets being realized. Comments received from DFO have resulted in the use of additional metrics to quantify both the impact and the success of the works on an annual basis that accounts for the time lag between impacts and offset measure success.

These metrics include the number and biomass of fish per hectare per year for Springpole Lake and Birch Lake.

The Project has distinct and meaningful extenuating factors that justify the time lag and use of restored mine areas as described in this plan including:

- There is direction in the ongoing Indigenous community engagement and planning efforts to avoid additional unnecessary land disturbance, and to restore and re-use the lands previously developed.
- The Project area is remote and surrounded by extensive waterbodies and fisheries, and additional new local waterbodies have not been identified as a need for fisheries management.
- There are no known or identified existing areas in the Project area with significant fish habitat degradation that would make suitable habitat restoration projects (with the exception of the decline of Lake Sturgeon and abandoned South Bay Mine).
- There are sensitive terrestrial Species at Risk, Wolverine and Caribou (Boreal population), that make development of new waterbodies at the cost of terrestrial landscape unattractive, with the exception of the fish habitat development area, which is contiguous with the affected area of the proposed open pit and has the benefit of multiple uses (this will also support the mine development as a location to extract aggregate).

Some of the measures proposed can be implemented concurrently with the start of the Project. This includes building out replacement Lake Trout and Lake Whitefish spawning shoals along the south face of the dikes, enhancing existing shorelines with coarse wood habitat structures and efforts to research Lake Sturgeon. Reclamation of the abandoned South Bay Mine would commence during early operations as well. Additional measures may be developed and implemented as revisions to this FHOCP based on consultation and engagement.

Diverse options for fish habitat offsetting and compensation measures have been developed. Not all of the measures are expected to be required to counterbalance the impacts from the Project, but they are presented here to provide assurance that suitable and feasible measures are available as needed. The currently proposed base case offset and compensation measures to be implemented for the Project will include several of the following, to be finalized through discussions with communities and regulators:

- Overbuild and integrate spawning shoals along the active lake-facing embankments of the dikes to replace Lake Trout and Lake Whitefish spawning opportunities lost within the dewatered basin.
- Coordinate with the provincial government (MINES) to implement the reclamation of the abandoned South Bay Mine.
- Implement the investigation and study of Lake Sturgeon in the Birch River and Cat River system and consider measures to reinstate or augment the population.
- Place coarse wood structure along Springpole Lake shorelines currently lacking structural diversity.
- Construct a new and significant embayment (46 ha fish habitat development area) to the east of the dewatered area to be functional at closure.
- Enhance the open pit basin (dewatered) area for selected key species (determined during engagement and consultation) by modifying cover, structure and substrates to improve habitat suitability where appropriate.
- Contour the north end of the main open pit and the Phase 1 pit and optimize fish habitat structures, substrates and depth for selected key species as determined during engagement and consultation.

- Restore flow to unnamed lake L-1 on completion of mining and filling of the dewatered basin.

The estimated habitat quantities for each of the above measures are provided in Table 8-1.

8.2 Reclaimed Open Pit Basin

During the construction and operation phases, an area of the north basin of Springpole Lake of approximately 156 ha will be temporarily isolated and dewatered to facilitate safe development of the open pit. The area of existing lake overprinted by the open pit is approximately 71 ha. This area of the existing lake bed will be excavated through open pit mining to a new water depth of approximately 303 m and as such will be permanently altered. Adjacent to the open pit footprint, an additional 85 ha of existing lake basin will be isolated by the dike structures (west and east structures) and dewatered for the life of mine. At the end of mining, the final surface area of the former open pit deep water zone is expected to be ~105 ha, consisting of the 71 ha of existing Springpole Lake area and an additional 34 ha of former terrestrial area. This area of pit development will have steep side slopes in the order of 39° to 54° (1 to 1.4 vertical to 1 horizontal) to a depth of approximately 303 m water depth. At this depth, the column of water in the former pit is expected to be meromictic (i.e., not expected to fully turn over). The surface waters will mix part way through the column (zone referred to as mixolimnion) to a depth comparable to the adjacent natural deep lake basins (30 to 35 m), providing pelagic habitat for species such as Lake Trout, Lake Whitefish and Walleye similar to conditions currently provided by deep water basins but without a coupled benthic zone. The mixolimnion is expected to stratify into an epilimnion, metalimnion and hypolimnion similar to existing conditions with oxygenated water (i.e., greater than 5 milligrams per litre [mg/L] dissolved oxygen) extending to depth of up to 40 m.

There is high confidence in the pelagic former pit area to be used along with the adjacent littoral and profundal zones surrounding it based on similar examples of pit lakes provided in Table 8-2.

An additional portion of the former open pit area (north end) will be recontoured with rock (Figure 8-1) to develop an enhanced littoral and profundal area (up to 25 m deep) with a coupled benthic zone. The Phase 1 pit will be similarly recontoured (to a maximum water depth of 25 m). The recontouring occurs during the latter part of mining, and the pit can be contoured to ideal depths for species of interest. Based on comments received during the draft EIS/EA and on targeted fisheries workshops, the species of interest include those currently using the north basin, and as such the proposed depth will emulate the deep basins habitat.

The north end of the pit will be recontoured over an area of approximately 2.14 ha, with a backslope of approximately 37° (1 vertical to 1.3 horizontal) into the remaining open pit pelagic habitat. Recontouring of the Phase 1 pit is estimated to provide an additional 9 ha of enhanced littoral habitat after filling with water.

The deep water pelagic habitat of the former open pit will be surrounded by the 85 ha of relatively unchanged dewatered basin. This area can be progressively enhanced with fish habitat structure and substrate during operations to increase productivity of the area post-closure as shown in Attachment E of this FHOCP. The dewatered open pit basin will be analyzed in detail and enhanced during mining such that substrates, cover and basin morphology can be maximized for habitat suitability for the species of interest (i.e., Lake Trout, Lake Whitefish, Walleye and other species).

A fish habitat development area has been proposed to the east of the existing Springpole Lake, adjacent to the proposed dewatered open pit (Figure 8-1). This new fish habitat basin is proposed to be approximately 46 ha in area. The objective of the fish habitat area is to provide replacement littoral and profundal habitats to counterbalance much of the alteration that will result from the deepening of the open pit area. Efforts have been made to minimize the overall Project site footprint, and accordingly mine construction material will be extracted from portions of the proposed fish habitat area during early site development to avoid disturbing additional terrestrial areas. This co-use of the proposed fish habitat development area is in keeping with the re-use and restore direction of land use planning for the area.

In the areas where the open pit is recontoured (north end and Phase 1 pit) and in the excavated fish habitat development area, substrates, habitat structure and plantings will be used to promote naturalized and highly functional fish habitat. Preliminary drawings are provided in Attachment E of this FHOCP and will be refined through discussions with communities and regulators prior to construction.

In total, a combined area of approximately 247.5 ha will be developed during the open pit basin reclamation efforts, quantified as follows:

- 85 ha restored and enhanced dewatered basin including dike areas;
- 11.5 ha recontoured open pit areas (2.5 ha north end of pit and 9 ha in Phase 1 pit);
- 46 ha of fish habitat development area; and
- 105 ha of deep open pit pelagic area.

It is estimated that the filling of the combined open pit / fish habitat area dewatered basin with water will require approximately three to five years (as described in Section 8.2.1) using active filling from Springpole Lake. Assuming isolation of the basin occurs in the first year of construction (Year -2) and filling begins in Year 10, the basin can be filled and ready for reconnection to Springpole Lake in approximately Year 17 of the Project.

8.2.1 Restored Basin Filling

The Birch River is a large system with a drainage area of approximately 1,274 km^2 at the inflow to Springpole Lake (WSP 2024h). At completion of open pit mining in approximately Year 10, an engineered water taking system within one or both dikes is proposed to enable controlled taking of water from Springpole Lake to support refilling of the basin with water. The proposed active filling rate would be adjustable to reflect between 10% to 15% of the inflows to Springpole Lake. Based on guidance provided in *Framework for Assessing the Ecological Flow Requirements to Support Fisheries in Canada* (DFO 2013) and, *A Desk-top Method for Establishing Environmental Flows in Alberta Rivers and Streams* (Locke and Paul 2011), a 10% to 15% reduction in instantaneous flows is unlikely to have detectable ecological effects on downstream habitat.

At this proposed active filling rate, the reclaimed open pit basin was calculated to require 2.9 to 4.3 years to fill using the current average elevation of Springpole Lake (elevation 391 m amsl), and assuming average flow conditions during those years. Comments on the draft EIS/EA requested that a monthly analysis of flow be completed to instead of the annual average. An analysis of the maximum water taking by month is provided in Table 8-3 including an average flow condition, as well as dry and wet years.

Table 8-4 provides a range of months to fill the open pit basin under average conditions, as well as dry and wet flow years. For a base case scenario, the time to fill of 56 months (4.7 years) assumes average flow conditions and an active filling rate of 10% of the lake inflow volume. Using dry and wet years, the duration to fill the basing could range from 3.3 to 6.3 years.

8.3 Lake Sturgeon Program

Engagement with CLFN, SFN and LSFN, as well as with MON, has shared an understanding of historical Lake Sturgeon presence in area waters and the cultural value placed on the species. The discussions have contributed ideas to the proposed measure of reintroducing and restoring Lake Sturgeon into waterbodies locally that were previously inhabited.

Baseline investigations and collected data for Birch Lake and Springpole Lake have all suggested the absence or very low abundance of Lake Sturgeon from the immediate study area. Records from the MNR Red Lake District include a scattered record of anecdotal captures in the area with the most recent record from 1997. Traditional Knowledge including the Cat Lake / Slate Falls / MNRF (n.d.) *2015/2016 Species at Risk Stewardship Fund Project*; documented historical and current populations of Lake Sturgeon in Birch Lake, Springpole Lake, Seagrave Lake, Cat Lake and Lake St. Joseph and the connecting rivers (Birch River and Cat River). Work to date as part of the Species at Risk Stewardship Fund Project has determined that the abundance of Lake Sturgeon is greatly reduced, but that the species may persist in many of the waterways and that additional research is needed to better establish distribution and relative abundance.

The Traditional Knowledge and absence of catch in the Springpole Lake and Birch Lake capture results, combined with current MNR records, suggest that Lake Sturgeon populations in the area are locally extirpated or are at extremely low abundance. In both cases, there is a strong case for intervention and efforts to restore Lake Sturgeon to the historical waterways in the Project area with a goal of re-establishing their abundance.

The draft EIS/EA proposed the supplemental stocking of Lake Sturgeon into the lakes and rivers surrounding the Project. Although there was some interest in this measure, there were a number of comments that questions whether sufficient data existed to accurately document the current presence and distribution of Lake Sturgeon. Through engagement and workshops, this measure has been modified to include a two-stage measure, described below.

Stage 1 – Research Program

Stage 1 would consist of a research program designed to increase the knowledge of Lake Sturgeon presence and distribution in the Birch River and Cat River system. FMG proposes a cooperative effort of the Project team along with a research team from the University of Manitoba and the University of Winnipeg. The research program would be lead by Dr. Gary Anderson who would be responsible for managing the research and disseminating the results.

The research program would include:

- Continued collection of Indigenous Knowledge;
- Better definition of current habitat conditions and species distribution;
- Use of paleolimnology to examine history conditions and timing of decline; and
- Informing the need and probability of successful recovery / reintroduction if supported by the collected data.

A detailed proposal for the Lake Sturgeon research is provided in Attachment D of this FHOCP.

This Stage 1 research program would be considered a complementary measure (research based) and receive a smaller amount of credit towards the overall offset plan. For the purpose of this revised FHOCP, it is assumed a habitat equivalency of 25 ha reflecting approximately 10% of the compensation plan area; however, further discussion with DFO may increase the credited amount of offsetting for this measure.

Stage 2 – Population Support

Dependant of the findings of the research program, recommendation would be made to support and augment the population of Lake Sturgeon. The intent of Stage 2 would be the implementation of measures that would either support and increase a remnant population or reintroduce a population through stocking.

If Stage 2 of the Lake Sturgeon is implemented, the program would include waterbodies totalling a minimum of 10,000 ha in surface area. For context, the combined areas of Birch Lake, Springpole Lake and Seagrave Lake would exceed this value. An associated fish habitat offset and compensation credit of 2% of the total surface area (200 ha) is proposed for this effort. This relatively small 2% value is proposed to reflect the importance of the species both ecologically and culturally to the natural system, but also recognizing that the waterbodies are existing, functional fisheries and that no new habitat area would be developed. The typical species richness is 24 to 26 species for these local waterbodies, excluding Lake Sturgeon. Increasing the species richness by one species would result in a 4% increase in species richness and as such the 2% area credit has been proposed.

8.4 Coarse Wood Structure Shoreline Enhancement

The shoreline of Springpole Lake has a notable absence of log / wood structure in many nearshore areas. Although a natural condition, these areas provide little to no cover for small fish such as cyprinids (minnows), sticklebacks, and juvenile fish. Studies have shown that enhancement of shoreline sections with coarse wood structure would increase habitat use by forage fish (e.g., Spottail Shiner) and life stages for other species such as Northern Pike and White Sucker (Theis et al. 2023) and provide refuge from predation (Everett and Ruiz 1993). The presence or absence of coarse wood structure was demonstrated to be a significant factor to reduced yellow perch abundance when removed from a control lake (Helmus and Sass 2008)

Seven fish habitat transects were surveyed in Springpole Lake during spring 2023 to characterize fish habitat offset and compensation opportunities within Springpole Lake. Surveys at these locations (Appendix O-4 Figures A1-1a to A1-1e of the Final EIS/EA) noted a lack of coarse wood structure in nearshore littoral zones. Most structures were on-shore, with little to no coverage in the near-shore littoral zone. A total of 36 log structures were noted in 3,800 m of shoreline surveyed, averaging approximately one log structure every 100 m of shoreline. It was noted that water levels were extremely low during the survey, with most structures observed on-shore and with little to no coverage in the near-shore littoral zone. Based on the observed conditions, there is an opportunity to increase habitat use by supplementing coarse wood structure within the littoral zone along shorelines lacking in habitat heterogeneity.

For the purpose of this FHOCP, the enhancement of 3 km of shoreline in Springpole Lake is proposed through the placement of wood clusters in staggered arrangements across a band of 30 m to target multiple water depths and water level conditions. Structures will consist of three to five logs per cluster with anchors spaced between 15 and 30 m apart, similar to the spaced and clustered structure placements used by Theis et al. (2023). The area of enhancement is calculated as 3,000 m of littoral shoreline by the 30 m wide band resulting in 9 ha of enhancement. The measure is scalable, such that additional structures could be added over time based on the observed success of the measure.

8.5 South Bay Mine

The South Bay Mine was an underground copper and zinc mine, which operated between 1971 and 1981 on the northeastern shore of Confederation Lake's South Bay (MOECC 2015). The mine is located approximately 45 km southwest of the Springpole Project (Figure 8-4). The mine created 760,000 tonnes of mine tailings, which are now located in a tailings management area that is approximately 25 ha in size. The former mill site area, which is next to the tailings management area, is approximately 10 ha in size (MOECC 2015). Some restoration works were completed in the 1980s, before the site was returned to the Crown in approximately 1990 (CH2M 2018). Despite restoration efforts, water, sediment and biological sampling has shown effects of acid rock drainage in the adjacent lakes including elevated zinc, copper, cadmium, cobalt, and manganese (MOECC 2015). Zinc levels in fish were elevated in waterbodies proximal to the mine, and zinc and manganese were considered bioavailable and benthic communities showed impairment closer to the mine (MOECC 2015).

Other than the main Confederation Lake, three smaller lakes receive drainage from the mine: Mud Lake (10 ha), Amanda Lake (52 ha) and Boomerang Lake (25 ha). All three lakes show severe impairment in water quality, and specifically in pH, which was measured between 2 and 3.5 (MOECC 2015). Water quality measured at the outflow of Boomerang Lake by WSP in 2023 also measured less than 3 for pH. Federal long-term water quality guidelines for pH in fresh water indicate an acceptable range of 6.5 to 9.0 (CCME 2024). The observed values in all three lakes are below levels where normal life processes are disturbed and mortality of eggs and larval fish occurs (DFO 2024c). Boomerang Lake, which historically supported Lake Whitefish (MNR 2024) that may support other coldwater species (e.g., Lake Trout), was confirmed to be fishless (MECP 2015), and fish are not expected to be able to persist or reproduce in Mud or Amanda lakes.

FMG is coordinating with the Ontario Ministry of Mines (MINES) to rehabilitate the South Bay Mine and restore the three lakes to the ability to support fish again. A Letter / Agreement in Principle / Memorandum of Understanding between FMG and MINES is Provided in Appendix F. Under the agreement, FMG will aid the province and contribute funds to the restoration works, and conduct monitoring to document the pre- and post-construction conditions. The current preferred restoration option for the mine is to cap the tailings area in place, install a perimeter slurry wall and place a permeable reactive barrier at the southwest corner of the tailings area. As detailed design occurs, this base plan may be refined during the early phase of the operations for Springpole.

The proposed mine rehabilitation is expected to remediate the drainage to Boomerang Lake, Mud Lake and Amanda Lake, resulting in the restoration of fish communities in the combined 87 ha of currently impacted fish habitat.

8.6 Restored Lake L-2

L-2 is a small deep headwater lake with a surface area of 11.5 ha and a maximum depth of 27 m. It is located central to the proposed mine site, and will receive drainage from multiple sources, such as the haul roads and the plant site, and is within the dewatering influence of the open pit. This lake is proposed for use as the CWSP during construction and operations and into closure.

At closure, the CWSP will be decommissioned and reclaimed. The reclaimed lake will drain passively to Springpole Lake. Restoration of L-2 will follow these steps:

- The lake will be sampled post-operation to demonstrate suitable water quality and sediment quality following the approximately 13 to 15 years of use as a water management facility. Water and sediment samples will be compared to the provincial and federal environmental quality guidelines (for protection of aquatic life) and baseline values. This is primarily to confirm that contaminants have not accumulated in the pond.
- If water and sediment quality does not meet provincial and federal guidelines or is not similar to baseline values, the sediment will be removed and placed in an appropriate storage location, or more likely will be capped in placed with overburden / sediments stockpiled from the initial site development. Previous sampling identified low oxygen concentration less than 2 mg/L below 20 m in June 2012, which indicates that the lower portion of the lake could be capped if necessary while retaining the upper oxygenated thermocline and hypolimnion capable of support all species present in the baseline condition.
- Once water quality and sediment quality are confirmed to be acceptable, remaining infrastructure (i.e., pipes, pumps, pads and access) will be removed from below the highwater mark and banks restored and stabilized.

- A connection to Springpole Lake will be re-established and enhanced from lake L-2 consistent with original pre-mining conditions.
- Due to the proximity of Springpole Lake, colonization of L-2 by fish is expected to occur quickly (two to three years); however, an option of transferring fish from the adjacent waterbodies during post-Project monitoring will be retained.

Following closure and reclamation, L-2 is expected to be capable of supporting fish and have an ecology consistent with baseline conditions. However, given its listing on Schedule 2 of the MDMER and the potential to use the CWSP for contingency water treatment, this is not considered as an offset measure in this FHOCP, nor is its area included in the habitat accounting (Section 9).

8.7 Restored Lake L-1

L-1 drains to either Birch Lake to the north or L-2 to the south, depending on beaver activity between the two lakes. During mine development and operation, the flow will be blocked at L-2 and diverted towards Birch Lake. Groundwater modelling has shown that L-1 is within the dewatering influence of the open pit and will be impacted by mine dewatering, such that the lake may be largely dewatered during operations. Other than the dewatering effect, there are no predicted physical impacts to the lake, and no pathways anticipated to result in contaminant loading to the lake or its sediments.

In approximately Year 10, the pit dewatering will cease, and active filling of the dewatered open pit basin will be initiated. When the dewatered basin is filled, L-1 is expected to be returned to pre-mining water levels.

It is likely that remnant fish populations will remain in the lake, but if necessary, colonization of L-1 by fish is expected to occur quickly (two to three years) due to the proximity of Birch Lake. An option of transferring fish from the adjacent waterbodies during post-closure monitoring will also be retained.

Following closure, L-1 is expected to be fully restored and provide 9.0 ha of fish habitat consistent with baseline conditions.

8.8 Overbuild Dikes and Develop New Spawning and Rearing Shoals in Springpole Lake

During the first year of the construction phase, two dikes (west dike and east dike) will be constructed to isolate a small portion of the north basin of Springpole Lake so that mining can occur. The dikes will overprint and/or isolate several existing spawning shoals for Lake Trout and Lake Whitefish in Springpole Lake (Section 4.0, Table 4-4, Figure 4-1). The intent of the dike overbuild measure is to provide replacement spawning and rearing habitats for Lake Trout and Lake Whitefish during the Project and into closure.

It is expected that fish that previously used the overprinted or isolated shoals will readily locate and use alternate spawning locations if available. This behaviour was observed in a study conducted in Sudbury, Ontario where Lake Trout spawning shoals were made unavailable and fish actively located and used alternate spawning sites, and no significant change in population was noted after three study years (McAughey 1998). Fitzsimons (1996) corroborates that man-made structures can be effective spawning areas for lake trout where a review of spawning at man-made and natural spawning areas indicated consistently higher abundance of eggs, fry and young-of-the-year lake trout associated with man-made structures. A study involving 29 constructed reefs in Lake Huron also demonstrated the reef construction has increased the capacity for fry production without apparently decreasing the use of the natural reef (Marsden et al. 2016). Other artificial reefs constructed in Lake Huron showed similar improvements in the use by adult fish, and the presence of both Lake Trout and Lake Whitefish fry demonstrated successful reproduction (Foster and Kennedy 2014).

The replacement shoals will be initially built to extend into the active lake side (south) of the dikes as shown in Figure 8-1 and Figure 8-2 and in Appendix E of this FHOCP. Add closure additional shoal habitat will be developed from the decommissioned dike material. The shoals are designed to mimic the existing substrate composition and depth of the existing shoals.

Spawning surveys completed in 2012, 2013 and 2014 identified 50 groups of Lake Trout with spawning behaviour observed on 34 occasions (FMG and Portt 2018). All confirmed spawning sites had boulder or coarse rock rubble substrate and were proximal to deep water basins and less than 5 m deep. Spawning surveys for Lake Whitefish in 2012 reflected similar spawning locations as Lake Trout providing confidence that the constructed shoals will benefit both species. Similar observation that Lake Trout and Lake Whitefish use similar spawning locations was noted by Whitaker and Wood (2021) in northern Maine.

Underwater video (Photo 8-1) was used to document the existing Springpole Lake shoal conditions which reflect the following design criteria:

- Spawning shoals are adjacent to steep drops in water depth and are generally greater than 2 m in depth.
- Substrates are clean deposits of gravel, cobble and boulders ranging from 5 to 50 cm with minimal fines.
- Deep interstitial spaces are present promoting egg deposition and water movement.

Preliminary plan views and cross section designs are provided in Appendix E of FHOCP. The dikes and built-out shoals will be constructed of non-acid generating rock blasted or crushed to the appropriate gradation, and shoal material will be washed or screened to remove fines. A combined approximately 10 ha of new spawning shoals will be developed early in the Project over the upstream length of the two dikes. Additional shoal features will be developed along the downstream (dewatered) side of the dikes at closure as part of the open pit basin enhancements and dike removal as discussed in Section 8.2.

8.9 Monitoring the Implementation and Effectiveness of the Offset and Compensation Measures

Implementation and effectiveness of the offset and compensation measures will be determined by confirming that measures have been constructed per the approved plans and are functioning as intended using the criteria outlined in Table 8-5. A combination of onsite monitors and qualified designates as required will be used to document compliance with the approved plans.

The monitoring results will be documented in an as-constructed report or reports and in performance monitoring reports submitted to DFO according to an approved schedule. The as-constructed report(s) will be prepared for any of the physical habitat construction and in-water works (e.g., fish development area and overbuilt dikes spawning shoals) and will be due within 12 months of completing the compensation measures. Due to the timing of construction for different measures, separate as-constructed reports may be required for the construction phase and then again at closure.

Performance monitoring reports will be due following each year of monitoring. It is proposed that monitoring be based on the individual offsetting and compensation measures as described in Table 8-5.

If the results of the monitoring indicate that the measures are not completed on time and/or are not functioning according to the FHOCP, written notice will be given to DFO and contingency measures per Table 8-6 will be implemented and additional monitoring completed.

8.10 Cost Estimate and Letter of Credit or Equivalent Financial Guarantee

Per Schedule 1 of Authorizations Concerning Fish and Fish Habitat Protection Regulations (SOR/2019-286) Paragraph 2(1)(b) and MDMER Paragraph 27.1(4), the proponent is required to provide irrevocable letters of credit or an equivalent financial guarantee issued by a recognized Canadian financial institution to cover the costs of implementing the offsetting and compensation plan.

DFO may draw upon funds of the letters of credit or other financial guarantee provided to cover the cost of implementing the offsetting and compensation measures, including the associated monitoring and reporting measures included in this plan, as needed.

This FHOCP is intended to undergo review and consultation, which may result in modifications and changes to the proposed offset measures and areas. As such, the values of the financial guarantee will be determined with DFO and submitted under separate cover or in the revised FHOCP with the final application documents, and prior to Schedule 2 listing, respectively.

Table 8-1: Summary of Fish Habitat Offset and Compensation Measures

Proposed Offset / Compensation Measure	Type of Offset Measure (1)	Approximate Offset Measure Area or Area Equivalent (ha)	Project Phase of Implementation(3) and/or Duration
Overbuilding of dikes and development of new spawning and rearing shoals in Springpole Lake	Habitat restoration and enhancement	10	Construction
South Bay Mine – reclamation of impacted lakes	Habitat restoration and enhancement	87	Operations
Lake Sturgeon Program – Stage 1, Lake Research Program	Complementary measure	25 (2a)	Construction through closure
Lake Sturgeon Program – Stage 2, Population Support – reintroduction of Lake Sturgeon in selected previously inhabited waters	Biological manipulations	200 (2b)	Construction through closure
Fish habitat development area – new fish habitat area excavated east of the dewatered basin	Habitat creation	46	Closure
Reclaimed and enhanced dewatered area	Habitat restoration and enhancement	82.6	Closure
Restoration of flows to unnamed lake L-1	Habitat restoration and enhancement	9	Closure
Phase 1 pit backfill and recontour	Habitat creation	9	Closure
Backfilling and contouring of north end of open pit	Habitat creation	2.14	Closure
Reclaimed main open pit area (pelagic habitat)	Habitat restoration and enhancement	105	Closure
Total potential area of new, reclaimed or enhanced fish habitat		**Up to 575.7**	Varies

Notes:
(1) Grouped per Fish and Fish Habitat Protection Policy Statement (DFO 2019a).
(2a) Lake Sturgeon research program to better define the current status of Lake Sturgeon in the Project area and possible sources of population decline. Considered a complementary measure and area equivalent calculated as 10% of the offset area required.
(2b) Reintroduction and restoration efforts for Lake Sturgeon in select previously inhabited lakes. Credit calculated as 2% of a targeted 10,000 ha lake area including lakes such as Cat Lake, Springpole Lake, Birch Lake and Seagrave Lake.
(3) The temporal boundaries for the Project phases are defined as follows:

- Construction Phase: Years -3 to -1, representing the construction period for the Project.
- Operations Phase: Years 1 to 10, with the first year potentially representing a partial year as the Project transitions from construction into operations.
- Closure Phase:
  - Active Closure: Preliminary timing of Years 11 to 15, when final decommissioning and the majority of active reclamation activities are carried out; and
  - Post-closure: Years 16+, corresponding to primarily the monitoring period for the Project but also when the filled open pit basin will be reconnected to Springpole Lake.

Table 8-2 Examples of Pit Lakes and Trout Colonization

Example	Description
Development of Aquatic Communities in High-Altitude Mine Pit Lake Systems of West-Central Alberta (Sonnenberg) Constructing Habitat for a Sustainable Native Fisheries in the Sphinx Lake End Pit Lake System (Brinker et al.)	Reclamation on the Cardinal River and Gregg River coal mines includes the construction of mine pit lakes connected to stream environments. Sphinx Lake and Pit Lake exhibit meromictic (partial mixing) tendencies, but still function in a similar fashion to shallower, natural sub-alpine lakes. Athabasca Rainbow Trout populations are self-propagating (spawning at the outlets) with higher densities downstream than there were prior to lake reclamation. The five-year post-reclamation fish habitat and population assessment indicates a surging Rainbow Trout population, high growth rates and enhanced habitat conditions as compared with the pre-mine coldwater, lotic system. The development of sub-alpine mine-pit lakes connected to the stream environment appears to be an appropriate and beneficial reclamation technique in this area. Lac Des Roches, Alberta, Can. Former truck and shovel coal mine open pit. 70 m deep and only 5% littoral habitat has successful natural reproduction for Rainbow Trout, Bull Trout and Brook Trout
Creating Lakes from Open Pit Mines: Processes and Considerations – with Emphasis on Northern Environments (Gammons et. al.)	The Portsmouth Mine Pit Lake in Minnesota is a good example of a very large man-made lake formed after flooding of an iron ore (hematite) mine. This is one of the deepest lakes in Minnesota at 137 m, and is one of the largest of >200 pit lakes in the region left behind from historical iron mining. A recent fisheries survey indicated a trout density of 56 individuals per hectare, which is similar to natural lakes in Minnesota. This relatively high fish density is informative, considering that the lake is also reported to be essentially devoid of littoral habitat. Two other large mining pit lakes in the same region with 13% to 14% littoral habitat had slightly lower fish densities than Portsmouth Lake.
Canisteo Mine Pit, Minnesota	Canisteo Mine Pit is a complex of mine pits abandoned in 1985. Since then, groundwater has been filling the pit. The complex has an area of 1,425 acres, a maximum depth over 300 feet (91.4 m), a mean depth near 100 feet (30.5 m), and limited littoral area as of 2010. Canisteo has been managed for lake trout since the initial survey in 1995. Adult Tullibee (Whitefish) were introduced twice (2006 and 2008) in an attempt to provide a second, naturally sustaining prey species. Both species are documented as naturally reproducing.
Campbell Pit – Detour Lake Mine in Ontario Detour Lake Project. Aquatic Resources 2009 Baseline Study Investigations. May 2010.	A former open pit and underground gold mine in northeastern Ontario was mined from 1983 to 1999 to a pit depth of 120 m. Following a state of inactivity, the pit was colonized by naturally reproducing fish community consisting of Northern Pike. Burbot, Yellow Perch, White Sucker and Mottled Sculpin. Littoral area (<10 m water depth) was less than 10% of the pit area.

Sources:
Sonnenberg 2003; Brinker et al. 2011; Gammons et al. 2009; Canisteo Mine Pit: https://www.lake-link.com/minnesota-lakes/itasca-county/canisteo-lake-pit-pit/7862 (Minnesota Department of Natural Resources); AMEC. 2009..
Note:
> = greater than; < = less than.

Table 8-3: Open Pit Filling Rate and Duration

Maximum Springpole Lake Water Taking Rate (10% of available flow) (m^3/s)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average year	0.67	0.57	0.50	0.72	2.08	2.13	1.57	1.14	1.09	1.12	1.08	0.85
Dry flow sequence (1975–1981)	0.51	0.46	0.42	0.68	1.71	1.54	1.12	0.74	0.71	0.63	0.65	0.53
Wet flow sequence (2007–2010)	0.79	0.64	0.55	0.69	2.07	2.84	2.72	2.20	1.47	1.73	1.70	1.20

Notes:
Dry and wet flow sequence values are based on a seven-year and four-year rolling average, respectively. The dry and wet flow sequences are based on the 1st and 99th percentile flows over the respective duration.
Values presented in the table are the average monthly flows over the respective flow sequence duration.

Table 8-4: Open Pit Filling Duration

Scenario	Total Duration (months)	Total Duration (years)
Average year	56	4.7
Dry flow sequence (1975–1981)	76	6.3
Wet flow sequence (2007–2010)	39	3.3

Table 8-5: Criteria and Timing to Assess Offsetting and Compensation Measures Implementation and Effectiveness Success

Attribute	Success Criteria	Date (Post-Construction / Restoration)
Physical construction of offset measures (new or restored habitat)	• As-constructed survey demonstrates that measures are constructed per the approved plans.(1,2) • Separate as-constructed survey reports will be necessary to account for time separation between measures (i.e., post-construction and post-closure).	Within 12 months of features being constructed
Physical function of offset measures (new or restored habitat)	• Water levels, water depth, flow paths and connectivity are consistent with those specified in the design and facilitate conditions for fish passage. • Aerial extent of works per the plans (habitat quantity consistent with design).(1)	Within 12 months of features being constructed
Stability of structures (new or restored habitat)	• Constructed habitat features remain in place (shoal structures, rock and vegetation structures in place).(3) • Banks and habitat features are stable and not eroding (more than 90% of features are considered stable). • Riparian vegetation cover and plantings achieve 90% survival.	Years 1, 2, 3, 5, 10 and 15
Physicochemical and primary productivity (reclaimed open pit basin)	• Plankton sampling statistically comparable (P>0.1) to other Springpole Lake basins and Birch Lake (values in Appendix B or as amended). • Invertebrate sampling consistent with baseline. • Water and sediment quality assessment consistent with baseline.	Years 1,5, 10 post-closure

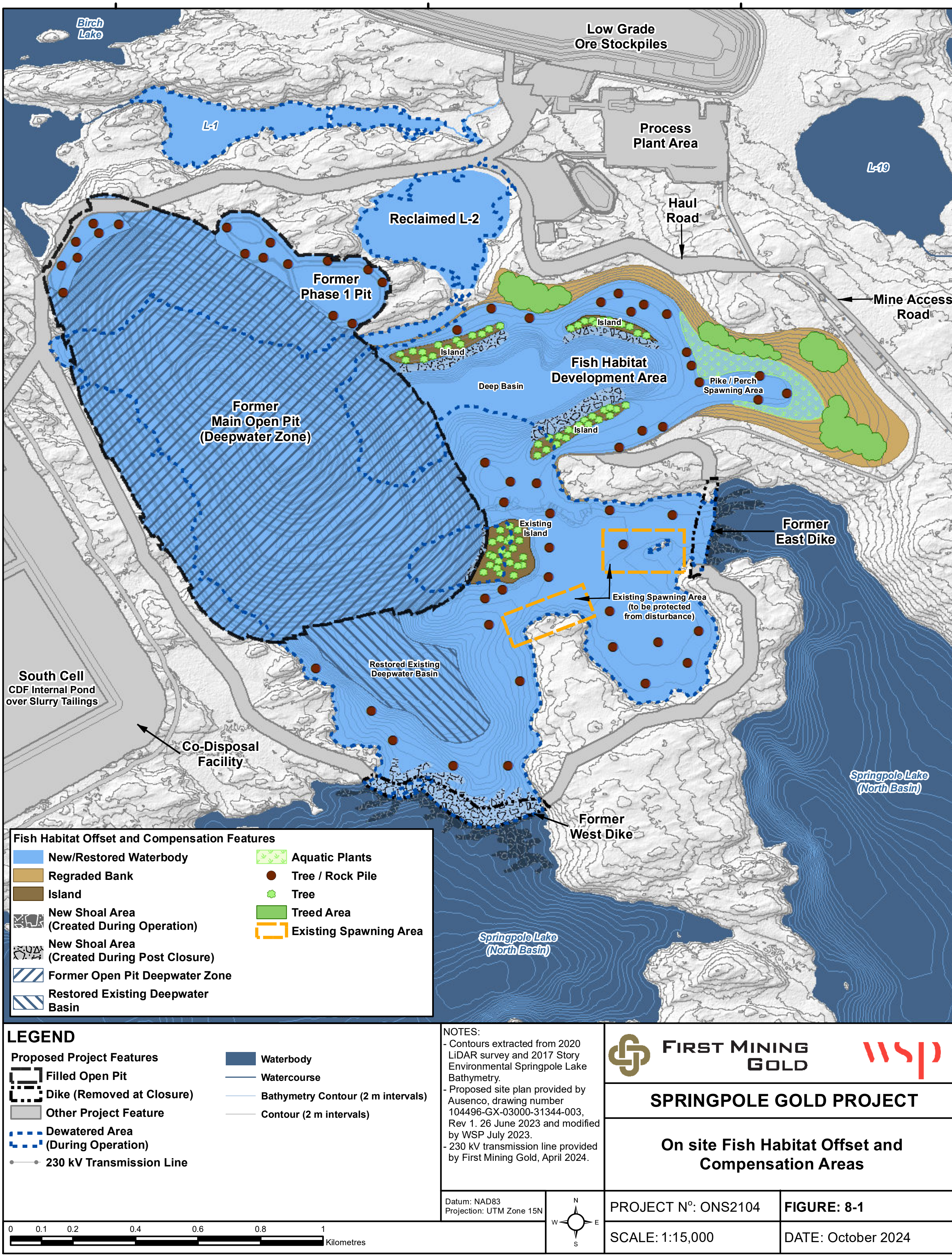
Table 8-5: Criteria and Timing to Assess Offsetting and Compensation Measures Implementation and Effectiveness Success

Attribute	Success Criteria	Date (Post-Construction / Restoration)
Species presence (new or restored habitat)	• A comparison will be made between the newly constructed or restored onsite habitat and the baseline data for the same or adjacent waterbodies. The comparison will use the existing baseline data, as well as data collected during the fish removal efforts during construction to better define the fish communities. • In each location, species richness success criteria is achieved at 80% of the target community (i.e., 8 out of 10 species). It is expected that even at 80% species matching, the new habitat will represent a functional fish community. In the cases where a sportfish community was expected to develop based on baseline occurrence, presence of the sport fish will be part of the success criteria.	Years 1, 2, 3, 5, 10 and 15
Fish biomass and density (reclaimed open pit basin)	• BsM survey demonstrates comparable biomass per hectare to historical surveys, other Springpole Lake basins and Birch Lake (for statistical test assume P>0.1 using data in Appendix B of this FHOCP and as updated). • BsM survey demonstrates comparable Walleye and Lake Trout density to historical surveys, other Springpole Lake basins and Birch Lake (for statistical test assume P>0.1 using data in Appendix B of this FHOCP and as updated).	Years 1,5, 10 post-closure
Full life cycle usage (new or restored habitat)	• Multiple year classes including young of the year fish are present.	Years 1, 2, 3, 5, 10 and 15
Fish abundance (new or restored habitat)	• Average CPUE / abundance consistent with baseline values. (hydroacoustic, electrofishing, minnow traps, gill nets). • Use of accepted monitoring protocols on large lakes (BsM) for comparison to baseline data. • Average abundance values within the offset habitats will be comparable to baseline conditions	Years 1, 2, 3, 5, 10 and 15
Lake Sturgeon Research Program	• Proposal completed per Appendix D of this FHOCP.	As specified in Lake Sturgeon Research Plan

Notes:
(1) Localized field fits may be required during construction based on site-specific existing conditions. It is proposed that the habitats be constructed to a tolerance of +/- 10% for area. This would equal +/- 0.1 ha (100 m2) per 1 ha (10,000 m2).
(2) Presence of 98% or greater of structures (i.e., boulder clusters / tree piles) at initial construction as shown in as-constructed records.
(3) 80% or greater functionality based on percent of structure available to fish use.

Table 8-6: Contingency Measures for Implementation Success

Attribute	Mode of Failure	Contingency
Physical construction of offset measures	• Habitat not constructed per plan. • Water area, depths and/or habitat structures not in place or present per the plans.	• Engineer / biologist to assess failure and recommend corrective actions. • FMG to take required corrective action.
Physical function of offset measures	• Conditions do not provide for fish passage or targeted life stage purpose (i.e., spawning).	• Engineer / biologist to assess cause of failure and recommend corrective actions. • FMG to take required corrective action.
	• Water level not consistent with those specified in plans.	• Adjust grades of structures to alter water levels. • Excavate pools to specified depths. • Add more substrate or regrade substrates.
Stability of structures	• Constructed habitat features (wood, rock and vegetation structures) missing or not functional.	• Repair or replace structures.
	• Banks not stable (less than 90% of banks are considered stable).	• Assess cause and areas of instability. • Add permanent erosion control (rock, vegetation) in areas of erosion. • Regrade habitat.
	• Riparian vegetation cover less than 90% coverage of area.	• Apply seed and replacement plantings where required. • Substitute species and/or use soil amendments if conditions require.
Species presence	• Less than 80% of baseline species of fish are present in the offset measure or absence of target sportfish.	• Use monitoring data to assess limiting factors for other species. • Supplement limiting factors through additional works or assess habitat use by other species.
Life cycle usage	• Absence of expected year classes.	• Use monitoring data to assess limiting factors for spawning or overwintering. • Supplement limiting factors through additional planting, structure placement or excavation.
Fish abundance	• Overall CPUE / abundance metric does not meet targets.	• Use monitoring data to assess limiting factors for abundance. • Supplement limiting factors through additional planting, structure or excavation. • Consider longer term monitoring program if trend shows increasing abundance.
Lake Sturgeon Research Program	• Research program not completed.	• Reassess status and cause of program delay and develop solution.


549000
550000
551000
5694000
5693000
5692000
Birch Lake
Low Grade Ore Stockpiles
L-1
Process Plant Area
L-19
Reclaimed L-2
Haul Road
Former Phase 1 Pit
Mine Access Road
Island
Island
Fish Habitat Development Area
Deep Basin
Pike / Perch Spawning Area
Former Main Open Pit (Deepwater Zone)
Island
Existing Island
Former East Dike
Existing Spawning Area (to be protected from disturbance)
South Cell CDF Internal Pond over Slurry Tailings
Restored Existing Deepwater Basin
Co-Disposal Facility
Springpole Lake (North Basin)
Former West Dike
Springpole Lake (North Basin)
X:\CA\CAOAK300-OAK\MIS-FS1-ProjectF\2021\Projects\ONS2104_FMG_Springpole_EIS\11_GIS\Aquatic\Fisheries_Compensation_Oct2021\MXD\Restored_Open_Pit_7.mxd
Fish Habitat Offset and Compensation Features
New/Restored Waterbody
Regraded Bank
Island
New Shoal Area (Created During Operation)
New Shoal Area (Created During Post Closure)
Former Open Pit Deepwater Zone
Restored Existing Deepwater Basin
Aquatic Plants
Tree / Rock Pile
Tree
Treed Area
Existing Spawning Area
LEGEND
Proposed Project Features
Filled Open Pit
Dike (Removed at Closure)
Other Project Feature
Dewatered Area (During Operation)
230 kV Transmission Line
Waterbody
Watercourse
Bathymetry Contour (2 m intervals)
Contour (2 m intervals)
NOTES:
- Contours extracted from 2020 LiDAR survey and 2017 Story Environmental Springpole Lake Bathymetry.
- Proposed site plan provided by Ausenco, drawing number 104496-GX-03000-31344-003, Rev 1. 26 June 2023 and modified by WSP July 2023.
- 230 kV transmission line provided by First Mining Gold, April 2024.
FIRST MINING GOLD
wsp
SPRINGPOLE GOLD PROJECT
On site Fish Habitat Offset and Compensation Areas
Datum: NAD83
Projection: UTM Zone 15N
N
W
E
S
PROJECT N°: ONS2104
FIGURE: 8-1
SCALE: 1:15,000
DATE: October 2024
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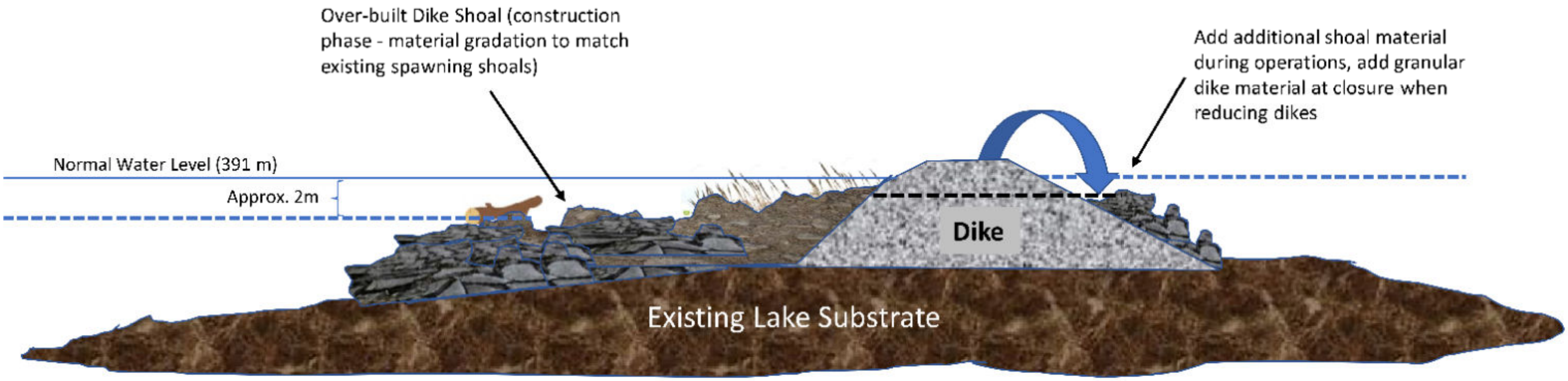
0.1
0.2
0.4
0.6
0.8
1
Kilometres



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LEGEND

NOTES:

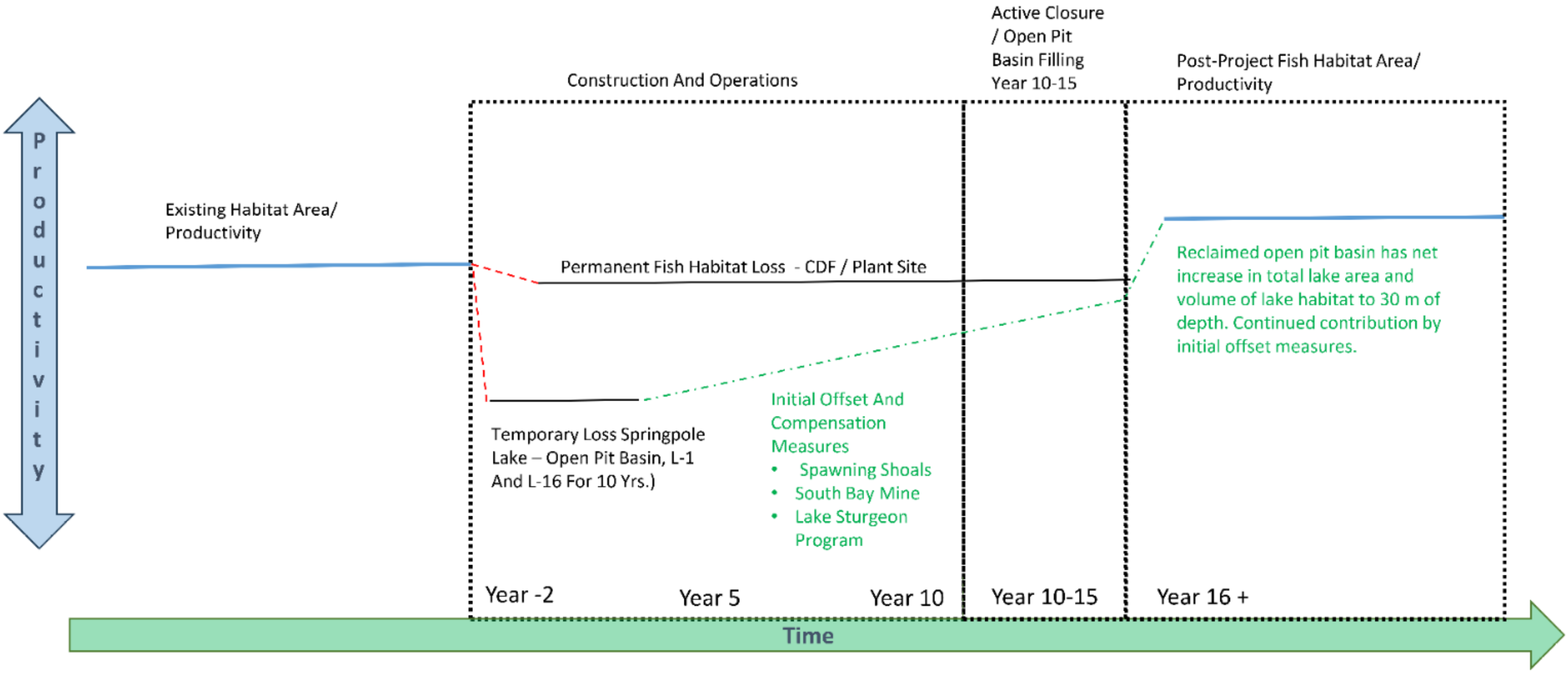
FIRST MINING GOLD

wsp

SPRINGPOLE GOLD PROJECT

Example Schematic of Overbuilt Dike Spawning and Rearing Shoal

PROJECT N°: ONS2104	**FIGURE: 8-2**
SCALE: N.T.S.	DATE: September 2024



LEGEND

NOTES:

FIRST MINING GOLD

wsp

SPRINGPOLE GOLD PROJECT

Schematic of Fish Habitat Productivity Timeline - Proposed Implementation Strategy

PROJECT N°: ONS2104	**FIGURE: 8-3**
SCALE: N.T.S.	DATE: September 2024

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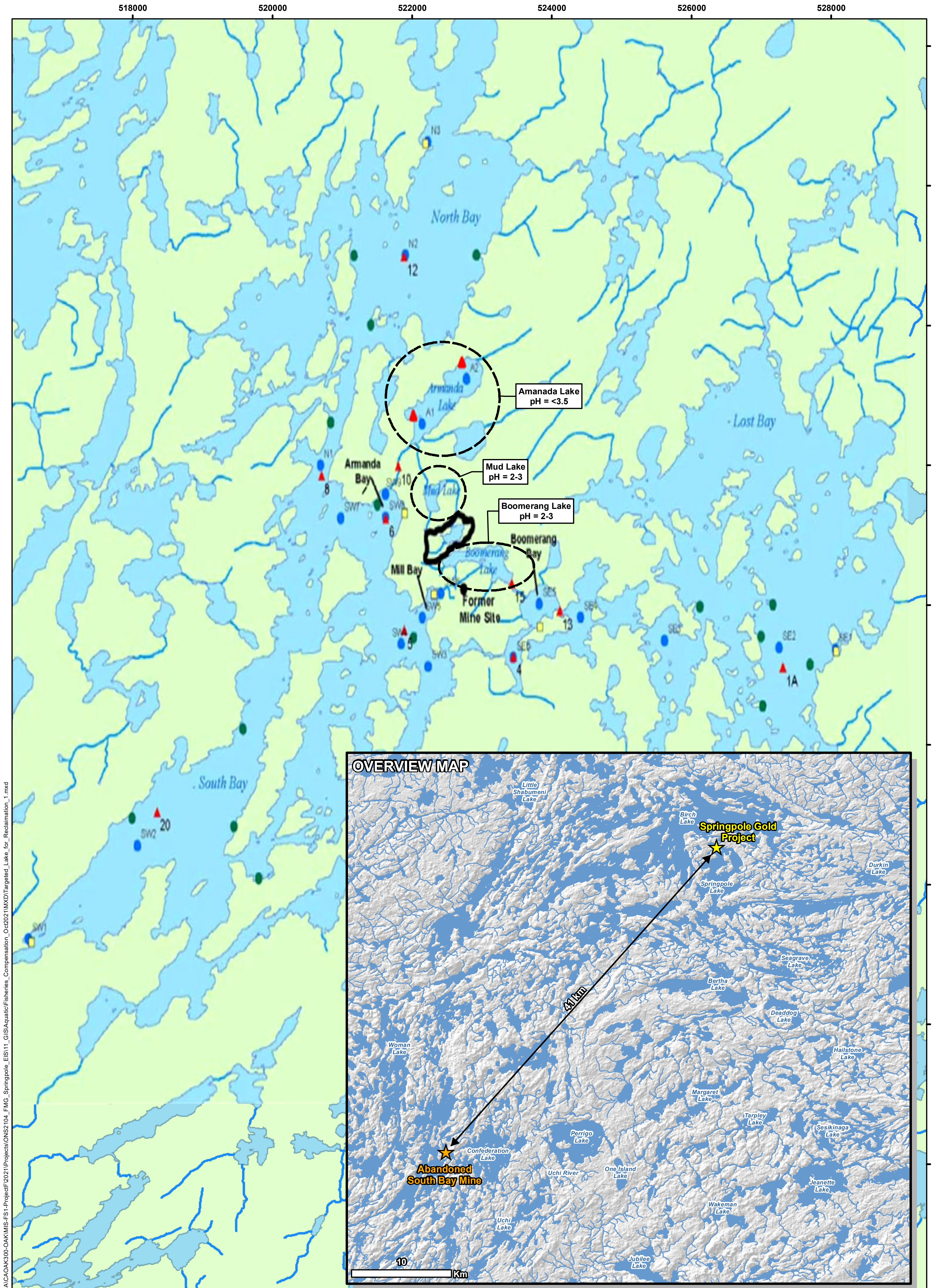

LEGEND

Targeted Lakes for Reclamation

Springpole Gold Project

Abandoned South Bay Mine

NOTES:

Datum: NAD83
Projection: UTM Zone 15N

0 0.5 1 2 3 4 5 Kilometres

FIRST MINING GOLD

wsp

SPRINGPOLE GOLD PROJECT

Abandoned South Bay Mine and Targeted Lakes for Reclamation

PROJECT Nº: ONS2104	**FIGURE: 8-4**
SCALE: 1:50,000	DATE: September 2024

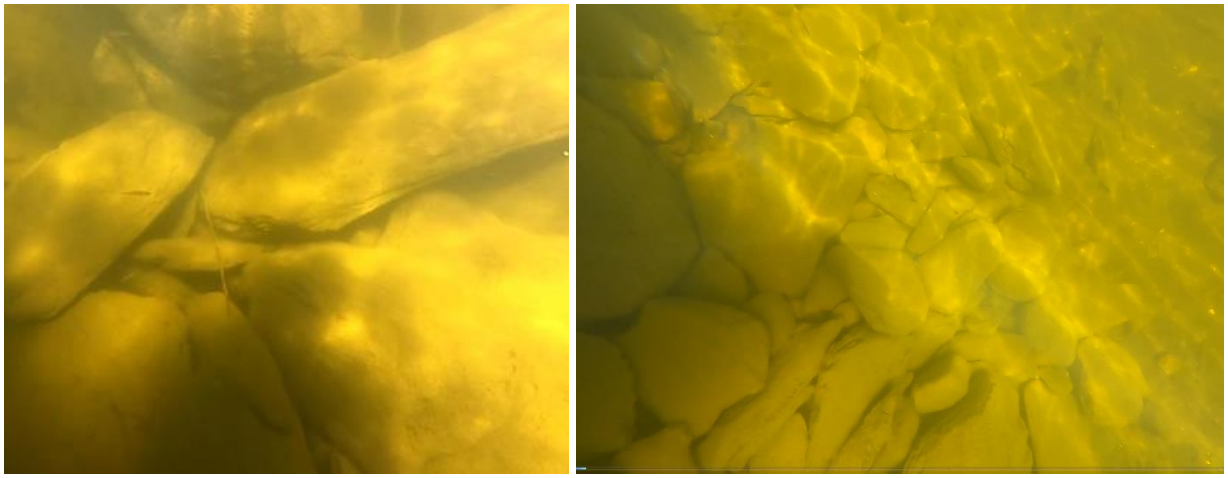

Photo 8-1: Existing Spawning Shoal Material at Two Locations

9.0 FISHERIES OFFSET ACCOUNTING AND BALANCING

A conservatively calculated area of 213.2 ha will be impacted by the development of the Project and its associated facilities as summarized in Table 6-1, Table 6-2 and Table 6-3, with the majority (84%) of impacts identified as Section 35 HADD impacts. MDMER Schedule 2 waterbody listing impacts account for the remaining 16% (Table 6-3).

The currently proposed offsetting and compensation measures in this revised FHOCP could result in the development, restoration or enhancement of up to 575.7 ha of new or enhanced habitat or equivalent value as shown in (Table 9-1), resulting in a net habitat gain or enhancement of up to 267.7 ha and a loss to gain ratio of up to approximately 2.7:1. Not all of the measures may be needed but are included to demonstrate that sufficient measures are proposed to offset the predicted impacts.

It is recognized that this document is the second iteration of the FHOCP, and that additional revisions to the selected measures and quantities may be required in subsequent versions based on consultation and comments received during the final EIS/EA process. However, the FHOCP in its current state provides a descriptive account of predicted impacts (HADD and waters to be listed on Schedule 2 of the MDMER) and viable measures to be implemented to offset the impacts.

Table 9-1: Offset Area Accounting and Balance Summary

Segment Description	Initial Impact Area (ha)	Calculated Offset / Compensation Area (ha)
Combined impacts per Table 6-3	-213.2	
Restored open pit basin		245.0
Lake Sturgeon Program Stage 1 – Research Program		25(1)
Lake Sturgeon Program Stage 2 – Population Support		200.0(2)
South Bay Mine reclamation		87
Restoration of L-1		9.0
Overbuild dike to create shoals		10.0
Summary	-213.2	575.7
Net difference up to		362.7
Net ratio up to		2.7:1

Notes:
(1) Estimated habitat equivalent of 10% of offset plan habitat area.
(2) Estimated as 2% of a targeted 10,000 ha of lake habitat.

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Attachment A

Chronological Summary of Aquatic Baseline Studies in the Springpole Gold Project Area and Location of Data

Attachment A
Springpole Gold Project

Red Lake District, Northwest Ontario
Project #ONS2104

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Table A1: Chronological Summary of Aquatic Baseline Studies in the Springpole Gold Project Area and Location of Data

Year	Surveyor	Study	Description and Rationale	Location of Data
2009	OMNRF	Broadscale Monitoring	Cycle #1 of the Broadscale Monitoring (BsM) survey conducted by OMNRF staff.	https://www.publicdocs.mnr.gov.on.ca/fwsb/BsM/BsM-EN-Birch_Lake-FMZ4-Cyc01-15-5452-56951/BsM-EN-Birch_Lake-FMZ4-Cyc01-15-5452-56951.html
2011	DST Consulting Engineers, C. Portt and Associates, and Story Environmental	Water Quality Profiles	To describe the stratification characteristics of the lakes, water quality measurements were collected at 1 m increments from surface to bottom in the six deepest basins of Springpole Lake, one location in Birch Lake, and four locations in Seagrave Lake during July and August when the lake was stratified.	EIS/EA Appendix O1 • Figures 6 to 9 (Springpole Lake) • Figure 38 (Birch Lake) • Figure 47 (Seagrave Lake) • Tables 2 and 3 (Springpole Lake) • Appendix 5 (Springpole Lake), Appendix 15 (Birch Lake) and Appendix 17 (Seagrave Lake)
		Springpole Lake Fish Community Survey	Fish community assessment using Fall Walleye Index Nets (FWIN) and modified sampling approach. Nets were set when water temperatures were between 10°C to 15°C and followed the FWIN protocol (Morgan, 2002) using a stratified random approach, however netting was stopped early due to high catches of Walleye to reduce mortality and comply with the MNRF License to Collect Fish for Scientific Purposes (LCFSP; FMG & Portt 2018). Live capture methods (minnow traps) were used to characterize the small bodied fish community in Springpole Lake and selected based upon habitat type for each sampling location.	EIS/EA Appendix O1 FWIN Data: • Figures 15 to 18 • Tables 4 and 5 • Appendix 6 Small body fish sampling: • Figures 23 and 24 • Tables 7 and 8 • Appendices 9 and 10
2012		Water Quality Profiles	To describe the stratification characteristics of the lakes, water quality measurements were collected at 1 m increments from surface to bottom in the six deepest basins of Springpole Lake, one location in Birch Lake, and four locations in Seagrave Lake during July and August when the lake was stratified.	EIS/EA Appendix O1 • Figures 6 to 9 (Springpole Lake) • Figure 38 (Birch Lake) • Figure 47 (Seagrave Lake) • Tables 2 and 3 (Springpole Lake) • Appendix 5 (Springpole Lake), Appendix 15 (Birch Lake) and Appendix 17 (Seagrave Lake)
		Aquatic Baseline Study	Surface water quality, sediment quality and physical properties, and benthic invertebrate sampling from Birch Lake, Springpole Lake and Seagrave Lake.	EIS/EA Appendix O1 • Appendix 1
		Inland Waterbody Fish Community and Habitat	Lethal spring, summer, and fall assessments to characterize the fish community in the inland waterbodies using BsM nets set perpendicular to shore or depth contours, with a total of 2 to 4 each lake. Each net was fished for at least 16 hrs and no more than 24 hrs, with a target of 18 hrs.	EIS/EA Appendix O1 • Figures 48 to 89 • Tables 24 to 41 • Appendix 18
		Springpole Lake Fish Community	In Springpole Lake, 11 BsM nets were used during summer when water temperatures were above 18°C using a modified BsM sampling approach, along with 44 Lake Sturgeon targeted nets (see RIN protocol; Jones and Yunker 2009) by DST Consulting and C. Portt and Associates. In the 44 Lake Sturgeon targeted net sets, no Lake Sturgeon were caught. Live capture methods (minnow traps) were used to characterize the small bodied fish community in Springpole Lake and selected based upon habitat type for each sampling location.	EIS/EA Appendix O1 BsM Data: • Figures 19 to 21 • Table 6 • Appendix 7 Small body fish sampling: • Figures 23 and 24 • Tables 7 and 8 • Appendices 9 and 10 Lake Sturgeon Netting: • Figure 22 • Appendix 8
		Fish Tissue Analysis	Walleye captured during the 2012 Springpole Lake Fish Community surveys were sent for tissue analysis.	EIS/EA Appendix O1 • Figures 25 to 27 • Table 9 • Appendix 11

Table A1: Chronological Summary of Aquatic Baseline Studies in the Springpole Gold Project Area and Location of Data

Year	Surveyor	Study	Description and Rationale	Location of Data
		Acoustic Telemetry Surveys	During June, September, and October 2012, Walleye (15) and Lake Trout (25) from the proposed dewatered basin of Springpole Lake were implanted with acoustic telemetry tags for movement and residency analysis. In 2012, 13 receivers were deployed within Springpole Lake.	EIS/EA Appendix O1 • Figures 35 and 36 • Tables 14 to 23 • Appendix 13 and 14
		Bathymetric Mapping	Bathymetic surveys to characterize Springpole Lake habitat were used to collect information on depth, bottom hardness, substrate, and aquatic macrophytes.	EIS/EA Appendix O1 • Figures 10 to 14 • Appendix 2 and 3
		Springpole Lake Spawning Surveys	During fall (October) nighttime Lake Trout and Lake Whitefish spawning surveys were conducted along the shoreline, islands, and reefs using submersible LED spotlights from a small boat.	EIS/EA Appendix O1 • Figures 28, 29, 33, and 34 • Tables 10 and 13
		Benthic Invertebrate Surveys	The benthic invertebrate community (BIC) was assessed in Birch and Seagrave Lakes to determine baseline conditions.	EIS/EA Appendix O1 • Appendix 1
2013		Water Quality Profiles	To describe the stratification characteristics of the lakes, water quality measurements were collected at 1 m increments from surface to bottom in the six deepest basins of Springpole Lake and one location in Birch Lake during July and August when the lake was stratified.	EIS/EA Appendix O1 • Figures 6 to 9 (Springpole Lake) • Figure 38 (Birch Lake) • Figure 47 (Seagrave Lake) • Tables 2 and 3 (Springpole Lake) • Appendix 5 (Springpole Lake), Appendix 15 (Birch Lake) and Appendix 17 (Seagrave Lake)
		Inland Waterbody Fish Community and Habitat	Lethal spring, summer, and fall assessments to characterize the fish community in the inland waterbodies using BsM nets set perpendicular to shore or depth contours, with a total of 2 to 4 each lake. Each net was fished for at least 16 hrs and no more than 24 hrs, with a target of 18 hrs.	EIS/EA Appendix O1 • Figures 48 to 89 • Tables 24 to 41 • Appendix 18
		Springpole Lake Fish Community	During 2013 8 total Lake Sturgeon targeted nets (see RIN protocol; Jones and Yunker 2009) were deployed by DST Consulting and C. Portt and Associates. In the 52 Lake Sturgeon targeted net sets across 2012 and 2013, no Lake Sturgeon were caught. Live capture methods (minnow traps) were used to characterize the small bodied fish community in Springpole Lake and selected based upon habitat type for each sampling location.	EIS/EA Appendix O1 Small body fish sampling: • Figures 23 and 24 • Tables 7 and 8 • Appendices 9 and 10 Lake Sturgeon Netting: • Figure 22 • Appendix 8
		Acoustic Telemetry Surveys	During October 2013, 12 Lake Trout from Springpole Lake were implanted with acoustic telemetry tags for movement and residency analysis. A total of 5 more receivers were deployed within Springpole Lake and the Birch River.	• EIS/EA Appendix O1 • Figures 35 and 36 • Tables 14 to 23 • Appendix 13 and 14
		Springpole Lake Spawning Surveys	During fall (October) nighttime Lake Trout spawning surveys were conducted along the shoreline, islands, and reefs using submersible LED spotlights from a small boat.	EIS/EA Appendix O1 • Figures 28 and 29 • Table 10
		Bathymetic Mapping	Bathymetic surveys to characterize Springpole Lake habitat was used to collect depth, bottom hardness, substrate, and aquatic macrophytes.	EIS/EA Appendix O1 • Figures 10 to 14 • Appendix 2 and 3
2014	OMNRF	Broadscale Monitoring	Cycle #2 of the BsM survey conducted by OMNRF staff.	https://www.publicdocs.mnr.gov.on.ca/fwsb/BsM/BsM-EN-Birch_Lake-FMZ4-Cyc02-15-5452-56951/BsM-EN-Birch_Lake-FMZ4-Cyc02-15-5452-56951.html
	DST Consulting Engineers, C. Portt and Associates, and Story Environmental	Springpole Lake Spawning Surveys	During fall (October) nighttime Lake Trout spawning surveys were conducted along the shoreline, islands, and reefs using submersible LED spotlights from a small boat.	EIS/EA Appendix O1 • Figures 28 and 29 • Table 10

Table A1: Chronological Summary of Aquatic Baseline Studies in the Springpole Gold Project Area and Location of Data

Year	Surveyor	Study	Description and Rationale	Location of Data
		Acoustic Telemetry Surveys	Two additional acoustic telemetry receivers were deployed in Seagrave Lake.	EIS/EA Appendix O1 • Figures 35 and 36 • Tables 14 to 23 • Appendix 13 and 14
2015		Water Quality Profiles	To describe the stratification characteristics of the lakes, water quality measurements were collected at 1 m increments from surface to bottom in the six deepest basins of Springpole Lake and one location in Birch Lake during July and August when the lake was stratified.	EIS/EA Appendix O1 • Figures 6 to 9 (Springpole Lake) • Figure 38 (Birch Lake) • Figure 47 (Seagrave Lake) • Tables 2 and 3 (Springpole Lake) • Appendix 5 (Springpole Lake), Appendix 15 (Birch Lake) and Appendix 17 (Seagrave Lake)
		Summer and Fall Inland Waterbodies Fish Community	Lethal summer and fall assessments to characterize the fish community in the inland waterbodies using BsM nets set perpendicular to shore or depth contours, with a total of 2 to 4 each lake. Each net was fished for at least 16 hrs and no more than 24 hrs, with a target of 18 hrs.	EIS/EA Appendix O1 • Figures 48 to 89 • Tables 24 to 41 • Appendix 18
		Springpole Lake Fish Community	Live capture methods (seine nets) were used to characterize the small bodied fish community in Springpole Lake and selected based upon habitat type for each sampling location. Seine nets were only used in the north basin.	EIS/EA Appendix O1 • Small body fish sampling: • Figures 23 and 24 • Tables 7 and 8 • Appendices 9 and 10
		Springpole Lake Spawning Surveys	During spring (May) nighttime Walleye spawning surveys were conducted along the shoreline, islands, and reefs using submersible LED spotlights from a small boat. Northern Pike spawning surveys were also conducted during the daylight hours of this period.	EIS/EA Appendix O1 • Figures 30, 31, and 32 • Tables 11 and 12 • Appendix 12
		Acoustic Telemetry Surveys	During October 2015, 30 Lake Trout from Springpole Lake were implanted with acoustic telemetry tags for movement and residency analysis.	EIS/EA Appendix O1 • Figures 35 and 36 • Tables 14 to 23 • Appendix 13 and 14
2016		Water Quality Profiles	To describe the stratification characteristics of the lakes, water quality measurements were collected at 1 m increments from surface to bottom in the six deepest basins of Springpole Lake and one location in Birch Lake during July and August when the lake was stratified.	EIS/EA Appendix O1 • Figures 6 to 9 (Springpole Lake) • Figure 38 (Birch Lake) • Figure 47 (Seagrave Lake) • Tables 2 and 3 (Springpole Lake) • Appendix 5 (Springpole Lake), Appendix 15 (Birch Lake) and Appendix 17 (Seagrave Lake)
2017		Summer and Fall Inland Waterbodies Fish Community	Lethal summer and fall assessments to characterize the fish community in the inland waterbodies using BsM nets set perpendicular to shore or depth contours, with a total of 2 to 4 each lake. Each net was fished for at least 16 hrs and no more than 24 hrs, with a target of 18 hrs.	EIS/EA Appendix O1 • Figures 48 to 89 • Tables 24 to 41 • Appendix 18
		Springpole Lake Spawning Surveys	During spring (May) nighttime Walleye spawning surveys were conducted along the shoreline, islands, and reefs using submersible LED spotlights from a small boat. Northern Pike spawning surveys were also conducted during the daylight hours of this period.	EIS/EA Appendix O1 • Figures 30, 31, and 32 • Tables 11 and 12 • Appendix 12
2019	OMNRF	Broadscale Monitoring	Cycle #3 of the BsM survey conducted by OMNRF staff.	https://www.publicdocs.mnr.gov.on.ca/fwsb/BsM/BsM-EN-Birch_Lake-FMZ4-Cyc03-15-5452-56951/BsM-EN-Birch_Lake-FMZ4-Cyc03-15-5452-56951.html
	Story Environmental	Sediment and Benthic Sampling	Sediment and BIC surveys were conducted in Springpole Lake to characterize the candidate treated mine effluent outfall location.	EIS/EA Appendix O2 • Section 3.5.1 and 3.5.2 • Appendix D

Table A1: Chronological Summary of Aquatic Baseline Studies in the Springpole Gold Project Area and Location of Data

Year	Surveyor	Study	Description and Rationale	Location of Data
	Wood PLC	Fish Community Assessments	Multi-season inland waterbody conditions assessments, including CPUE, for unnamed watercourses including the connection between L-6 and L-16, L-5 outlet, L-2 outlet, and the upper reaches of S-9.	EIS/EA Appendix O2 • Section 3.1 • Appendix A
		Fish Tissue and Aging Analysis	Lab analysis of fish tissue and aging samples from the small bodied fish community of inland waterbodies and large bodied fish community in Springpole Lake. The large bodied fish include Yellow Perch and Northern Pike to increase the species sampled for tissue contaminants in Springpole Lake.	EIS/EA Appendix O2 • Sections 3.1 and 3.3 • Appendix B and C
		Road Alignment Assessment	Assessment of water crossings within the proposed road alignment to determine suitability.	EIS/EA Appendix O2 • Section 3.2
2020		Springpole Lake Fish Community	Fish community assessments were conducted in Springpole Lake to characterize the candidate treated mine effluent outfall location.	EIS/EA Appendix O2 • Section 3.4 • Appendix A
		Springpole Lake Sediment and BIC Assessment	Sediment and BIC surveys were conducted in Springpole Lake to characterize the candidate treated mine effluent outfall location.	EIS/EA Appendix O2 • Section 3.4 • Appendix D
2021		Physicochemical Profile Data Collection	To describe the lake characteristics, water quality measurements were collected at 1 m increments from surface to bottom in the six deepest basins of Springpole Lake and two deep basins of Birch Lake near the project site across all seasons.	EIS/EA Appendix O3 • Sections 3.5.4 and 3.6.4 • Appendix A
		Lower Trophic / Primary Productivity Assessment	To describe the lower trophic community and primary productivity of the lakes, chlorophyll-a, phytoplankton, and zooplankton were surveyed at the six deepest basins of Springpole Lake and the two deep basins of Birch Lake near the project site across multiple seasons.	EIS/EA Appendix O3 • Sections 3.5.4 and 3.6.4 • Appendix A
		MVWHDO Assessment	The mean volume weighted hypolimnetic dissolved oxygen concentration (MVWHDO) was calculated for each of the Springpole and Birch lakes deep basins profile locations as per the provincial guideline (MNR 2018). The intent was to characterize the quantity of optimal habitat for Lake Trout within the Project area.	EIS/EA Appendix O3 • Section 3.5.1 • Appendix A
		Fish Community Assessments	Fish community was further assessed in Springpole and Birch Lakes to supplement existing baseline data. Further sampling in previously unsampled inland waterbodies (L-17, L-18, and L-19) was conducted to characterize their fish community and habitat.	EIS/EA Appendix O3 • Sections 3.1.2, 3.2.2, 3.3.2, 3.5.2, and 3.6.2 • Appendix A
		Fish Tissue and Aging Analysis	Lab analysis of fish tissue and aging samples from the small bodied fish community of Springpole Lake, Birch Lake, and inland waterbodies.	EIS/EA Appendix O3 • Sections 3.1.3, 3.2.3, 3.3.3, 3.5.3, and 3.6.3 • Appendix B and C
2022	WSP Canada Inc.	Physicochemical Profile Data Collection	To describe the lake characteristics, water quality measurements were collected at 1 m increments from surface to bottom in the six deepest basins of Springpole Lake and two deep basins of Birch Lake near the project site across all seasons.	EIS/EA Appendix O4 • Sections 3.1.5 and 3.2.5 • Appendix E
		Lower Trophic / Primary Productivity Assessment	To describe the lower trophic community and primary productivity of the lakes, chlorophyll-a, phytoplankton, and zooplankton were sampled at the six deepest basins of Springpole Lake and the two deep basins of Birch Lake near the project site across multiple seasons.	EIS/EA Appendix O4 • Sections 3.1.6 and 3.2.6 • Appendix E
		Spring Lethal Fish Community Sampling	Small bodied fish community lethal sampling to supplement previous baseline fish composite studies and collect information from near the treated effluent discharge location.	EIS/EA Appendix O4 • Sections 3.1.2, 3.1.3, and 3.1.4 • Appendix B and D
		Northern Pike Spawning Surveys	Additional Northern Pike spawning surveys in Springpole Lake to supplement the existing dataset.	EIS/EA Appendix O4 • Section 3.1.1 • Appendix A
		Fish Habitat Assessments	Fish habitat assessments in Birch Lake along the proposed Co-disposal facility shoreline to define baseline conditions.	EIS/EA Appendix O4 • Section 3.2.1 • Appendix A
		Fish Community Assessments	Non-lethal fish community assessments in Springpole Lake, Birch Lake, and previously sampled inland waterbodies to increase sampling effort and solidify baseline condition understanding.	EIS/EA Appendix O4 • Sections 3.1.2 and 3.2.2 • Appendix B

Table A1: Chronological Summary of Aquatic Baseline Studies in the Springpole Gold Project Area and Location of Data

Year	Surveyor	Study	Description and Rationale	Location of Data
		Lake Sturgeon Netting Program	Targeted modified riverine index netting (RIN) protocol toward any potential Lake Sturgeon presence or movement in the SE Arm of Springpole Lake during the spring spawning period.	EIS/EA Appendix O4 • Section 3.1.2 • Figure 2-2 • Appendix B
		Lake Sturgeon focused eDNA Program	Metabarcoding (full fish community) analysis of eDNA samples taken in conjunction with the spring targeted Lake Sturgeon netting program and at additional locations during spring and summer 2022. Additional sample locations were taken in areas most likely to capture the full fish community of Springpole Lake and areas of Birch Lake near the project site.	EIS/EA Appendix O4 • Sections 3.1.2 and 3.2.2 • Figure 2-2 • Appendix C
		Broadscale Monitoring (BsM) Program	A full BsM program during summer (August) 2022 following provincial protocol (Sandstrom et al. 2013) to allow for repeatable sampling and comparison with other lakes sampled in the same manner.	EIS/EA Appendix O4 • Sections 3.1.2, 3.1.3, and 3.1.4 • Figure 2-3 • Appendix B and D
		Hydroacoustic Program	A hydroacoustic survey of Springpole Lake using the 2022 BsM data as a reference to provide context. Hydroacoustic surveys provide increased detail for biomass and density estimates.	EIS/EA Appendix O4 • Section 3.1.2 • Appendix B
		Sediment and BIC Assessment	Sediment quality and BIC surveys in Birch Lake along the Co-disposal facility shoreline, including outside of the S-16 outlet, within L-16, and outside the L-16 outlet in Springpole Lake. Samples were intended to characterize the area surrounding the co-disposal facility, inform future monitoring, and in response to review comments regarding potential impacts to L-16 and downstream impacts to Springpole Lake.	EIS/EA Appendix O4 • Sections 3.1.7, 3.1.8, 3.2.7, 3.2.8, 3.8.4, and 3.8.5 • Figure 2-4 • Appendix F
2023		Physicochemical Profile Data Collection	To describe the lake characteristics, water quality measurements were collected at 1 m increments from surface to bottom in the six deepest basins of Springpole Lake and two deep basins of Birch Lake near the project site across all seasons. One location in Springpole Lake outside of the proposed dike location and another location near-shore in Birch Lake near the project site were also sampled during winter and spring to inform future monitoring pending mine approvals.	EIS/EA Appendix O4 • Sections 3.1.5 and 3.2.5 • Appendix E
		Lower Trophic / Primary Productivity Assessment	To describe the lower trophic community and primary productivity of the lakes, chlorophyll-a, phytoplankton, and zooplankton were sampled at the six deepest basins of Springpole Lake and the two deep basins of Birch Lake near the project site across multiple seasons. One location in Springpole Lake outside of the proposed dike location and another location near-shore in Birch Lake near the project site were also sampled during winter to inform future monitoring pending mine approvals.	EIS/EA Appendix O4 • Sections 3.1.6 and 3.2.6 • Appendix E
		Springpole Lake Fish Habitat Assessments for Candidate Offsetting Measures	Fish habitat transects within Springpole Lake to assess large woody debris in the lake and shoreline as a proxy for small bodied fish community refugia.	EIS/EA Appendix O4 • Section 3.1.1 • Appendix A
		Lake Sturgeon eDNA Program	Targeted qPCR analysis using a Lake Sturgeon assay on spring 2023 eDNA samples. Samples were taken within the regional study area at First Nation, MNRF, and desktop identified spawning locations in an attempt to locate the species within the project area and surrounding region.	EIS/EA Appendix O4 • Section 3.1.2 • Figure 2-2 • Appendix C

Attachment B
Broadscale Monitoring Data and Comparisons

Attachment B
Springpole Gold Project

Red Lake District, Northwest Ontario
Project #ONS2104

Prepared for:

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Table B1: Comparison of Condition Factor by Species for Springpole Lake and Birch Lake

Burbot							
Source of Variation	SS	df	MS	F	P-value	p<0.05	Direction
Between Groups	0.00142	1	0.0014216	0.237	0.63	N	
Error	0.95988	160	0.0059993				
Cisco							
Source of Variation	SS	df	MS	F	P-value	p<0.05	Direction
Between Groups	0.2437	1	0.243743	4.8604	0.03	Y	BIRCH>SPRINGPOLE
Error	17.0003	339	0.050148				
Lake Trout							
Source of Variation	SS	df	MS	F	P-value	p<0.05	Direction
Between Groups	0.01122	1	0.011222	0.6448	0.43	N	
Error	0.38293	22	0.017406				
Lake Whitefish							
Source of Variation	SS	df	MS	F	P-value	p<0.05	Direction
Between Groups	0.1663	1	0.166252	6.6759	0.01	Y	BIRCH>SPRINGPOLE
Error	3.3122	133	0.024903				
Northern Pike							
Source of Variation	SS	df	MS	F	P-value	p<0.05	Direction
Between Groups	0.00052	1	0.0005198	0.1481	0.70	N	
Error	0.60035	171	0.0035108				
Shorthead Redhorse							
Source of Variation	SS	df	MS	F	P-value	p<0.05	Direction
Between Groups	0.001158	1	0.0011581	0.0857	0.78	N	
Error	0.148585	11	0.0135077				
Walleye							
Source of Variation	SS	df	MS	F	P-value	p<0.05	Direction
Between Groups	0.0209	1	0.0209081	3.8713	0.05	N	
Error	6.8645	1271	0.0054008				
White Sucker							
Source of Variation	SS	df	MS	F	P-value	p<0.05	Direction
Between Groups	0.2621	1	0.262103	22.976	3.891e-06	Y	BIRCH>SPRINGPOLE
Error	1.7225	151	0.011407				
Yellow Perch							
Source of Variation	SS	df	MS	F	P-value	p<0.05	Direction
Between Groups	0.31349	1	0.313491	10.757	0.0019	Y	
Error	1.48636	51	0.313491				

Notes:

Broadscale monitoring data for Springpole Lake (WSP 2022) and Birch Lake (MNR 2009, 2017, 2019) include fish caught within the NA1 (North American large mesh) nets and only individuals considered “recruit-sized” to the NA1 nets (Lake Trout < 350 mm, Lake Whitefish < 400 mm, Northern Pike < 500 mm, and Walleye < 350 mm; Walker et al. 2013)

All sampling area comparisons were completed using Analysis of Variance (ANOVA)

"df" represents degrees of freedom

"SS" represents sums of squares

"MS" represents mean square

"F" statistic represents the between / within group variability

"p-value" represents the level of marginal significance within a statistical hypothesis test

"p<0.05" indicated significance of test for null hypothesis (equal means) at an α of 0.05

Table B2: Comparison of Recruitment Biomass by Species for Springpole Lake and Birch Lake

Burbot							
Source of Variation	SS	df	MS	F	P-value	p<0.05	Direction
Between Groups	192183	1	192183	0.7454	0.39	N	
Error	41250721	160	257817				
Cisco							
Source of Variation	SS	df	MS	F	P-value	p<0.05	Direction
Between Groups	1521898	1	1521898	15.648	9.294e-05	Y	BIRCH>SPRINGPOLE
Error	32970730	339	97259				
Lake Trout							
Source of Variation	SS	df	MS	F	P-value	p<0.05	Direction
Between Groups	2620865	1	2620865	0.9102	0.35	N	
Error	63344581	22	2879299				
Lake Whitefish							
Source of Variation	SS	df	MS	F	P-value	p<0.05	Direction
Between Groups	1335412	1	1335412	6.2259	0.01	Y	BIRCH>SPRINGPOLE
Error	28527518	133	214493				
Northern Pike							
Source of Variation	SS	df	MS	F	P-value	p<0.05	Direction
Between Groups	73280	1	73280	0.1593	0.69	N	
Error	78656850	171	459982				
Shorthead Redhorse							
Source of Variation	SS	df	MS	F	P-value	p<0.05	Direction
Between Groups	244454	1	244454	6.6072	0.03	Y	BIRCH>SPRINGPOLE
Error	406979	11	36998				
Walleye							
Source of Variation	SS	df	MS	F	P-value	p<0.05	Direction
Between Groups	273745		273745	2.1833	0.14	N	
Error	159356566		125379				
White Sucker							
Source of Variation	SS	df	MS	F	P-value	p<0.05	Direction
Between Groups	514819	1	514819	1.1919	0.28	N	
Error	65219226		431915				
Yellow Perch							
Source of Variation	SS	df	MS	F	P-value	p<0.05	Direction
Between Groups	2182	1	2182.25	2.8238	0.10	N	
Error	39412	51	772.79				

Broadscale monitoring data for Springpole Lake (WSP 2022) and Birch Lake (MNR 2009, 2017, 2019) include fish caught within the NA1 (North American large mesh) nets and only individuals considered “recruit-sized” to the NA1 nets (Lake Trout < 350 mm, Lake Whitefish < 400 mm, Northern Pike < 500 mm, and Walleye < 350 mm; Walker et al. 2013)
All sampling area comparisons were completed using Analysis of Variance (ANOVA)
"df" represents degrees of freedom
"SS" represents sums of squares
"MS" represents mean square
"F" statistic represents the between / within group variability
"p-value" represents the level of marginal significance within a statistical hypothesis test
"p<0.05" indicated significance of test for null hypothesis (equal means) at an α of 0.05

Table B3: Comparison of Zooplankton Density by Order for Springpole Lake and Birch Lake

Bosminidae							
Source of Variation	SS	df	MS	F	P-value	p<0.05	Direction
Between Groups	1572725	1	1572725	0.312	0.58	N	
Error	257042284	51	5040045				
Calanoida							
Source of Variation	SS	df	MS	F	P-value	p<0.05	Direction
Between Groups	80654	1	80654	0.0468	0.83	N	
Error	577083961	335	1722639				
Chydoridae							
Source of Variation	SS	df	MS	F	P-value	p<0.05	Direction
Between Groups	63236	1	63236	0.1384	0.71	N	
Error	15995184	35	457005				
Cyclopoida							
Source of Variation	SS	df	MS	F	P-value	p<0.05	Direction
Between Groups	3603288	1	3603288	0.1067	0.74	N	
Error	8474650763	251	33763549				
Daphniidae							
Source of Variation	SS	df	MS	F	P-value	p<0.05	Direction
Between Groups	427155	1	427155	1.0005	0.32	N	
Error	52943002	124	426960				
Diptera							
Source of Variation	SS	df	MS	F	P-value	p<0.05	Direction
Between Groups	0.44903	1	0.44903	2.7401	0.17	N	
Error	0.65549	4	0.16387				
Flosculariaceae							
Source of Variation	SS	df	MS	F	P-value	p<0.05	Direction
Between Groups	5.996	1	5.9955	0.5627	0.46	N	
Error	223.744	21	10.6545				
Holopedidae							
Source of Variation	SS	df	MS	F	P-value	p<0.05	Direction
Between Groups	52009	1	52009	0.0025	0.96	N	
Error	778806712	38	20494913				
Ploima							
Source of Variation	SS	df	MS	F	P-value	p<0.05	Direction
Between Groups	28.89	1	28.8911	4.3897	0.04	Y	SPRINGPOLE>BIRCH
Error	1000.40	152	6.5816				
Polyphemidae							
Source of Variation	SS	df	MS	F	P-value	p<0.05	Direction
Between Groups	0.003944	1	0.0039435	0.287	0.62	N	
Error	0.068696	5	0.0137392				
Sididae							
Source of Variation	SS	df	MS	F	P-value	p<0.05	Direction
Between Groups	293973	1	293973	0.8006	0.378	N	
Error	12117915	33	367210				

Data analysis included seasonal sampling results from Springpole Lake and Birch Lake 2021 to 2023 which include taxonomic zooplankton orders detected in both lakes.
All sampling area comparisons were completed using Analysis of Variance (ANOVA)
"df" represents degrees of freedom
"SS" represents sums of squares
"MS" represents mean square
"F" statistic represents the between / within group variability
"p-value" represents the level of marginal significance within a statistical hypothesis test
"p<0.05" indicated significance of test for null hypothesis (equal means) at an α of 0.05

Table B4: Comparison of Zooplankton Biomass by Order for Springpole Lake and Birch Lake

Bosminidae							
Source of Variation	SS	df	MS	F	P-value	p<0.05	Direction
Between Groups	23.14	1	23.1358	2.5421	0.12	N	
Error	464.16	51	9.1011				
Calanoida							
Source of Variation	SS	df	MS	F	P-value	p<0.05	Direction
Between Groups	143	1	142.57	0.4720	0.49	N	
Error	101200	335	302.09				
Chydoridae							
Source of Variation	SS	df	MS	F	P-value	p<0.05	Direction
Between Groups	14.93	1	14.9301	1.7686	0.19	N	
Error	295.46	35	8.4418				
Cyclopoida							
Source of Variation	SS	df	MS	F	P-value	p<0.05	Direction
Between Groups	162.3	1	162.311	1.6325	0.20	N	
Error	24955.0	251	99.422				
Daphniidae							
Source of Variation	SS	df	MS	F	P-value	p<0.05	Direction
Between Groups	100	1	99.97	0.2100	0.65	N	
Error	59027	124	476.03				
Diptera							
Source of Variation	SS	df	MS	F	P-value	p<0.05	Direction
Between Groups	0.8096	1	0.80960	2.7400	0.17	N	
Error	1.1819	4	0.29547				
Floscularaceae							
Source of Variation	SS	df	MS	F	P-value	p<0.05	Direction
Between Groups	1.773	1	1.7732	0.4734	0.50	N	
Error	78.649	21	3.7452				
Holopedidae							
Source of Variation	SS	df	MS	F	P-value	p<0.05	Direction
Between Groups	3704	1	3704.4	0.2673	0.61	N	
Error	526539	38	13856.3				
Ploima							
Source of Variation	SS	df	MS	F	P-value	p<0.05	Direction
Between Groups	0.035	1	0.03516	0.0171	0.90	N	
Error	313.407	152	2.06189				
Polyphemidae							
Source of Variation	SS	df	MS	F	P-value	p<0.05	Direction
Between Groups	631.4	1	631.44	0.2872	0.62	N	
Error	10993.7	5	2198.74				

Table B4: Comparison of Zooplankton Biomass by Order for Springpole Lake and Birch Lake

Sididae							
Source of Variation	SS	df	MS	F	P-value	p<0.05	Direction
Between Groups	40.22	1	40.216	0.4471	0.51	N	
Error	2968.35	33	89.950				

Data analysis included seasonal sampling results from Springpole Lake and Birch Lake 2021 to 2023 which include taxonomic zooplankton orders detected in both lakes.
All sampling area comparisons were completed using Analysis of Variance (ANOVA)
"df" represents degrees of freedom
"SS" represents sums of squares
"MS" represents mean square
"F" statistic represents the between / within group variability
"p-value" represents the level of marginal significance within a statistical hypothesis test
"p<0.05" indicated significance of test for null hypothesis (equal means) at an α of 0.05

Table B5: Comparison of Phytoplankton Density by Class for Springpole Lake and Birch Lake

Bacillariophyceae							
Source of Variation	SS	df	MS	F	P-value	p<0.05	Direction
Between Groups	1.5233e+09	1	1523331482	1.0378	0.31	N	
Error	4.9614e+11	338	1467877117				
Chlorophyceae							
Source of Variation	SS	df	MS	F	P-value	p<0.05	Direction
Between Groups	1.2782e+09	1	1278219999	1.5601	0.21	N	
Error	2.7610e+11	337	819293553				
Chrysophyceae							
Source of Variation	SS	df	MS	F	P-value	p<0.05	Direction
Between Groups	2.1608e+11	1	2.1608e+11	1.1933	0.28	N	
Error	3.4948e+13	193	1.8108e+11				
Cryptophyceae							
Source of Variation	SS	df	MS	F	P-value	p<0.05	Direction
Between Groups	2.8658e+10	1	2.8658e+10	0.8814	0.35	N	
Error	3.7067e+12	114	3.2515e+10				
Cyanophyceae							
Source of Variation	SS	df	MS	F	P-value	p<0.05	Direction
Between Groups	1.2460e+09	1	1245979965	1.2515	0.26	N	
Error	2.4492e+11	246	995614411				
Dinophyceae							
Source of Variation	SS	df	MS	F	P-value	p<0.05	Direction
Between Groups	117865	1	117865	0.0088	0.93	N	
Error	711409408	53	13422819				
Euglenophyceae							
Source of Variation	SS	df	MS	F	P-value	p<0.05	Direction
Between Groups	1111111	1	1111111	0.1254	0.73	N	
Error	70888889	8	8861111				

Data analysis included seasonal sampling results from Springpole Lake and Birch Lake 2021 to 2023 which include phytoplankton classes detected in both lakes.
All sampling area comparisons were completed using Analysis of Variance (ANOVA)
"df" represents degrees of freedom
"SS" represents sums of squares
"MS" represents mean square
"F" statistic represents the between / within group variability
"p-value" represents the level of marginal significance within a statistical hypothesis test
"p<0.05" indicated significance of test for null hypothesis (equal means) at an α of 0.05

Table B6: Comparison of Phytoplankton Biomass by Class for Springpole Lake and Birch Lake

Bacillariophyceae							
Source of Variation	SS	df	MS	F	P-value	p<0.05	Direction
Between Groups	1.3459e+08	1	134587467	0.7901	0.38	N	
Error	5.7572e+10	338	170332271				
Chlorophyceae							
Source of Variation	SS	df	MS	F	P-value	p<0.05	Direction
Between Groups	1.1846e+07	1	11845988	0.042	0.84	N	
Error	9.4997e+10	337	281888854				
Chrysophyceae							
Source of Variation	SS	df	MS	F	P-value	p<0.05	Direction
Between Groups	4331718	1	4331718	0.2148	0.64	N	
Error	3891759855	193	20164559				
Cryptophyceae							
Source of Variation	SS	df	MS	F	P-value	p<0.05	Direction
Between Groups	11246778	1	11246778	0.7188	0.40	N	
Error	1783687370	114	15646380				
Cyanophyceae							
Source of Variation	SS	df	MS	F	P-value	p<0.05	Direction
Between Groups	2.7775e+08	1	277746068	0.685	0.41	N	
Error	9.9739e+10	246	405443236				
Dinophyceae							
Source of Variation	SS	df	MS	F	P-value	p<0.05	Direction
Between Groups	2.8475e+07	1	28474533	0.0265	0.87	N	
Error	5.7012e+10	53	1075694681				
Euglenophyceae							
Source of Variation	SS	df	MS	F	P-value	p<0.05	Direction
Between Groups	2800174	1	2800174	0.0271	0.87	N	
Error	827138889	8	103392361				

Data analysis included seasonal sampling results from Springpole Lake and Birch Lake 2021 to 2023 which include phytoplankton classes detected in both lakes.
All sampling area comparisons were completed using Analysis of Variance (ANOVA)
"df" represents degrees of freedom
"SS" represents sums of squares
"MS" represents mean square
"F" statistic represents the between / within group variability
"p-value" represents the level of marginal significance within a statistical hypothesis test
"p<0.05" indicated significance of test for null hypothesis (equal means) at an α of 0.05

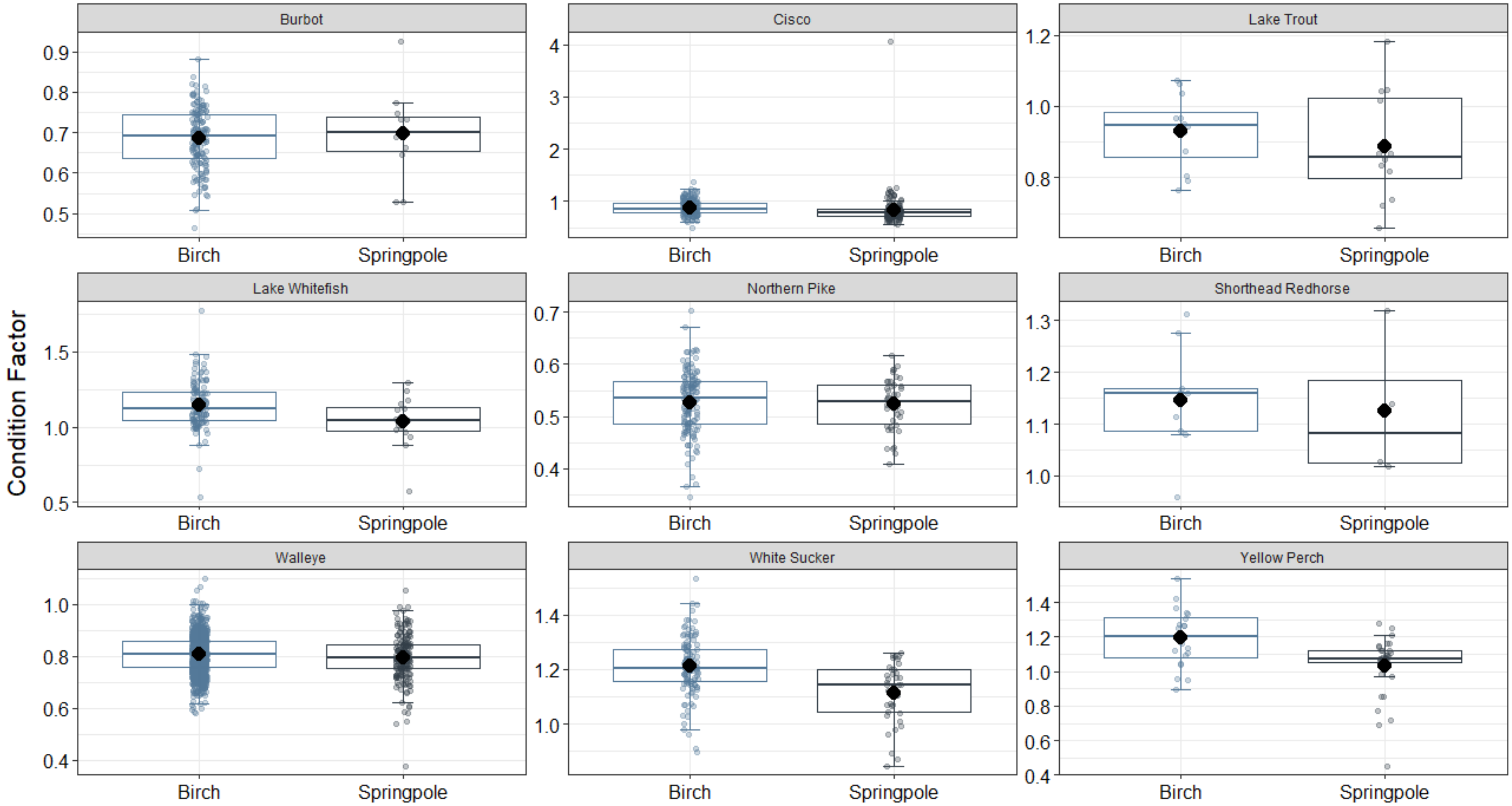


Figure B1: Condition Factor by Species for Springpole Lake and Birch Lake

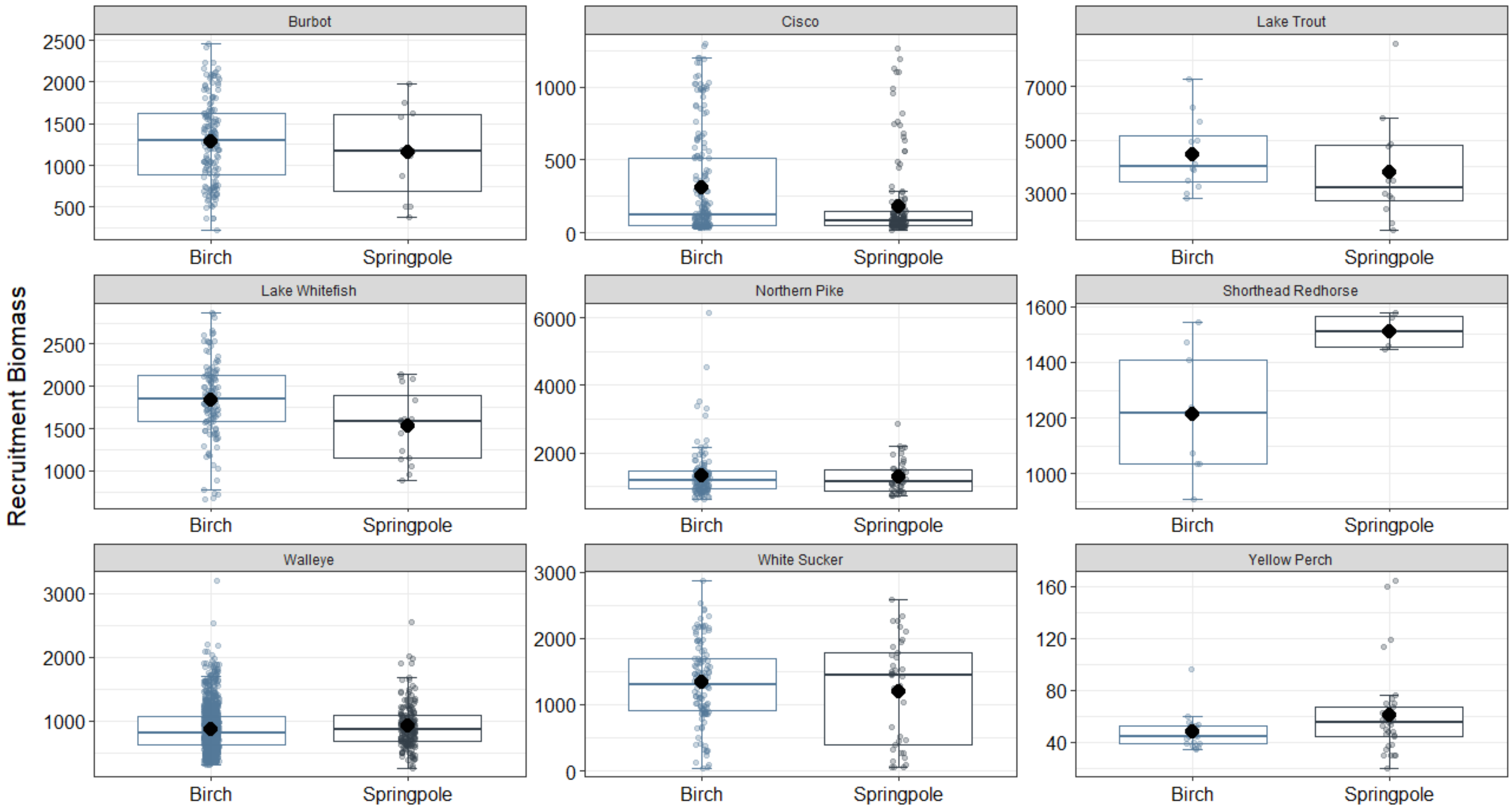


Figure B2: Recruitment Biomass by Species for Springpole Lake and Birch Lake

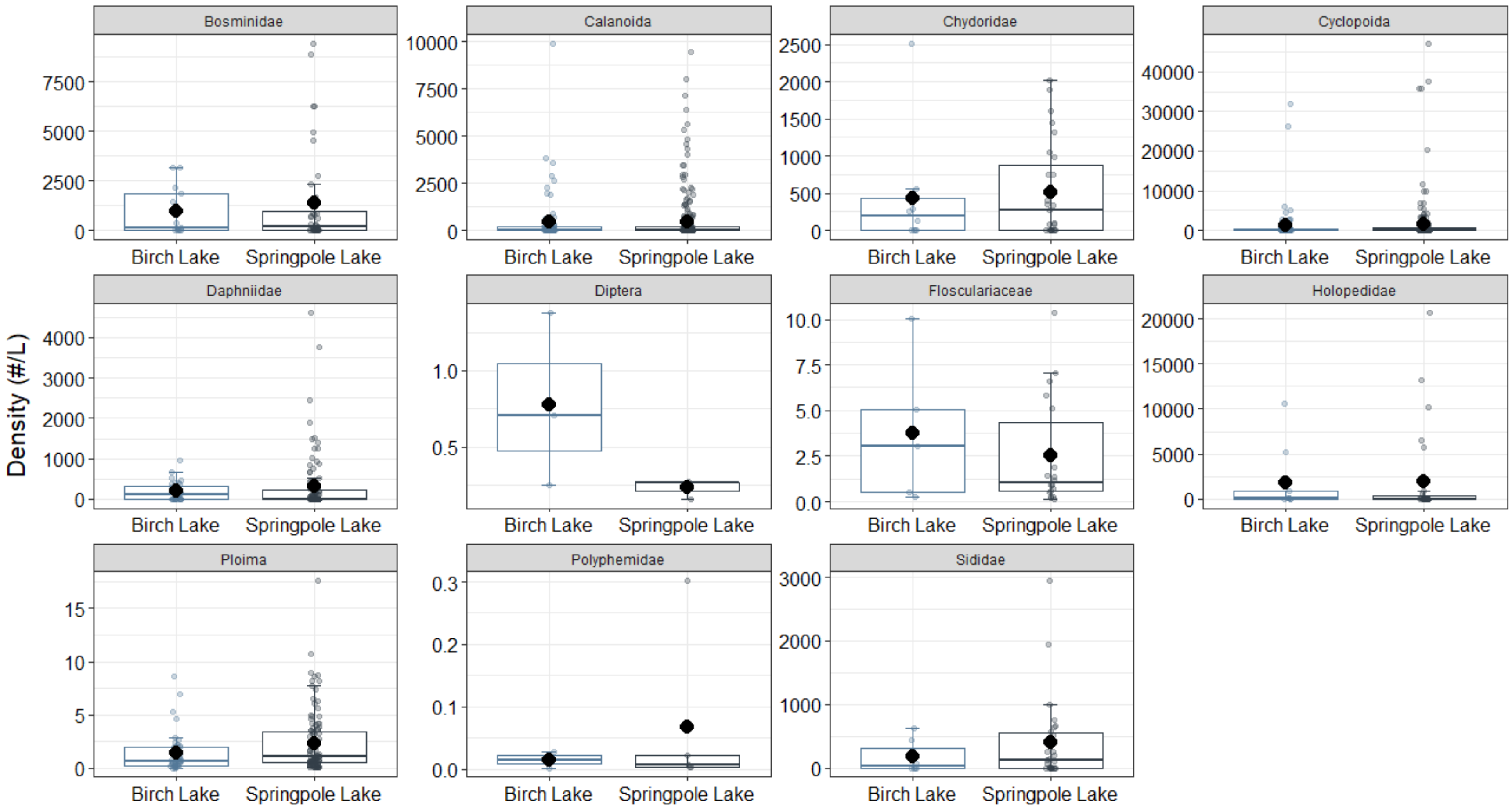


Figure B3: Zooplankton Density by Order for Springpole Lake and Birch Lake

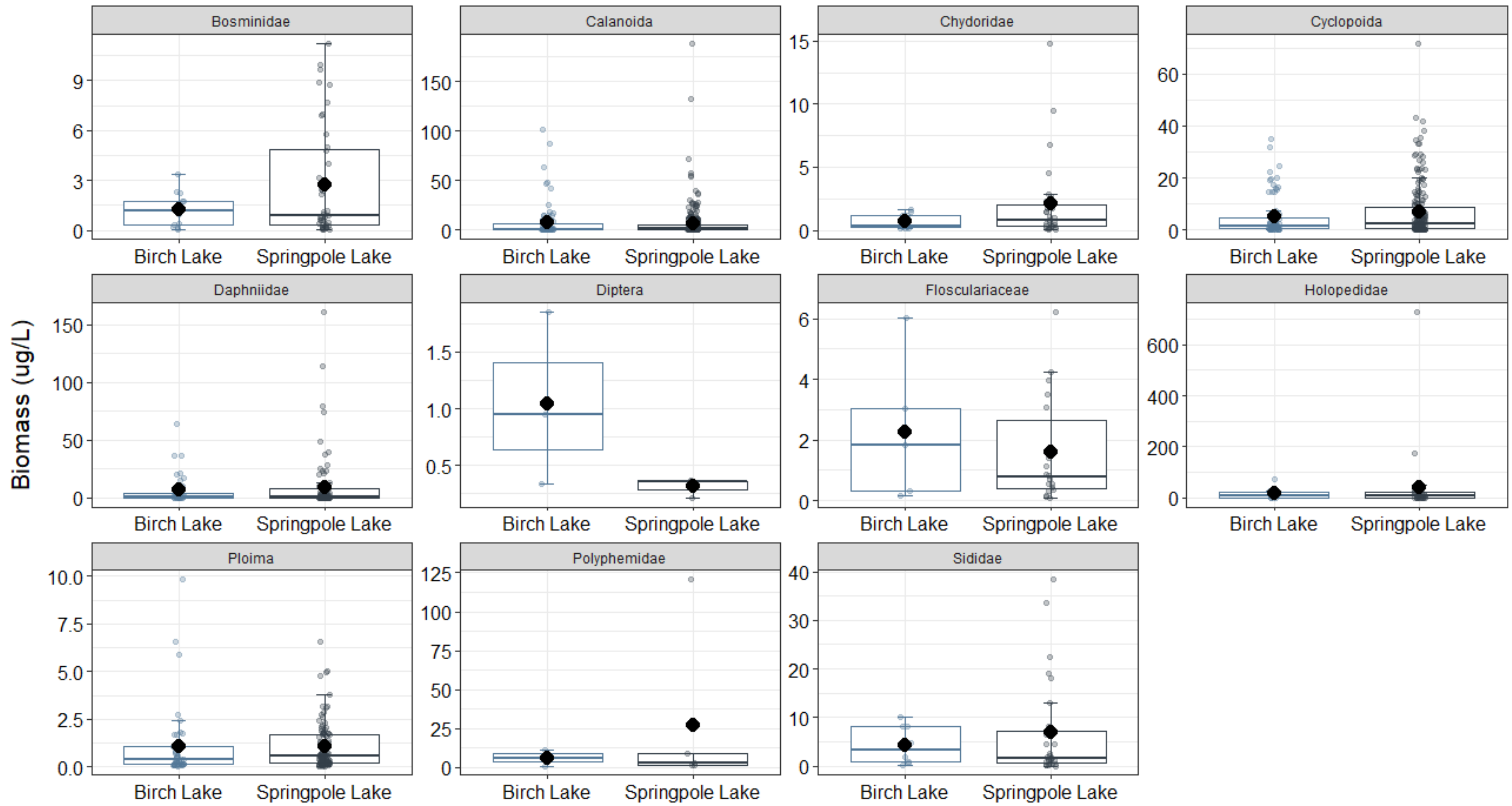


Figure B4: Zooplankton Biomass by Order for Springpole Lake and Birch Lake

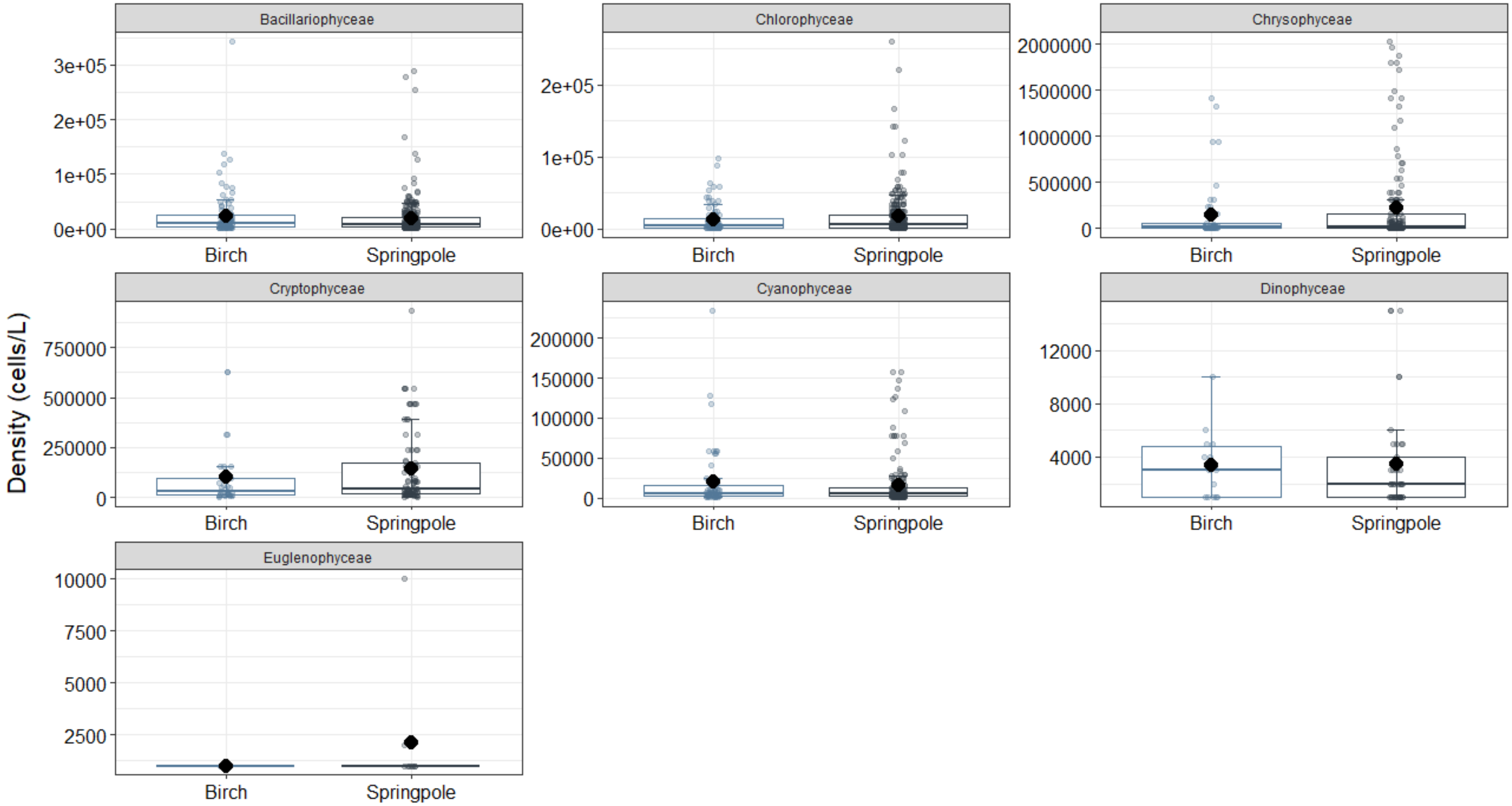


Figure B4: Phytoplankton Density by Class for Springpole Lake and Birch Lake

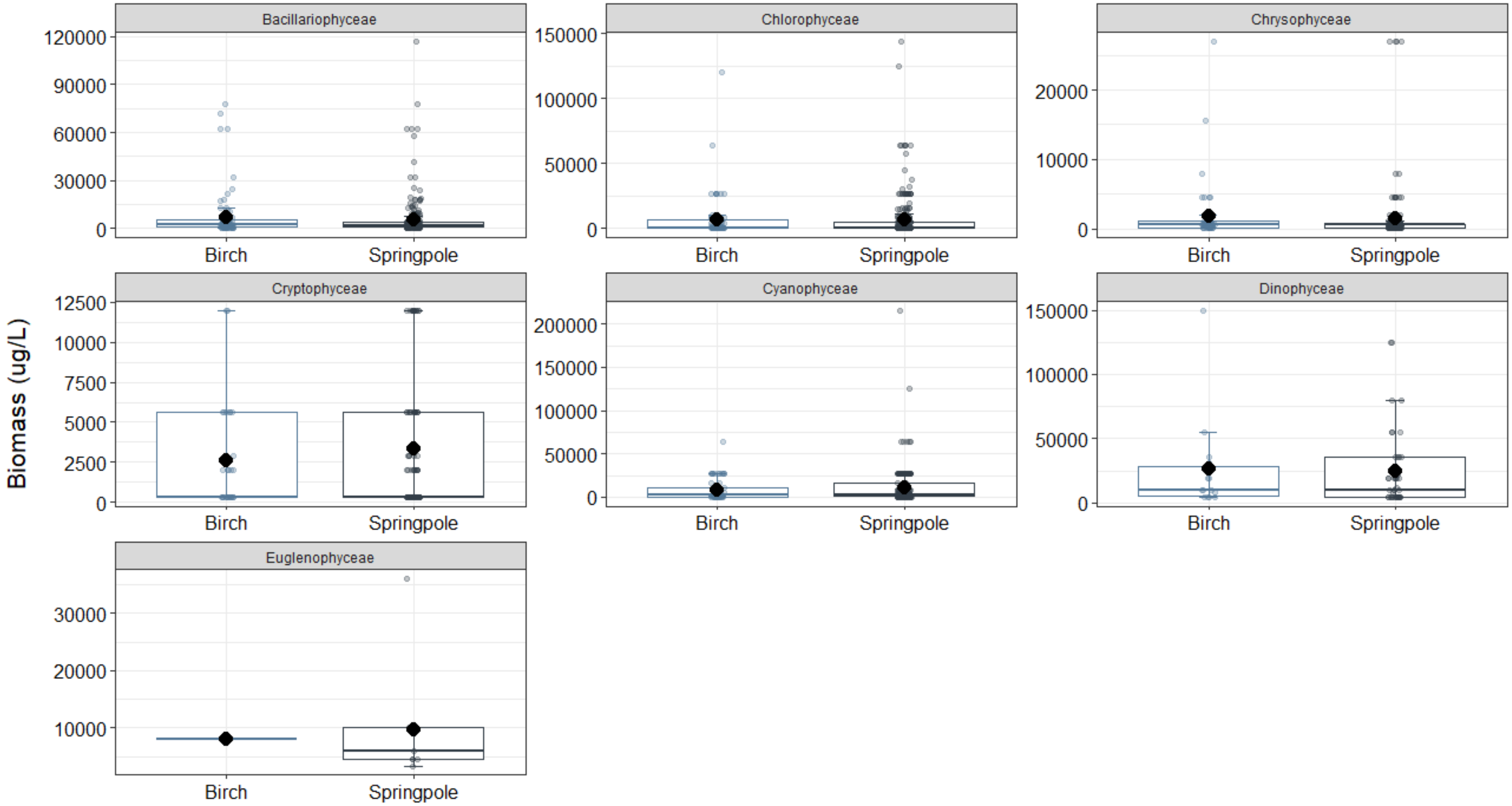


Figure B5: Phytoplankton Biomass by Class for Springpole Lake and Birch Lake

Attachment C
Pathways of Effects Analysis

Attachment C1: Co-disposal Facility – Pathways of Effects Analysis

Work, Activity or Undertaking

Construction, operation and closure of a Co-disposal facility to permanently store mine rock and tailings.

The facility will have a footprint area of 380 ha surrounded by a perimeter road and seepage system which will overprint inland waterbodies and watercourses within the footprint.

A rock quarry will be developed inside the footprint of the CDF to provide construction material .

Surface runoff and seepage will be collected during construction and operations for reuse and or treatment which will reduce flow to adjacent watercourses and waterbodies.

Perimeter roads and ditches will be removed / reclaimed at final closure.

Pathways of Effects

- Vegetation Clearing
- Use of Industrial Equipment
- Placement of material or structures in water
- Water extraction
- Change in timing, duration and frequency of flow
- Fish passage issues
- Structure removal
- Use of explosives

Potential Effects	Mitigation			Remaining Effect to Offset
Change in sediment concentrations	Isolate temporary in-water work zones to maintain clean flow around the work zone at all times.	Limit disturbance to banks or areas adjacent to waterbodies, to the extent required to install the intake.		None
Change in contaminant concentrations	Vehicle and equipment re-fuelling and maintenance conducted away from the water.	Spill containment plan	Runoff and seepage management to follow Provincial and Federal regulation	None
Potential Mortality of fish/ eggs/ ova from equipment	Minimize work area to extent practicable	Remove fish from overprinted waterbodies prior to construction	Avoid work during sensitive seasonal timing periods (spawning)	Some incidental mortality will occur during infilling
Change in habitat structure or cover	Minimize work area to extent practicable	Locate intake in area of common habitat conditions (e.g., non spawning)		Footprint of structure (27.86 ha)
Change in nutrient concentrations	Stabilize disturbed banks and revegetated with native ground cover.	Avoid or minimize the use of fertilizer	Runoff and seepage management to follow Provincial and Federal regulation	None
Change in food supply	Retain 120 m buffer between facility and adjacent Birch and Springpole Lake.	Stabilize disturbed banks and revegetated with native ground cover.	Avoid or minimize the use of fertilizer	None
Direct mortality of fish	Avoid impacts to fishes by excluding, moving, or frightening fishes away from work area	Remove fish from overprinted waterbodies prior to construction	Interim code of practice: end-of-pipe fish protection screens for small water intakes in freshwater	None
Displacement or stranding of fish	Avoid impacts to fishes by excluding, moving, or frightening fishes away from work area	Avoid work during sensitive seasonal timing periods (spawning)	Remove fish from overprinted waterbodies prior to construction	None
Change in migration/access to habitats	Avoid work during sensitive seasonal timing periods (spawning)	Work avoids known migration routes		Flow reductions (7.46 ha)
Interbasin Transfer of Species	All works, and water discharge to occur within the Birch River watershed and the naturally connected flow path.			None
Incidental entrainment, impingement or mortality of resident species	Remove fish from overprinted waterbodies prior to construction	Interim code of practice: end-of-pipe fish protection screens for small water intakes in freshwater		None
Lethal or sublethal effects on fish	Detailed blasting management plan to adhere to DFO guidance (Wright, D.G. and G.E. Hopky. 1998; and Cott, P. and Hanna, B. 2005 or as otherwise determined with DFO)	Avoid impacts to fishes by excluding, moving, or frightening fishes away from work area		None

Attachment C2: Open Pit Basin – Pathways of Effects Analysis

Work, Activity or Undertaking

Construction, operation and closure of an open pit mines.

The facility will have a footprint area of 380 ha surrounded by a perimeter road and seepage system which will overprint inland waterbodies and watercourses within the footprint.

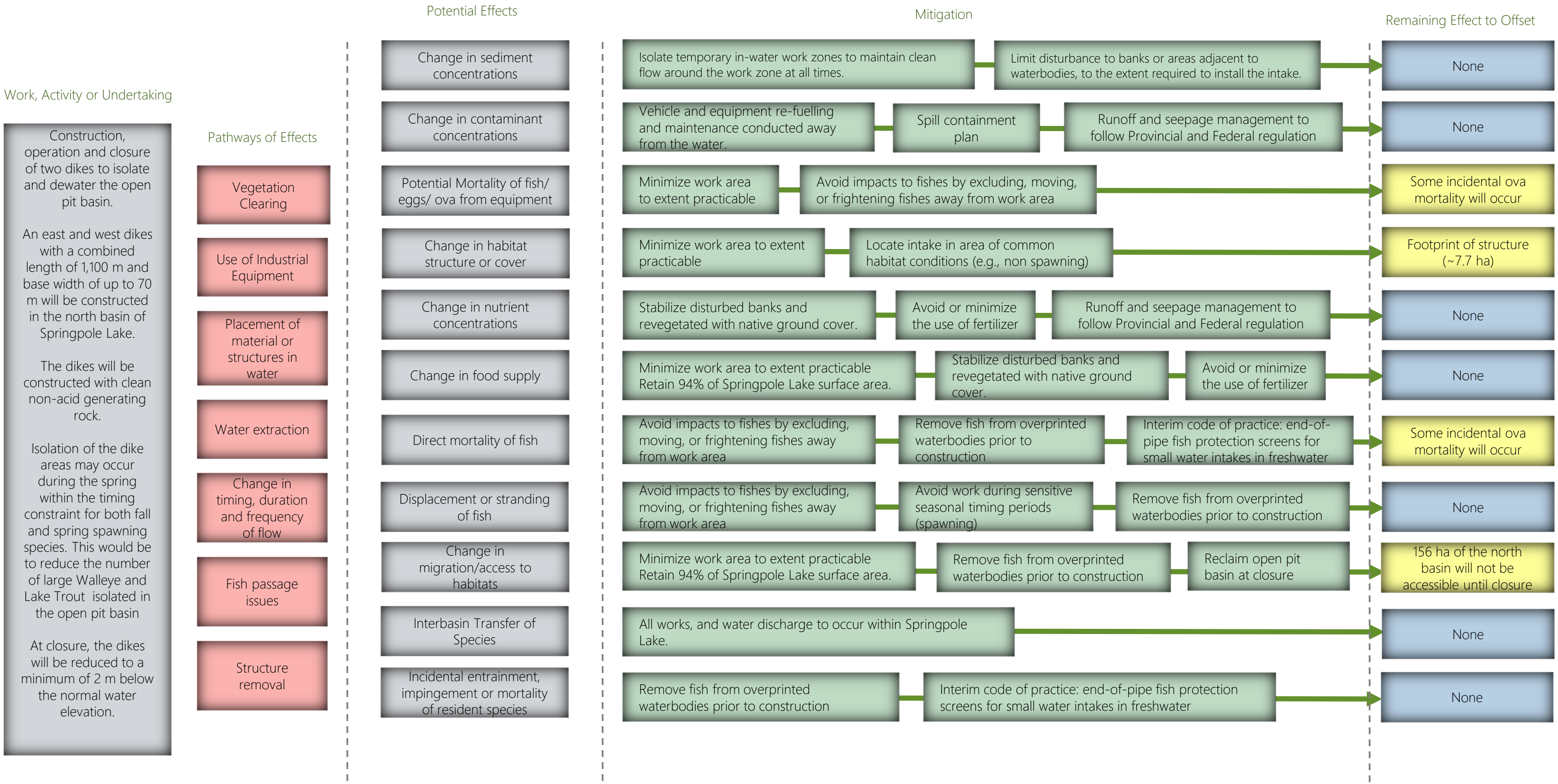
Surface runoff and seepage will be collected during construction and operations for reuse and or treatment which will reduce flow to adjacent watercourses and waterbodies.

Pathways of Effects

- Vegetation Clearing
- Use of Industrial Equipment
- Placement of material or structures in water
- Water extraction
- Change in timing, duration and frequency of flow
- Fish passage issues
- Structure removal
- Use of explosives

Potential Effects	Mitigation	Remaining Effect to Offset
Change in sediment concentrations	Isolate temporary in-water work zones to maintain clean flow around the work zone at all times. → Limit disturbance to banks or areas adjacent to waterbodies, to the extent required to install the intake.	None
Change in contaminant concentrations	Vehicle and equipment re-fuelling and maintenance conducted away from the water. → Spill containment plan → Runoff and seepage management to follow Provincial and Federal regulation	None
Potential Mortality of fish/ eggs/ ova from equipment	Minimize work area to extent practicable → Avoid impacts to fishes by excluding, moving, or frightening fishes away from work area → Avoid work during sensitive seasonal timing periods (spawning)	None
Change in habitat structure or cover	Minimize work area to extent practicable → Locate intake in area of common habitat conditions (e.g., non spawning)	Footprint of Open Pit (71.12 ha)
Change in nutrient concentrations	Stabilize disturbed banks and revegetated with native ground cover. → Avoid or minimize the use of fertilizer → Runoff and seepage management to follow Provincial and Federal regulation	None
Change in food supply	Retain 120 m buffer between facility and adjacent Birch and Springpole Lake. → Stabilize disturbed banks and revegetated with native ground cover. → Avoid or minimize the use of fertilizer	None
Direct mortality of fish	Avoid impacts to fishes by excluding, moving, or frightening fishes away from work area → Remove fish from overprinted waterbodies prior to construction → Interim code of practice: end-of-pipe fish protection screens for small water intakes in freshwater	None
Displacement or stranding of fish	Avoid impacts to fishes by excluding, moving, or frightening fishes away from work area → Avoid work during sensitive seasonal timing periods (spawning) → Remove fish from overprinted waterbodies prior to construction	None
Change in migration/access to habitats	Avoid work during sensitive seasonal timing periods (spawning) → Work avoids known migration routes	None
Interbasin Transfer of Species	All works, and water discharge to occur within Springpole Lake.	None
Incidental entrainment, impingement or mortality of resident species	Remove fish from overprinted waterbodies prior to construction → Interim code of practice: end-of-pipe fish protection screens for small water intakes in freshwater	None
Lethal or sublethal effects on fish	Detailed blasting management plan to follow DFO guidance. → Avoid impacts to fishes by excluding, moving, or frightening fishes away from work area → Avoid work during sensitive seasonal timing periods (spawning)	Area exceeding 50 Kpa overpressure (1.4 ha)

Attachment C3: Dikes – Pathways of Effects Analysis



Attachment C4a: Plant Site and Stockpiles – Pathways of Effects Analysis

Work, Activity or Undertaking

Plant site, stockpiles, laydown areas, accommodation complex, and support roads.

Includes the development of the ore stockpiles, surficial soil stockpile, central water storage pond and associated infrastructure

The intake structure, discharge structure, road and discharge pipeline are assessed separately

Pathways of Effects

- Vegetation Clearing
- Use of Industrial Equipment
- Placement of material or structures in water
- Water extraction
- Change in timing, duration and frequency of flow
- Fish passage issues
- Structure removal

Potential Effects	Mitigation			Remaining Effect to Offset
Change in sediment concentrations	Isolate temporary work zones to maintain clean flow around the work zone at all times.	Limit disturbance to banks or areas adjacent to waterbodies, to the extent required to install the intake.		None
Change in contaminant concentrations	Vehicle and equipment re-fuelling and maintenance conducted away from the water. Equipment shall be free of fluid leaks and externally cleaned before entering the water.	Spill containment plan		None
Potential Mortality of fish/ eggs/ ova from equipment	Avoid impacts to fishes by excluding, moving, or frightening fishes away from work area	Avoid work during sensitive seasonal timing periods (spawning)		None
Change in habitat structure or cover	Minimize work area to diameter of pipeline, anchors and intake structure	Locate intake in area of common habitat conditions (e.g., non spawning)		Footprint of CWSP (11.5 ha)
Change in nutrient concentrations	Replace disturbed substrates with similar composition material.	Stabilize disturbed banks and revegetated with native ground cover.	Avoid or minimize the use of fertilizer	None
Change in food supply	Replace disturbed substrates with similar composition material.	Stabilize disturbed banks and revegetated with native ground cover.	Avoid or minimize the use of fertilizer	None
Direct mortality of fish	Avoid impacts to fishes by excluding, moving, or frightening fishes away from work area	Avoid work during sensitive seasonal timing periods (spawning)	Interim code of practice: end-of-pipe fish protection screens for small water intakes in freshwater	None
Displacement or stranding of fish	Avoid impacts to fishes by excluding, moving, or frightening fishes away from work area	Avoid work during sensitive seasonal timing periods (spawning)	Locate structure in sufficient depth to allow fish movement.	None
Change in migration/access to habitats	Avoid work during sensitive seasonal timing periods (spawning)	Locate structure in sufficient depth to allow fish movement.		None
Interbasin Transfer of Species	All works, water intake and water discharge to occur within the Birch River watershed and the naturally connected flow path.			None
Incidental entrainment, impingement or mortality of resident species	Locate intake in sufficient depth (6-9 m) to reduce interaction with larval fish.	Interim code of practice: end-of-pipe fish protection screens for small water intakes in freshwater		None
Changes in access to habitats	Avoid work during sensitive seasonal timing periods (spawning)	Locate structure in sufficient depth to allow fish movement.		None

Attachment C4b: Fresh Water Intake – Pathways of Effects Analysis

Work, Activity or Undertaking

Freshwater Intake (Birch Lake)

Installation of intake structure and underwater pipeline.

Assumed design to include submerged pipeline anchored to natural substrate with pipe anchors. Structure length to be less than 100 m including intake. Average width of disturbed footprint assumed as 0.5 m. Area is 100 m x 0.5 m = 50m^2 (0.005 ha).

The intake structure and pipeline will be removed at closure.

Pathways of Effects

- Vegetation Clearing
- Use of Industrial Equipment
- Placement of material or structures in water
- Water extraction
- Change in timing, duration and frequency of flow
- Fish passage issues
- Structure removal

Potential Effects	Mitigation			Remaining Effect to Offset
Change in sediment concentrations	Isolate temporary in-water work zones to maintain clean flow around the work zone at all times.	Limit disturbance to banks or areas adjacent to waterbodies, to the extent required to install the intake.		None
Change in contaminant concentrations	Vehicle and equipment re-fuelling and maintenance conducted away from the water. Equipment shall be free of fluid leaks and externally cleaned before entering the water.	Spill containment plan		None
Potential Mortality of fish/ eggs/ ova from equipment	Avoid impacts to fishes by excluding, moving, or frightening fishes away from work area	Avoid work during sensitive seasonal timing periods (spawning)		None
Change in habitat structure or cover	Minimize work area to diameter of pipeline, anchors and intake structure	Locate intake in area of common habitat conditions (e.g., non spawning)		Footprint of structure (0.005 ha)
Change in nutrient concentrations	Replace disturbed substrates with similar composition material.	Stabilize disturbed banks and revegetated with native ground cover.	Avoid or minimize the use of fertilizer	None
Change in food supply	Replace disturbed substrates with similar composition material.	Stabilize disturbed banks and revegetated with native ground cover.	Avoid or minimize the use of fertilizer	None
Direct mortality of fish	Avoid impacts to fishes by excluding, moving, or frightening fishes away from work area	Avoid work during sensitive seasonal timing periods (spawning)	Interim code of practice: end-of-pipe fish protection screens for small water intakes in freshwater	None
Displacement or stranding of fish	Avoid impacts to fishes by excluding, moving, or frightening fishes away from work area	Avoid work during sensitive seasonal timing periods (spawning)	Locate structure in sufficient depth to allow fish movement.	None
Change in migration/access to habitats	Avoid work during sensitive seasonal timing periods (spawning)	Locate structure in sufficient depth to allow fish movement.		None
Interbasin Transfer of Species	All works, water intake and water discharge to occur within the Birch River watershed and the naturally connected flow path.			None
Incidental entrainment, impingement or mortality of resident species	Locate intake in sufficient depth (6-9 m) to reduce interaction with larval fish.	Interim code of practice: end-of-pipe fish protection screens for small water intakes in freshwater		None
Changes in access to habitats	Avoid work during sensitive seasonal timing periods (spawning)	Locate structure in sufficient depth to allow fish movement.		None

Attachment C4c: Treated Effluent Discharge – Pathways of Effects Analysis

Work, Activity or Undertaking

Treated Effluent Discharge (Springpole Lake)

Installation of discharge structure (diffuser) and underwater pipeline. Assumed design to include submerged pipeline anchored to natural substrate with pipe anchors.

Structure length to be less than 100 m including diffuser. Average width of disturbed footprint assumed as 0.5 m. Area is 100 m x 0.5 m = 50m² (0.005 ha).

Diffuser and pipeline to be removed at closure.

Pathways of Effects

- Vegetation Clearing
- Use of Industrial Equipment
- Placement of material or structures in water
- Change in timing, duration and frequency of flow
- Fish passage issues
- Structure removal

Potential Effects	Mitigation	Remaining Effect to Offset
Change in sediment concentrations	Isolate temporary in-water work zones to maintain clean flow around the work zone at all times. → Limit disturbance to banks or areas adjacent to waterbodies, to the extent required to install the intake. → Use diffuser to reduce velocity of discharge to avoid erosion	None
Change in contaminant concentrations	Vehicle and equipment re-fuelling and maintenance conducted away from the water. Equipment shall be free of fluid leaks and externally cleaned before entering the water. → Spill containment plan	None
Potential Mortality of fish/ eggs/ ova from equipment	Avoid impacts to fishes by excluding, moving, or frightening fishes away from work area → Avoid work during sensitive seasonal timing periods (spawning)	None
Change in habitat structure or cover	Minimize work area to diameter of pipeline, anchors and diffuser → Locate discharge in area of common habitat conditions (e.g., non spawning)	Footprint of structure (0.005 ha)
Change in nutrient concentrations	Replace disturbed substrates with similar composition material. → Stabilize disturbed banks and revegetated with native ground cover. → Avoid or minimize the use of fertilizer → Treat effluent to Provincial and Federal criteria	None
Change in food supply	Replace disturbed substrates with similar composition material. → Stabilize disturbed banks and revegetated with native ground cover. → Avoid or minimize the use of fertilizer → Treat effluent to Provincial and Federal criteria	None
Direct mortality of fish	Avoid impacts to fishes by excluding, moving, or frightening fishes away from work area → Avoid work during sensitive seasonal timing periods (spawning)	None
Displacement or stranding of fish	Avoid impacts to fishes by excluding, moving, or frightening fishes away from work area → Avoid work during sensitive seasonal timing periods (spawning) → Locate structure in sufficient depth to allow fish movement.	None
Change in migration/access to habitats	Avoid work during sensitive seasonal timing periods (spawning) → Locate structure in sufficient depth to allow fish movement. → Treat effluent to Provincial and Federal criteria to avoid chemical barrier	None
Interbasin Transfer of Species	All works, water intake and water discharge to occur within the Birch River watershed and the naturally connected flow path.	None
Changes in access to habitats	Avoid work during sensitive seasonal timing periods (spawning) → Locate structure in sufficient depth to allow fish movement.	None

Attachment C5: Access Road and Discharge Pipeline – Pathways of Effects Analysis

Work, Activity or Undertaking

Treated Effluent Discharge (Springpole Lake)

Installation of discharge structure (diffuser) and underwater pipeline. Assumed design to include submerged pipeline anchored to natural substrate with pipe anchors.

Structure length to be less than 100 m including diffuser. Average width of disturbed footprint assumed as 0.5 m. Area is 100 m x 0.5 m = 50m² (0.005 ha).

Diffuser and pipeline to be removed at closure.

Pathways of Effects

- Vegetation Clearing
- Use of Industrial Equipment
- Placement of material or structures in water
- Change in timing, duration and frequency of flow
- Fish passage issues
- Structure removal

Potential Effects	Mitigation	Remaining Effect to Offset
Change in sediment concentrations	Isolate temporary in-water work zones to maintain clean flow around the work zone at all times. → Limit disturbance to banks or areas adjacent to waterbodies, to the extent required to install the intake. → Use diffuser to reduce velocity of discharge to avoid erosion	None
Change in contaminant concentrations	Vehicle and equipment re-fuelling and maintenance conducted away from the water. Equipment shall be free of fluid leaks and externally cleaned before entering the water. → Spill containment plan	None
Potential Mortality of fish/ eggs/ ova from equipment	Avoid impacts to fishes by excluding, moving, or frightening fishes away from work area → Avoid work during sensitive seasonal timing periods (spawning)	None
Change in habitat structure or cover	Minimize work area to diameter of pipeline, anchors and diffuser → Locate discharge in area of common habitat conditions (e.g., non spawning)	Footprint of structure (0.005 ha)
Change in nutrient concentrations	Replace disturbed substrates with similar composition material. → Stabilize disturbed banks and revegetated with native ground cover. → Avoid or minimize the use of fertilizer → Treat effluent to Provincial and Federal criteria	None
Change in food supply	Replace disturbed substrates with similar composition material. → Stabilize disturbed banks and revegetated with native ground cover. → Avoid or minimize the use of fertilizer → Treat effluent to Provincial and Federal criteria	None
Direct mortality of fish	Avoid impacts to fishes by excluding, moving, or frightening fishes away from work area → Avoid work during sensitive seasonal timing periods (spawning)	None
Displacement or stranding of fish	Avoid impacts to fishes by excluding, moving, or frightening fishes away from work area → Avoid work during sensitive seasonal timing periods (spawning) → Locate structure in sufficient depth to allow fish movement.	None
Change in migration/access to habitats	Avoid work during sensitive seasonal timing periods (spawning) → Locate structure in sufficient depth to allow fish movement. → Treat effluent to Provincial and Federal criteria to avoid chemical barrier	None
Interbasin Transfer of Species	All works, water intake and water discharge to occur within the Birch River watershed and the naturally connected flow path.	None
Changes in access to habitats	Avoid work during sensitive seasonal timing periods (spawning) → Locate structure in sufficient depth to allow fish movement.	None

Attachment C6: Transmission Line – Pathways of Effects Analysis

Work, Activity or Undertaking

Treated Effluent Discharge (Springpole Lake)

Installation of discharge structure (diffuser) and underwater pipeline. Assumed design to include submerged pipeline anchored to natural substrate with pipe anchors.

Structure length to be less than 100 m including diffuser. Average width of disturbed footprint assumed as 0.5 m. Area is 100 m x 0.5 m = 50m² (0.005 ha).

Diffuser and pipeline to be removed at closure.

Pathways of Effects

- Vegetation Clearing
- Use of Industrial Equipment
- Placement of material or structures in water
- Change in timing, duration and frequency of flow
- Fish passage issues
- Structure removal

Potential Effects	Mitigation	Remaining Effect to Offset
Change in sediment concentrations	Isolate temporary in-water work zones to maintain clean flow around the work zone at all times. → Limit disturbance to banks or areas adjacent to waterbodies, to the extent required to install the intake. → Use diffuser to reduce velocity of discharge to avoid erosion	None
Change in contaminant concentrations	Vehicle and equipment re-fuelling and maintenance conducted away from the water. Equipment shall be free of fluid leaks and externally cleaned before entering the water. → Spill containment plan	None
Potential Mortality of fish/ eggs/ ova from equipment	Avoid impacts to fishes by excluding, moving, or frightening fishes away from work area → Avoid work during sensitive seasonal timing periods (spawning)	None
Change in habitat structure or cover	Minimize work area to diameter of pipeline, anchors and diffuser → Locate discharge in area of common habitat conditions (e.g., non spawning)	Footprint of structure (0.005 ha)
Change in nutrient concentrations	Replace disturbed substrates with similar composition material. → Stabilize disturbed banks and revegetated with native ground cover. → Avoid or minimize the use of fertilizer → Treat effluent to Provincial and Federal criteria	None
Change in food supply	Replace disturbed substrates with similar composition material. → Stabilize disturbed banks and revegetated with native ground cover. → Avoid or minimize the use of fertilizer → Treat effluent to Provincial and Federal criteria	None
Direct mortality of fish	Avoid impacts to fishes by excluding, moving, or frightening fishes away from work area → Avoid work during sensitive seasonal timing periods (spawning)	None
Displacement or stranding of fish	Avoid impacts to fishes by excluding, moving, or frightening fishes away from work area → Avoid work during sensitive seasonal timing periods (spawning) → Locate structure in sufficient depth to allow fish movement.	None
Change in migration/access to habitats	Avoid work during sensitive seasonal timing periods (spawning) → Locate structure in sufficient depth to allow fish movement. → Treat effluent to Provincial and Federal criteria to avoid chemical barrier	None
Interbasin Transfer of Species	All works, water intake and water discharge to occur within the Birch River watershed and the naturally connected flow path.	None
Changes in access to habitats	Avoid work during sensitive seasonal timing periods (spawning) → Locate structure in sufficient depth to allow fish movement.	None

Attachment D
Lake Sturgeon Research Proposal

PROPOSAL

Springpole Gold Project Complementary Offsetting Measure: Lake Sturgeon Research Program

Proposal Draft

Submitted to:

Submitted by:

WSP Canada Inc.

Suite 200 - 2920 Virtual Way, Vancouver, British Columbia, V5M 0C4, Canada

+1 604 296 4200

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1.0 BACKGROUND AND RATIONALE

First Mining Gold (FMG) is proposing an open pit mine (the Project) located beneath Springpole Lake within the Canadian Shield in northwestern Ontario (Figure 1). The construction and operation of the Project will be subject to fish and fish habitat protection provisions of the federal *Fisheries Act* that are administered by Fisheries and Oceans Canada (DFO). These provisions regulate works, undertakings or activities that risk harming fish and fish habitat and prohibit against causing the death of fish, by means other than fishing, and the harmful, alteration, disruption, and destruction (HADD) of fish habitat unless authorization is obtained from DFO. As part of a *Fisheries Act Authorization* (FAA), fish habitat offsetting measures are also required to be developed, approved, and implemented as part of the Project, which may include the restoration, enhancement, and/or creation of habitat (DFO 2019). In addition to these measures, an offsetting plan can also include an option for complementary measures including the implementation of research and development activities. Complementary measures, such as data collection and scientific research, are intended to address substantial knowledge deficiencies in the conservation and protection of fish and their habitats (DFO 2019). These measures aim to establish fisheries management goals and local restoration priorities and should offer benefits beyond those provided by existing research or data collection programs.

Given the remote Project location, there is limited information available on current fish and fish habitat, including the conservation and protection of species in the region other than that collected for the Project. As such, the development of a research program is proposed as a complementary measure to the offsetting plan. Through direction of local Indigenous communities, the restoration of potentially extirpated Lake Sturgeon (*Acipenser fulvescens*) populations to Springpole Lake and the surrounding watersheds has been identified as a key objective for a complementary offsetting measure. To successfully implement a recovery program for Lake Sturgeon, knowledge gaps, such as current population status and distribution throughout the system, must be investigated. This proposal outlines a research program in collaboration with specialized academic researchers at the University of Manitoba and the University of Winnipeg aimed at examining current species distribution and abundance of Lake Sturgeon and the potential stressors that likely led to their reduced abundance and distribution in the Project area.

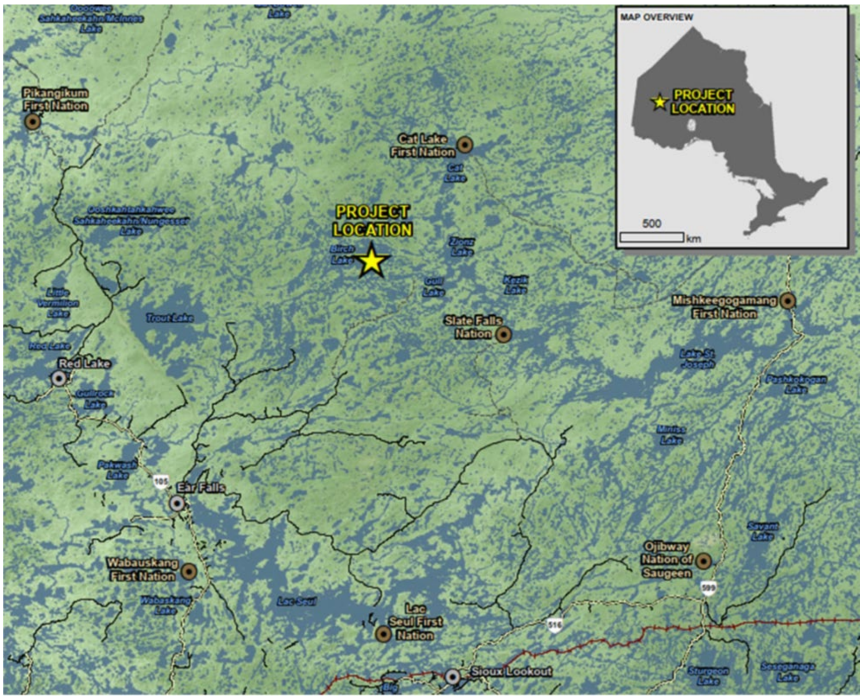

Figure 1: Map of Study Area Including the Project Location in Northwestern Ontario

Baseline Information

Springpole Lake has a surface area of 2,860 ha including a large, generally circular northern basin connected to a long and narrow southeast arm by a shallow channel (Figure 2; Wood 2021). Several deep holes exist on the lake ranging in depths from approximately 20 to 30 m. The lake is predominantly rocky with a heterogeneous shoreline containing numerous islands and rocky shoals. Baseline studies examining aquatic resources in the Project area have been conducted and fisheries and benthos data were used to characterize local aquatic ecosystems and determine environmental sensitivities to potential adverse effects (Wood 2021). During summer sampling efforts, temperatures ranged from 16 to 20°C in the shallower regions of the lake to 3 to 16°C in deeper areas. Habitats in the Project area were characterized to support two general fish community types including coolwater and coldwater species. Coolwater fish communities such as Walleye (*Sander vitreus*) and Northern Pike (*Esox lucius*) inhabit more shallow, productive waters with optimal temperatures of 15°C to 25°C (Scott and Crossman 1998), while coldwater species including Lake Trout (*Salvelinus namaycush*) and Lake Whitefish (*Coregonus clupeaformis*) prefer habitats characterized by cold (i.e., below 15°C), deep, and oligotrophic habitats (Scott and Crossman 1998).

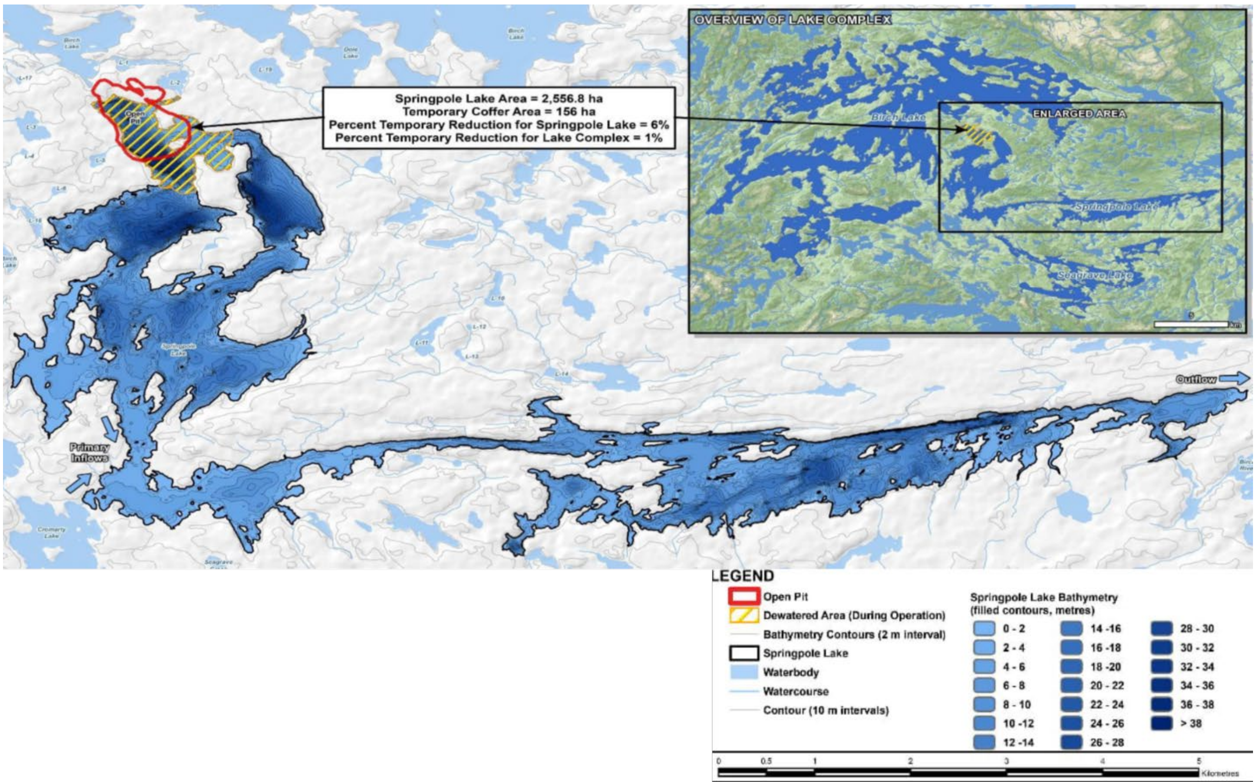

Figure 2: Bathymetric Map of Springpole Lake

Traditional knowledge from members of Slate Falls Nation (SFN), Mishkeegogamang Ojibway First Nation (MOFN), Lac Seul First Nation (LSFN), and Cat Lake First Nation (CLFN) have identified the historical presence of Lake Sturgeon (Na me in Ojibwe) in rivers and lakes surrounding the Project study area, including the Cat River system which Springpole Lake is a part of. Suitable habitat for Lake Sturgeon is present in Springpole Lake including a mixture of relatively shallow habitat (2 to 3 m) and deeper, cooler habitats (>9 m) with a series of connecting rivers (Wood 2021). Several historic spawning sites exist throughout the region between Lake St. Joseph and Cat Lake, and Lake St. Joseph and Shabumeni Lake, consisting of fast-flowing waters up to 5 m in depth with a mix of gravel, cobble, and boulder bottom (Dick et al 2006, Wood 2021). To confirm the presence / absence of Lake Sturgeon in the system, netting programs targeting Lake Sturgeon have been conducted on Springpole Lake and sections of the Birch River between Birch Lake and Springpole Lake since 2011 (MNRF

2015). Additionally, environmental DNA (eDNA) sampling was conducted in the spring and summer of 2022 and spring 2023 including metabarcoding and species-specific qPCR methods. Despite these efforts, no captures or eDNA detections of Lake Sturgeon have been reported. These results suggest that populations of Lake Sturgeon in the system are either small, making them elusive to find, or that they may have been extirpated from the region.

Theorized reasoning for the decline in Lake Sturgeon populations in the system may have been due to the construction of the Rat Rapids and Cedar's Channels hydroelectric dams in 1935 resulting in a loss of upstream access for the Albany River population (Mishkeegogamang First Nation 2010). Habitat fragmentation, particularly from the construction of hydroelectric facilities, has been identified as the primary factor that affects population abundance of Lake Sturgeon in Ontario (Haxton et al 2015). As a potadromous species with a large migratory range, hydroelectric dams may modify river habitats and act as physical barriers for Lake Sturgeon (Haxton et al 2014, Haxton et al. 2015). Additionally, a significant number of hydroelectric and water control structures have been constructed on historical spawning grounds of Lake Sturgeon, as these locations are typically the sites with the highest hydraulic head within tributaries (Auer 1999). Such modifications can have negative impacts on the recruitment and therefore recovery and productive capacity of a population compared to unregulated and unfragmented systems that facilitate annual recruitment (Daugherty et al 2009, Pratt et al 2014). Quantified data on the historical abundance of Lake Sturgeon in the Lake St. Joseph drainage basin is not available; thus, these inferences on the cause of population decline in the study area are qualitative and should be addressed to better execute a recovery plan and proposed alternative offsetting measure for the Project.

2.0 OBJECTIVES

Despite recent sampling efforts, knowledge gaps regarding the historic and current status of Lake Sturgeon in Springpole Lake and the surrounding watershed exist. To successfully implement a recovery program for Lake Sturgeon as an alternative offsetting measure for the Project, and satisfy requirements from DFO for an FAA, further research is required. The primary objective of the proposed research program is to demonstrate the need and likelihood of success for a Lake Sturgeon recovery program. This objective will take a two-phased approach including:

Stage 1: Understand current Lake Sturgeon distribution and abundance; Identify past distribution and abundance; Identify potential stressors and causes of reduced abundance; Investigate the probability of recovery if reintroduced.

Stage 2: Establish a rehabilitation or restocking program of Lake Sturgeon as an offsetting measure for the dewatering of the lake and construction of the mine.

3.0 PARTNERSHIP STRUCTURE

The research program would be funded and coordinated by FMG. FMG will also arrange and coordinate the collection of Indigenous knowledge during the research to aid in the collection and interpretation of data. The research, data interpretations and documentation of the findings would be completed by a team or researchers from the University of Manatoba and University of Winnepeg. The proposed research team is provided below

Dr. W. Gary Anderson, University of Manitoba – Principal Investigator

Dr. Anderson graduated with a PhD from the University of St. Andrews in Scotland in 1995. He then moved to Waterloo, Ontario where he spent 2 years as an environmental consultant and first worked with Lake Sturgeon designing and testing diversion systems for implementation at a hydro dam on the Ground Hog River in North Western Ontario. After this stint as an environmental consultant, he returned to academia for six years of post-doctoral research at the University of St. Andrews before obtaining a faculty position in the Department of Biological Sciences at the University of Manitoba in 2004. During his tenure as a faculty member Dr. Anderson was awarded a number of NSERC Collaborative Research and Development grants with Manitoba Hydro as the industrial partner and in 2015 Dr. Anderson was awarded a NSERC/Manitoba Hydro Industrial Research Chair in Conservation aquaculture of Lake Sturgeon and the funding was renewed in 2020 for a second five-year term. He served as member at large for three years and as Secretary on the Board of Governors for the North American Sturgeon and Paddlefish Society for three years. He and the people in his lab have presented their research findings associated with Lake Sturgeon every year since 2005 at national and international scientific meetings. Dr. Anderson has worked collaboratively with MB Hydro and partners in understanding factors that limit Lake Sturgeon distribution in the Winnipeg River; how natural and anthropogenic barriers may have influenced population structure and the impact of early life history on phenotypic development. He has worked with more than ninety undergraduate students, graduate students, post-doctoral fellows and technicians and with them published over sixty peer reviewed manuscripts on Lake Sturgeon physiology and ecology. Knowledge generated from the work conducted by the students, techs and PDFs in his lab has led to improved rearing strategies for Lake Sturgeon in conservation hatcheries. Further, his lab has developed novel marking techniques using stable isotopes of trace elements and/or elemental composition of the environment the fish resides in to understand habitat use of Lake Sturgeon. Research from his lab has also utilised chemical signatures in fin rays to determine key life history traits such as onset of sexual maturation which has important management implications for the conservation of the species. Most relevant to the present proposal in collaboration with Dr. Docker, they have developed two eDNA assay's for the detection Lake Sturgeon environmental DNA derived from mitochondrial and nuclear genetic material.

Dr. Margaret Docker, University of Manitoba – Co-Investigator

Dr. Docker obtained her PhD in Fisheries and Aquatic Sciences from the University of Guelph in 1992. As a postdoctoral researcher, she worked with Fisheries and Oceans Canada (at the Pacific Biological Station and West Vancouver Laboratory), as well as at several academic institutions (the University of New Hampshire, University of Northern British Columbia, and University of Windsor) before obtaining a faculty position at the University of Manitoba in 2006. She is now a Professor in the Department of Biological Sciences at the University of Manitoba. Her research focuses on population genetics of freshwater fish species of conservation concern and aquatic invasive species, and on developing and using eDNA tools for conservation and management. She is one of three co-leads on a multi-million-dollar Canada-wide initiative (GEN-FISH) funded by Genome Canada to develop genomic tools for the efficient assessment of the distribution and health of Canada's freshwater fishes (https://gen-fish.ca/); other funding comes from NSERC, Manitoba Habitat Heritage Corporation, Great Lakes Fishery Commission, and DFO Species at Risk Program. She has published over 100 peer-reviewed journal articles and book chapters, is editor of a two-volume book on the biology of lampreys for Springer's Fish and Fisheries series, is Editor-in-Chief of the journal Environmental Biology of Fishes, and is Co-chair of the Freshwater Fishes Species Specialist Subcommittee of the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). Dr. Docker will serve as a co-Researcher and be a member of the trainee's thesis advisory committees.

Dr. Cale Gushulak, University of Manitoba – Co-Investigator

Dr. Gushulak obtained his Ph.D. from Queen's University in 2020 where he used paleolimnological techniques to investigate changes in lake production and phototroph community composition in northern Ontario boreal lakes. He then held a three-year postdoctoral position in the Institute of Environmental Change and Society (IECS) at the University of Regina examining the effects of historical and current changes in land use, agricultural development, hydrologic management, and climate on the eutrophication of prairie lakes and wetlands in Saskatchewan and Manitoba. Dr. Gushulak then briefly took a second postdoctoral position at the Center for Limnology at the University of Wisconsin-Madison before becoming a faculty member at the University of Manitoba in 2024. Dr. Gushulak's research primarily uses paleolimnology to assess changes in water quality through time using biogeochemical markers (e.g., stable isotopes, photosynthetic pigments, algal sub-fossils) preserved in lake sediments. He has used these methodologies on a variety of lake and wetland systems in varied environments (boreal, montane, prairie, urban) and over multiple timescales (annual to millennial) to identify specific drivers and magnitudes of ecosystem changes in response to historic processes. In this project, Dr. Gushulak will apply methods of extracting eDNA from sediment samples to be used by Drs. Docker and Anderson to determine the presence or absence of Lake Sturgeon, as well as other fish population and community parameters in Springpole Lake through time.

Dr. Caleb Hasler, University of Winnipeg – Co-Investigator

Dr. Hasler holds a Ph.D. from Carleton University (2011) and a M.Sc. from Queen's University (2007). After his studies, he worked for three years as a consulting biologist and project manager at a national consulting company before returning to academic research as a postdoctoral research associate at the University of Illinois – Urbana/Champaign. In 2017, he joined the University of Winnipeg and is now an Associate Professor in the Department of Biology and Chancellor's Research Chair. His research program is funded by NSERC Discovery, NSERC Alliance, Manitoba Hydro, Research Manitoba, and the Manitoba Fisheries and Wildlife Enhancement Fund. Dr. Hasler's lab studies the impacts of environmental change on fish behaviour and physiology and conducts research to understand the effects anthropogenic activities, like hydropower and fisheries, have on fish and other freshwater organisms. He has mentored over 80 undergraduate and graduate students, and one postdoctoral fellow. He has co-edited two books on fish biology and fisheries science and authored 90 peer reviewed manuscripts. Relevant to this proposal, Dr. Hasler has recently collaborated with Dr. Docker on two eDNA focused studies and he has worked on Lake Sturgeon behaviour with Dr. Anderson. He has completed habitat models for largemouth bass and Blanding's turtles; and, has worked closely with industry partners to assess species-at-risk habitat needs and mitigations.

4.0 METHODOLOGY

WORK PACKAGE 1

Habitat Mapping and Food Availability

First, we will perform desktop and data gap analyses to identify historical range of Lake Sturgeon in the area as well as evidence of potential extirpation. We will then assess potential stressors and causes of reduced abundance and distribution. This will involve a review of monitoring reports and provincial and federal status reports and will identify what additional data may be needed. A specific focus of the desktop studies will be to examine any habitat mapping that has been either completed or inferred. Lake Sturgeon are a benthic species that feed primarily from the substrate; thus, knowing lake floor composition and water quality will aid in sampling efforts and determination of food availability (i.e., prey items). Ultimately, our desktop and data gap analyses will help to determine the likelihood that Lake Sturgeon were once present in Springpole Lake and what areas of the lake and river system they may be most likely to still be found. We will also be better able to comment on the likelihood that re-introduction of Lake Sturgeon would be successful.

Regardless of the existing data, we will need to sample Springpole Lake and the Birch River system including downstream of Rat Rapids and Cedar's Channels hydroelectric dams on the Albany River, for current habitat conditions and food availability. Habitat and food availability are key requirements to sustain a Lake Sturgeon population or to facilitate re-introduction. Lake Sturgeon inhabit large lakes and rivers in northwestern Ontario and are considered to be bottom dwellers (benthic) where they prefer fine to medium sand substrates and are often found near areas where there is current. Juvenile and adult Lake Sturgeon primarily feed on small food items found in or near the substrate, including, aquatic insects (mainly Trichopetera, Diptera, and Ephemeroptera, Barth et al. 2013), crayfish, and other benthic invertebrates, such as mussels (Barth et al. 2013). Fish-derived organic material such as eggs and fish carrion can also be a significant energy-source for Lake Sturgeon (Smith et al. 2016). To determine where Lake Sturgeon may be found and what the current conditions of existing habitat for them is, a detailed habitat and food availability study is needed.

To support re-introduction efforts and to quantify habitat and food availability for juvenile and adult Lake Sturgeon, we will use two approaches. The first approach will be to undertake a "classic" assessment of the benthic environment and the macroinvertebrate community. This will involve point sampling substrate, water velocity at depth, temperature, dissolved oxygen, water depth, and other limnological parameters. In addition, seasonal profiles for temperature, dissolved oxygen, and pH will be created for a few key locations in the study area using multiparameter sondes and habitat mapping of areas of interests will be mapped using a sonar system. The collected data will permit the creation of a habitat availability model that will be useful for targeting sampling efforts for the remainder of the work plan (e.g., spawning areas), will help to understand any positive eDNA results for Lake Sturgeon, and aid discussions about re-introduction efforts.

As part of the above sampling, the substrate and benthic macroinvertebrate community will be sampled using sediment grabs. Any macrofauna will be filtered from the substrate sample and enumerated by taxa. Importantly, visual identification of prey items to species-level is difficult and time consuming but is required to fully understand the benthic macroinvertebrate community and overall ecosystem health. This will be complemented with a second approach called DNA metabarcoding. DNA metabarcoding is a modern technique that's use has expanded in the last two decades (e.g. Emilson et al., 2017; Emmons et al., 2023). The approach relies on previously catalogued 'bar code' regions that have been sequenced from particular fragments of a species genome (often using the cytochrome c oxidase I (COX1) gene). The 'meta' approach to barcoding simply refers to the high throughput sequencing that allows for the identification of multiple species from a sample in parallel. For juvenile and adult Lake Sturgeon, which would likely be the focus of the early years of a re-introduction program, we will sample for macrofauna. Because we are only focused on macrofauna, bulk DNA metabarcoding is used. This involves preprocessing and separating the macroinvertebrates from the sediment by sieving and then preserving the collected specimens in the field. DNA is then extracted and samples are processed (i.e., sequenced and sequences identified) by the Canadian Centre for DNA Barcoding (CCDB) in Guelph, Ontario.

Work Flow

The desktop review will occur first and help to identify key locations for habitat sampling. For profile samples we will chose up to five sampling sites to deploy multiparameter sondes. Fifty sampling points throughout the study area will be randomly chosen for substrate/food availability assessment and water quality measurements at surface and depth. The sondes can be deployed for most of the ice-free period, and the random sampling points should be visited three times over the course of the ice-free period. Once the end-of-year sampling is completed, data can be graphically presented and summarized to determine important Lake Sturgeon habitat (e.g., areas with current, appropriate temperature, dissolved oxygen, and substrate).

Substrate and prey item sampling will occur in tandem with the random point sampling. This will involve using a Van Veen grab sampler. This is a device that, once it reaches the substrate, it closes collecting the upper 20 cm of substrate and anything dwelling in it. The sampler is then brought on board and emptied into a bin. Onshore, using sieves with varying sized openings, the sample is then 'washed' and the substrate composition is quantified and any macrofauna will be collected. Some of the collected macrofauna will be photographed and fixed in ethanol for identification in the lab. The remaining macrofauna will be fixed in ethanol and frozen for bulk DNA metabarcoding. eDNA metabarcoding analysis will be conducted following protocols established at the CCDB (e.g., Emilson et al. 2017). In brief, each macroinvertebrate sample will be homogenized in a sterile blender, transferred to a 50 mL falcon tube and incubated at 56 °C to evaporate excess ethanol, and DNA will be extracted using a commercially available kit. The well-established CO1 BE marker from each sample will be amplified through a two-step PCR regime using the B forward and E reverse primers, with products of the first round of PCR being purified prior to a second round of PCR to attach the Illumina-tailed primer required for sequencing. Purified Illumina-tailed amplicons will be dual indexed and sequenced on an Illumina MiSeq flow cell. Resulting sequences will be processed using a semi-automated bioinformatics pipeline established by

CCBD; briefly, raw paired-end sequences will be assembled and primer sequences will be removed, and then sequences will be clustered at 98% sequence similarity into Operational Taxonomic Units (OTUs) and compared to a COI reference database for taxonomic identification (e.g., to species, genus, or family). Importantly, while the reference database of macrofauna at the CCDB is extensive, it is not comprehensive so we have included additional sequencing costs into this work package to ensure as complete coverage of macrofauna as possible given the importance of this baseline work on understanding success of repatriation efforts.

WORK PACKAGE 2

eDNA Monitoring:

Environmental DNA or eDNA was first used in an ecological context in the early '90's (Amos et al.,1992), but did not really gain traction in the community until it was demonstrated as a viable method to determine presence/absence of invasive Bighead Carp (*Hypophthalmicthys nobillis*) and Silver Carp (*H. molitrix*) in canals around Chicago, IL, USA (Jerde et al. 2011). Since then, the field has exploded with a journal launched in 2019 dedicated to the discipline and many other journals publishing papers using eDNA methods. Research questions examined using eDNA in aquatic systems are well past binary questions of presence and absence of a single species with studies now including metabarcoding (for community composition), relative abundance based on eDNA signal strength, and determination of life stage for a given species. In 2018, the Docker lab developed a Lake Sturgeon species-specific eDNA assay based on the detection of the commonly used mitochondrial gene cytochrome B (cyt B) that was validated in a laboratory setting and field tested in the Winnipeg River (Yusishen et al., 2020). Recent collaborative work between the Anderson and Docker labs lead by current MSc student M. Anderson has involved further field testing of this assay throughout the Winnipeg River (Anderson M., unpublished).

Mitochondrial DNA (mtDNA) is most commonly used in the development of eDNA assays due to the abundance of mitochondrial genes per cell, 100's - 1000's of copies (Cole 2016) that may be shed into the environment by the target species. However, nuclear DNA (nuDNA) also provides the opportunity to develop species-specific eDNA assays (Jo et al., 2021 & 2022) and aids in how we may interpret the ecological relevance of changes in eDNA concentration in the environment we are assessing. Therefore, development and implementation of both assays increases the inference one can make from detection of this genetic material from water samples. For example an increase in eDNA using a mtDNA assay may indicate an increase in mass of the target species in a given area but combined with an increase in nuDNA (which is in high concentration in gametes, particularly sperm) allows the researcher to infer a biological reason for increased mass of the target species, such as a spawning aggregation (Holmes et al. 2022). Work from Dr. Docker's lab in collaboration with Dr. Anderson has developed a genus specific eDNA assay for sturgeon based on the nuclear internal transcribed spacer (IST1) region that lies between the small and large subunits of the ribosomal RNA (rRNA) gene sequence (Anderson M., unpublished). Laboratory and field testing of this assay holds promise in that the concentration of both the nuclear and mitochondrial target genes, using the developed eDNA assays, are positively correlated with likely spawning events by Lake Sturgeon in the Winnipeg River. While the validity and strength of eDNA sampling and testing continues to be refined and developed, there remain some drawbacks that can limit the scope of investigation and hinder rapid decision making processes. One such drawback for contemporary eDNA techniques and technology is that the assays take time; (at least 2–3 days between water collection in the field and sample processing in the lab using most methods). Furthermore, the sensitivity of detection, a major advantage of eDNA over conventional capture-based sampling (McKelvey et al. 2016; Strickland and Roberts 2019) also means that field sampling needs to be meticulous to avoid contamination and the introduction of false positives. Samples are generally collected on site, brought back to the lab and processed by extraction of DNA, then assessment using standard molecular techniques such as PCR. These techniques do require substantial training to perfect. Validation of samples and appropriate controls can take time and the collected samples also require appropriate preservation (eg cold temperature), something that can be challenging when in remote locations.

Concurrent with recent development of PCR based eDNA technologies, gene editing technologies have revolutionised medical research. Development of CRISPR (clustered regularly interspaced short palindromic repeats) technology is based off a naturally occurring defense mechanism identified in bacterial cells (Barrangou, et al., 2007) and is used to identify genetic mutations, promote drug development and understand disease models in humans among other biomedical applications. While the fields of ecology and conservation biology have not fully embraced these gene editing technologies, the CRISPR-based SHERLOCK assay (Specific High-sensitivity Enzymatic Reporter unLOCKing), primarily developed for diagnostic healthcare, has been shown to have promise in species detection in the field (Baerwald et al. 2020) and effectiveness in detection of species from eDNA sampling (Williams et al. 2019). A few major benefits of this technology for use in conservation biology are: remarkable species specificity and speed of analysis, potential for near instantaneous results at streamside. The speed of analysis is largely facilitated by needing only a single temperature to amplify the target product – making it amenable for development of instrumentation that allows for detection of a target genetic sequence in the field. Further, the specificity and isothermal reaction conditions allow for the potential to use lateral flow technology (similar to the technology used in store-bought COVID tests) thereby negating the need for instrumentation. However, it is important to balance time with resolution of the target signal in choosing the appropriate assay and measurement device. Regardless, CRISPR technology facilitates high resolution genetic identification of a target species in the field within one hour of sampling, making it an attractive technology for use in ecology and conservation biology.

Work Flow

The Docker lab has been working with eDNA assays for the past 10 years and has now developed species specific eDNA assays for almost 80 species in Manitoba and beyond. More recently, in collaboration with Dr. Anderson, they have developed mtDNA- and nuDNA- based eDNA assays for Lake Sturgeon, and MSc student M. Anderson is currently validating these assays from field and lab studies. In year one of the project, we propose to continue eDNA sampling throughout the Springpole Lake and Birch River system including downstream of Rat Rapids and Cedar's Channels hydroelectric dams on the Albany River. Through the habitat surveys identified from work package 1, likely spawning areas would be identified in year one so there would be a focus of sampling in these regions. Winter eDNA sampling has been demonstrated successfully for other fish species (e.g., Dunker et al., 2016) so if transport and sampling allow in these systems winter sampling could also be conducted and would take place in the deep holes previously identified as these are likely overwintering habitat for Lake Sturgeon in the area. Concurrent with sampling from the Springpole Lake Area, we will continue to refine and develop sampling and assay techniques using the captive population of Lake Sturgeon in the Animal Holding Facility at the University of Manitoba, where we can develop methodology to assess abundance of biomass under controlled conditions. Concurrent in the second and third year will be development and implementation of CRISPR based techniques in collaboration with Dr. Andrea Schreier at UC Davis California as her lab has developed this technology for use in species identification of endangered Longfin Smelt (*Spirinchus thaleicthys*) in the San Francisco Bay Area (Baerwald et al. 2020). For this aspect of the proposed research, we would use the Lake Sturgeon cytB primers already used in the Docker lab in combination with CRISPR and SHERLOCK gene editing tools to ultimately develop a streamside assay that would first be assessed using flourescent detecting machinery but ultimately translated to lateral flow technology. The development of CRISPR based assays and lateral flow use would occur over years two and three of the project, with final streamside field testing in the summer of 2027. Finally, throughout the refinement and development of eDNA assays from water samples using PCR and CRISPR technologies we will be working closely with Dr. Gushulak to develop methods appropriate for measurement of eDNA in sediment cores.

WORK PACKAGE 3

Paleolimnology is an integrative science in which physical, chemical, and biological markers are extracted from lake sediments and are used to interpret past environmental and climate conditions (Gregory-Eaves and Smol 2024). Lake sediment records are collected in vertical cores using a variety of techniques (Glew et al. 2001), typically from the deepest basin of the lake where sediment deposition and accumulation is highest. Following the geologic law of superposition, younger sediments are deposited on top of older sediments and are buried, preserving some biological remains and biogeochemical and geochemical markers in the sediment. Further, freshwater sediments store both autochthonous (i.e., within the lake) and allochthonous (i.e., from outside the lake) materials which allows paleolimnological studies to assess past changes in climate and environmental conditions at various spatial scales depending on the proxy used (Gregory-Eaves and Smol 2024). Because many of the markers preserved in lake sediments are derived from organisms with specific environmental optima and tolerances, changes in the relative abundances, concentrations, or accumulation rates of specific proxies can be used to reconstruct past environmental conditions quantitatively using transfer functions and other statistical techniques. Examples of common paleolimnological reconstructions include: regional temperature and precipitation from fossil pollen assemblages (Chevalier et al. 2020), salinity, pH, and total phosphorus from diatom subfossils (Wilson et al. 1996; Battarbee et al. 2008; Cumming et al. 2015), and hypolimnetic oxygen concentrations and water temperature from chironomid assemblages (Quinlan and Smol 2002; Quinlan et al. 2012).

Paleolimnological studies rely on accurately assigning ages to sediment intervals isolated from the core. Sediment chronology is produced by measuring the activities of various radioisotopes deposited into the sediment using various spectrometric techniques depending on the radioisotope being measured. Because the radioisotopes have known half-life values, the amount of radioactivity in sediment samples can be used with sedimentation rates to determine the age of the sediment (Last and Smol, 2001). In general, studies that are focused on shorter time scales (i.e., the last ~200 years) use the activities of ^{210}Pb, a naturally occurring radioisotope with a half-life of 22.2 years, and ^{137}Cs, (Binford et al. 1993; Foucher et al. 2021). Studies that examine longer time scales typically use ^{14}C to date sediment samples due to its higher half-life of 5730 years (Björk and Wohlfarth 2001). Sediment age is then estimated using statistical models (e.g. constant rate of supply; CRS) and applied to the core length (which has reliable ages) thereby creating an age-depth relationship (Binford et al. 1993). With a reliable age-depth model, changes in sediment proxies or markers can be assigned to specific dates and can be compared to historical records of climate, land use, shoreline development, or other environmental changes to assess the historical impact of these changes on the lake environment through time. In the absence of specific historical records, paleolimnological interpretations are one of the few methods able to determine the drivers and timing of environmental change in freshwater systems.

Changes in fish populations and communities have traditionally not been studied using paleolimnology due to relatively low abundances of fish remains (compared to zooplankton and algal fossils) preserved in lake sediments. However, advances in eDNA techniques (as described above) have begun to be applied to sediment records (Domaizon et al. 2017) to gain critical information regarding shifting fish populations and community structure through time (Thomson-Laing et al. 2022, 2023). A recent review by Thomson-Laing et al. (2022) identified two extraction methods that were effective at recovering extracellular fish DNA spiked into freshwater sediments. These methods included use of DNeasy PowerSoil DNA Isolation Kit (QIAGEN), and the ABPS protocol which involved an initial alkaline buffer extraction followed by the PowerSoil extraction kit. DNA extraction tests using these methods performed on larger (>0.25 g) sediment samples yielded the highest concentrations of target genes across multiple lake sediments and increased the overall likelihood of detecting fish sedDNA (sediment DNA). Both methods required additional optimization to recover the greatest amounts of DNA. The QIAGEN method required an additional ethanol DNA concentration step (PMET protocol) while the ABPS protocol required incubation at 65°C and pooling of multiple extractions due to the co-precipitation of organic content which is typically highest in surface sediments (i.e., taken at the sediment-water interface).

Despite this challenge, Thomson-Laing et al. (2022) recommend the ABPS protocol due to cheaper cost, which is likely a good starting point in extracting fish sedDNA for this project.

In practice, many limnological and sampling variables regulate the success of extracting eDNA from lake sediments including target species ecology (e.g., habitat) and abundance (Thomson-Laing et al. 2023). Critically, the location where the sediment core is collected (nearshore vs basin center) can result in substantial differences in fish and mollusc sedDNA results. Further, sedDNA is more difficult to extract in older sediments due to degradation through time, though studies have collected fish sedDNA from sediments over 300 years old (Thomson-Laing et al. 2023). Finally, fish sedDNA extraction is improved with greater masses of sediment analyzed which likely facilitates the need for the collection of multiple sediment cores to accurately extract and quantify Lake Sturgeon fish sedDNA for this project.

Work Flow

Sediment core collection is relatively unintensive once suitable coring targets are selected. In year one of the project, sediment coring equipment will be procured and tested before being used in the field while performing site selection by aiding with the goals of work package #1 led by Dr. Hasler. These sites may be initially tested for the presence of fish sedDNA in surface sediments using Van Veen grab samples as described above. Sediment core collection will occur in year two of the project based on the results of work package #1. Multiple cores should be collected from multiple sites to understand changes in fish populations across space as well as through time within the lake, as well as to target sites with the highest potential for Lake Sturgeon eDNA deposition. These cores will be dated using ^{210}Pb radioisotopes initially, with the possibility for ^{137}Cs supplemental analysis if needed. We will then work closely with Drs. Docker and Anderson to apply their Lake Sturgeon eDNA assays to sediment samples. In addition to assessing presence of potential prey items using the metabarcoding approach described in Workpackage #1. This work will provide insights into past fish biodiversity and may help understand changes in fish species distribution, and the population changes of Lake Sturgeon in Springpole Lake over time. In addition, analysis of other sedimentary proxies relevant to overall water quality and/or catchment dynamics (e.g., effects of the construction of the dams), such as sedimentary nutrients, metals, stable isotopes, or phototrophic pigments, may be performed during years 2 and 3 of the project to provide a more robust understanding of the systems changing conditions over time.

5.0 TIMELINE

The proposed timelines for this work will integrate information gained from each work package in an iterative fashion such that progress on each work package informs but does not impede progress in subsequent work packages. Importantly the timelines reflect reasonable expectations for development of methods and delivery of results. They do not include the timeline of graduate students that also includes program requirements such as completion of coursework, presentation of results at national and international conferences, analysis and interpretation of data, writing, submission and defence of a theses. A reasonable time to completion for a PhD student beginning their program in September of 2025 would be Fall 2029. As such the proposed budget reflects an additional year beyond September 2028 to facilitate completion of their program. Importantly, data relevant to the program would continue to be analysed and interpreted with the goal to publish the work in the peer reviewed literature. Further it is important to note that while update meetings are scheduled annually the research team would be in more-or-less constant communication throughout the course of the project; Drs Anderson, Docker and Gushulak are in the same Department at the University of Manitoba and Dr. Hasler is based at the University of Winnipeg so in-person meetings can be easily arranged. They will also make themselves available for update meetings at any time through the course of the project with associated partners if required in-person or remotely.

September 2025:	Recruit PhD student 1 and begin data gathering exercise to understand available habitat within the Springpole system that may support Lake Sturgeon, spawning, nursery and overwintering.
January to April 2026:	Recruit PhD student 2 in support of work package #2 Recruit PhD student 3 in support of work package #3
April – June 2026:	Prepare for eDNA water sampling using locations previously sampled alongside those identified in work package #1 for sampling in the summer field season of 2025 Prepare for collection of sediment cores throughout the system targeting sites identified in work package #1 Planning meeting for upcoming field season
July – September 2026:	Field sampling of water, benthic grabs and sediment cores
October – December 2026:	Sample processing, begin development of CRISPR based assay and update meeting with partners
January – May 2027:	Continued sample processing and development of CRISPR based assays Processing of sediment core analysis and refinement of eDNA assays for sediment samples Development of habitat maps within the study area appropriate for Lake Sturgeon Processing of samples for diet analysis
June-September 2027:	Field sampling of water and sediment cores
October – December 2027:	Sample processing of water and sediment cores
January – May 2027:	Continued sample processing and development of CRISPR based assays Lab based testing of CRISPR based assays using juvenile Lake Sturgeon Continued refinement of eDNA/CRISPR assays for sediment core analysis Completion of habitat surveys maps and recommendation for habitat enhancement for Lake Sturgeon and/or other target species
June – September 2027:	Final field sampling season and streamside testing of CRISPR assay
October – December 2027:	Sample processing and update meeting with partners
January – May 2028:	Continued sample processing, data analysis and initiation of report writing
May – September 2028:	Final report preparation and submission meet with partners for summary meeting.

6.0 BUDGET

Budget Summary

A total of $1,009,590 is requested to complete the proposed research within this project spread across four research labs examining large scale habitat availability for Lake Sturgeon; temporal changes in population structure of Lake Sturgeon and macroinvertebrates over time; and development of streamside eDNA detection assays that do not require specialized equipment. Approxiamtely 58% of the requested funds are allocated toward salary and training (travel) opportunities for the graduate students working on this project. If this proposal is approved we will leverage funds from MITACS to increase student involvement in the research. 19% of the overall budget is allocated to equipment. Importantly eDNA studies need dedicate laboratory equipment to reduce contamination issues and ensure reliable replicable results. Further, suitable habitat mapping will be needed to understand success of repatriation efforts as such the requested sonar system is critical for that success, in addition to appropriate storage of samples for laboratory analysis. Approximately 15% of the toal budget is allocated to consumables. These are needed costs mostly related to the development of eDNA assay that will underpin all three workpackages. Lastly, 8% of the budget is allocated to third party service fees. These costs are associated with the barcoding and sediment core broad scale analysis.

Salary

The requested salaries are based on 2024 recommendations by the Federal Government for MSc ($30,000 / annum) and PhD ($40,000 per annum) salaries. Importantly, support for salaries can be leveraged though the MITACS program such that cost for each individual PhD student would be approximately halved. However, there is no guarantee of success of MITACS support so we have retained full salary at this stage and if successful funds allocated to salary can support additional salary and/or consumable/equipment that would broaden the scope of the proposed project. We are also requesting salary support for summer undergraduate students for each of the PhD students in each of the years. This provides additional support for each graduate student, experience in research for undergraduate students and mentoring experience for the PhD students in the field and lab. Typical salary support for an undergraduate student during the summer months is $6,000. As with graduate student stipends this can be enhanced by the students receiving awards etc. Again we cannot guarantee this but if students are successful the additional funds will be directed to further support the research being conducted in this project.

	Year 1	Year 2	Year 3	Year 4
PhD 1	40,000	40,000	40,000	40,000
PhD 2	40,000	40,000	40,000	40,000
PhD 3	40,000	40,000	40,000	40,000
UG students	$18,000	$18,000	$18,000	$18,000
Totals	**$138,000**	**$138,000**	**$138,000**	**$138,000**
Subtotal	**$552,000**			

Equipment

Acquistion of equipment to conduct this research is paramount for the successful collection and preservation of samples and data. We have oganised this into each workpackage to reflec the discipline specific equipment needed to establish the appropriate work-flow for each workpackage described above.

	Year 1	Year 2	Year 3	Year 4
Workpackage #1				
Data Sondes for collection of environmental data A total of two portable systems for seasonal sampling @ ~ $7,000 each (YSI)	$ 14,000			
A total of 5 for year long deployment in key sites @ ~ 5,000 each – data will be downloaded periodically	$25,000			
Van Veen surface grabs @~ $500 each	$5,000			
YSI Dissolved Oxygen Probe and 20 m cable 3 units for concurrent sampling throughout the system @ ~ $7,000 each	$21,000			
Biosonics MX Aquatic Habitat Eco Sounder	Quote requested~ $45,000			
Workpackage #2				
eDNA Citizen scientist sampler (Smith Root). Three units for concurrent sampling throughout the system @ ~ $3,500 each	$10,500			
PCR workstations – these will be in high demand for all projects 2@ ~ $7,000 each in year 1. There is a limited shelf life and all projects will depend on these instruments so we request the opportunity to purchase a third in year three	$14,000		$7,000	
Laminar hoods to maintain clean area for eDNA extraction and measurement 2 @ ~ $5,000 each. The third unit in year 3 would complement the requested PCR unit.	$10,000		$5,000	
Fluorescent streamside reader			$8,000	
Workpackge #3				
Sediment core sampler(gravity corer)	$3,100			
Polycarbonate core tubes X10 @ ~110	$1,100			
Sediment extruder	$830			
Core extruding plugs X10 @ ~$32	$320			
Additional coring weights (to break through dense inorganic sediment) X4 @ ~$360	$1,440			
Freezer capacity for sample storage 1 -80 freezer @ ~$15,000 2 -20 freezers @ ~ $800 each		$16,600		
Totals	**$151,290**	**$16,600**	**$20,000**	
Subtotal	**$187,890**			

Consumables

	Year 1	Year 2	Year 3	Year 4
Workpackage #1				
Safety gear for field work (PFD's and survival suits for winter sampling)	$2,500	$2,500		
Membranes for probes	$500	$500	$500	$500
Chemicals for sample presevation	$350	$350	$350	$350
Plasticware and glassware	$1,500	$1,500	$1,000	$1,000
Workpackage #2				
Filters for water sampling – pre-loaded filters with self-preserving housing, proprietary for the requested water sampler; significantly reduces contamination and labour 500 @ $32 each	$ 16,000			
Molecular consumables for qPCR work (e.g., DNA extraction kis, Lake Sturgeon primers and probes, PCR reagents)	$25,000	$10,000	$5,000	$5,000
Molecular consumables for SHERLOCK assay development, in lab and streamside		$15,000	$10,000	$10,000
Pipette sets dedicated for each work station 3 @ ~ $2,100 each	$4,200		$2,100	
Plasticware and glassware	$2,500	$2,500	$2,500	$2,500
Molecular consumables for lateral flow assay development			$15,000	$10,000
Workpackage #3				
Plasticware and glassware		$2,500	$2,500	
Whirl-pack sample bags		$500	$500	
Totals	**$52,550**	**$35,350**	**$39,450**	**$29,350**
Subtotal	**$156,700**			

Fees for Service

	Year 1	Year 2	Year 3	Year 4
Workpackage #1				
Metabarcoding analysis at CCDB	Quote requested ~ $25,000			
Workpackage #2				
Custom manufacturing of lateral flow strips			$5,000	$5,000
Workpackage #3				
Radiosotope, stable isotope, heavy metal, algal and cyanobacterial community analysis for aging core samples. ~8 cores @ ~$6,000 per core @ Flett Research LTD (Winnipeg, MB). This costing is based on analysis of all the above parameters and quality of core sample. Cost may change dependeing on availability of suitable habitat for Lake Sturgeon.		$24,000	$24,000	
Totals	**$20,000**	**$24,000**	**$29,000**	**$5,000**
Subtotal	**$78,000**			

Travel

Travel budgets would include travel to and from field sites by graduate students and PI's. It is expected that all travel for field-work, and community consultation would be encompassed by the travel budget as requested by the partners in this project. Partners would agree to financially support and facilitate additional travel to and from the field site to ensure proper and sound collection of material for subsequent analysis and data generation by the four research personnel listed herein and the students working with them.

Travel for presentation to the proponents of this project and all additional stakeholders and knowledge keepers involved in the project would also be covered by the partners of this project.

Travel is also requested for presentation of data to the scientific community by the graduate students working on this project. Data permitting, graduate students are expected to attend and present at one national conference annually and one international conference at least once during their tenure. The cost of attendance at a national conference includes travel, registration and accommodation and is typically $1,500 per student. International travel is typically more expensive and so cost for attendance at an international conference is reasonably $2,000. Thus, for a PhD student to attend conferences during a 4 year program, total costs would be $10,000. Students are supported by other means to attend conferences (Department, faculty and society support), so we are requesting $6,000 per student to present their findings from this work over the course of four years. Undergraduate students involved in the work will also have an opportunity to attend national conferences and will be supported by PI existing budgets and travel scholarships.

Conference Travel

	Year 1	Year 2	Year 3	Year 4
PhD1	$1,000	$2,000	$1,000	$2,000
PhD2	$1,000	$2,000	$1,000	$2,000
PhD2	$1,000	$2,000	$1,000	$2,000
Totals	**$3,000**	**$6,000**	**$3,000**	**$6,000**
Subtotal	**$18,000**			

Lastly, travel to work with Dr. A Schreier at UC Davis is requested. It is anticipated a student would need to stay in Dr. Schreier's lab for about four weeks to understand and learn the fluorescent based SHERLOCK assay followed by a second month to develop the lateral flow equivalent prior to developing it in Dr. Docker's lab. Thus, we are requesting travel to and from UC Davis and accommodation during their time there for two one-month visits at ~ $6,000 each visit ($2,000 travel plus $4,000 accomodation).

7.0 POTENTIAL BENEFITS

This research program will fill significant knowledge gaps in the conservation and protection of Lake Sturgeon in northwestern Ontario. Understanding the historical presence of Lake Sturgeon in Springpole Lake and the surrounding watershed will inform the success of introducing a recovery program as a complementary offsetting measure to the Project. In addition, this research proposal presents a unique partnership between industry, academia, and Indigenous communities. Collaborations between universities and industry partners offer access to additional resources, enabling funding to diversify research interests for academics, while industries benefit from the research expertise and integrity. Collaboration with Indigenous communities and the integration of traditional knowledge provides access to local expertise and offers unique perspectives and understandings reflecting the depth and understanding that Indigenous Peoples have of their lands and environments. These partnerships foster innovation and facilitate knowledge exchange, allowing all parties to tackle complex challenges and enhance research outcomes leading to more effective, relevant, and sustainable outcomes.

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APPENDIX A

Academic CVs

DR. W. GARY ANDERSON
CURRICULUM VITAE – JANUARY 2022

PERSONAL DETAILS

Name: **W. Gary Anderson** Date of Birth: **19.12.68**
Nationality: **British and Canadian** Marital status: **Married**
Home address: 936 North Drive, Fort Garry, Winnipeg, MB R3T 0A8.
Work address: Department of Biological Sciences, University of Manitoba, Winnipeg, MB, Canada, R3T 2N2. Tel: (204) 474-7496; Fax: (204) 474-7588; e-mail: gary.anderson@umanitoba.ca

1. CURRENT POSITION

April 2022 – June 2027: Department Head, Department of Biological Sciences, University of Manitoba, Winnipeg, MB, Canada
March 2015-present: Professor, Department of Biological Sciences, University of Manitoba, Winnipeg, MB, Canada
April 2015-present: NSERC/Manitoba Hydro Industrial Research Chair in Conservation aquaculture of Lake Sturgeon, *Acipenser fulvescens*

2. EMPLOYMENT AND EDUCATIONAL RECORD

2008-2015: **Associate Professor**, Department of Biological Sciences, University of Manitoba, Winnipeg, MB, Canada
2004-2008: **Assistant Professor**, Department of Biological Sciences, University of Manitoba, Winnipeg, MB, Canada
2001-2004: **Named Postdoctoral Research Fellow at the University of St. Andrews, Scotland**. Project title: Investigation of osmoregulatory plasticity in the euryhaline bullshark, *Carcharhinus leucas*. UK NERC funded, grant ref. No. NER/A/S/2000/01270.
1998-2001: **Postdoctoral Research Fellow at the University of St. Andrews, Scotland**. Investigating the hyper-osmoregulatory strategy of the European Lesser spotted dogfish, *Scyliorhinus canicula*. UK NERC funded, grant ref. No. GR3/11420.
1996-1998: **Applications Director, Applied Biometrics Inc**. **Waterloo, Ontario, Canada.** Design, implementation and testing of fish protection measures at water intakes for hydroelectric generating stations and irrigation.
1995-1996: **Postdoctoral Fellow at the University of Waterloo, Ontario, Canada.** Examining catch and release effects on heart rate in Atlantic Salmon, *Salmo salar*
1991-1995: **Ph.D. Gatty Marine Lab, University of St. Andrews, Scotland**. The endocrine control of the rectal gland in the European lesser-spotted dogfish, *Scyliorhinus canicula* (S.E.R.C. funded). Supervisor: Dr. N. Hazon.
1987-1991: **B.Sc. (Hon), class 2.1 Animal Biology, University of St. Andrews, Scotland.** 1st and 2nd year courses: Chemistry, Genetics, Evolutionary Biology, Cell Biology and Zoology. Junior and senior honours years: Marine and Environmental Biology. Senior honours project: The effects of secretagogues

on cortisol production in the interenal gland of the European eel *Anguilla anguilla*.

3. RESEARCH

While my principle research interests are in comparative endocrinology they have evolved considerably in recent years as a result of growing and productive collaborations with colleagues both locally, nationally and internationally. Primarily I am interested in functional evolution of endocrine agents found throughout the vertebrate phyla and their role in the control of salt and water balance, specifically the more ancient fishes. The vertebrate group I have most extensively published on are the elasmobranch fishes, however, more recently the majority of my research has focused on physiological ecology of Lake Sturgeon, *Acipenser fulvescens*. Studies have included examination of the endocrine stress response, calcium metabolism, juvenile ecology, growth variation, reproductive endocrinology, inter-reservoir gene flow in Lake Sturgeon populations, the impact of hydro-electric dams on Lake Sturgeon movement ecology, gastro-intestinal physiology and detection of dietary cues. I have examined aspects of renal, cardiovascular and extra-renal mechanisms both from the perspective of environmental and endocrine manipulation. In addition to the growing publication record in Lake Sturgeon I have collaborations with a number of ecologists in the Department of Biological Sciences examining glucocorticoid levels in a variety of biological tissues including blood, fecal matter, hair and blubber. These collaborations are establishing correlations between the physiological glucocorticoid stress response to behavioural, life history and perceived environmental stressors in a variety of mammals including ground squirrels, arctic foxes, caribou, moose, wolves, beluga whales and ringed seals. I began the job of an academic to do research, I continue to do so, although I might not get hands on as regularly as I would like I am fortunate in that the people I work with involved in the many different research projects conducted in the lab continue to challenge me intellectually bringing new ideas and concepts to the work we do.

SUPERVISION

Postdoctoral

Dr. Erik Folkerts (Nov 2023-present): Effects of Temperature and organic pollutants on performance of isolated myocardial cells

Dr. Matt Thorstensen (Sept 2021 – present): Sequencing the Lake Sturgeon genome

Dr. Ian Bouyoucos (Sept 2020 – Nov 2023): Olfaction in Lake Sturgeon and energy budgets in elasmobranchs

Dr. Alyssa Weinrauch (March 2019 – Nov 2023): Gut function in ancient fishes

Dr. Kari Dammerman: Environment/genotype interactions in developing Lake Sturgeon (Oct 2015 – May 2016)

Dr. David Deslauriers: Modelling of energetics and swimming performance in developing Lake Sturgeon (Oct 2015 – Sept 2017)

Dr. Janet Genz: Reproductive endocrinology in the Lake Sturgeon, *Acipenser fulvescens* (April 2011 – May 2013)

Dr. L. Skyner: Shy-bold continuum in Richardson's ground squirrels. (April 2010-Sept 2010) (co-supervised with Dr. J. Hare)

Dr. P. J. Allen: Physiological ecology in lake sturgeon, using calcium regulation as a physiological correlate for reproductive status in wild lake sturgeon (Sept 2006 – June 2009).

Graduate Students
PhD

Tyler Edwards (Jan 2023 – present). Connecting olfaction to gut activity in the Lake Sturgeon, *Acipenser fulvescens*.
Alex Schoen (May 2019 – 2023). Understanding the role of 1α-hydroxycorticosterone in an elasmobranch fish.
Rex Yoon (September 2017 – 2022). Understanding the role of diet and environment in generating cold temperature tolerance in Lake Sturgeon.
Will Bugg (June 2017 – 2022). A transcriptomic approach to understanding thermal tolerance in Lake Sturgeon populations. *Co-supervised with Dr. Ken Jeffries*
Alison Loeppky (January 2017-2021). Trace element analysis and environmental effects in fin rays of Lake Sturgeon, *Acipenser fulvescens*.
Lisa Hoogenboom (May 2016-2022). Mechanisms of solute transport in the gut of the spiny dogfish, *Squalus acanthias*.
Luke Belding (deceased). Effects of environmental pH on the perception and of alarm signals in Lake Sturgeon, *Acipenser fulvescens*
Ben Kissinger (2017). Lake trout in the MacKenzie delta, salinity adaptation and distribution. *Co-supervised with Dr. Jim Reist*
Cheryl Klassen (2014). Growth Rate and Size Variability among Juvenile Lake Sturgeon, *Acipenser fulvescens*: Implications for Recruitment
Kyle Elliot (2013). Endocrine and behavioural indicators of senescene in seabirds. *Co-supervised with Dr. J. Hare*
Cameron C. Barth (2011). Ecology, behaviour, and biological characteristics of juvenile lake sturgeon, *Acipenser fulvescens*, within an impounded reach of the Winnipeg River, Manitoba, Canada. PhD thesis, University of Manitoba

MSc

Linh Miller (Jan 2024 – July 2024) The effect of thermal stress on whole body metabolic rate and cellular stress response in the truncate soft-shell clam, *Mya truncata*
Morgan Anderson (May 2021 – present) Developing eDNA tools to predict Lake Sturgeon density in remote locations
Alaina Taylor (May 2021 – 2023) Using fin ray microchemistry to predict spawning periodicity
Jenna Drummond (January 2021 – 2023) Nutrient absorption mechanisms across the intestine of ancient fishes
Kaitlynn Weisgerber (May 2021 – 2023) Polyploid genomes in wild and hatchery reared Lake Sturgeon
Tyler Edwards (September 2020 – 2022). Examining olfaction in Lake Sturgeon
Kassandra Merks (September 2019 – 2021). The effects of flow and substrate on the development of otolith and fin-rays in Lake Sturgeon
Eric Mullen (May 2018 – May 2020). Effects of catch and release angling on short term physiology in Lake Sturgeon

Alexandra Schoen (January 2018 – 2019). Steroidogenesis in Elasmobranch fish and potential role of bacteria. (transferred to PhD)
Catherine Brandt (May 2016-2018). Environmental effects on growth rate and swimming performance in larval Lake Sturgeon, *Acipenser fulvescens*
Madison Earhart (May 2016-2018). Development of the acute stress response in Lake Sturgeon, *Acipenser fulvescens*
Lisa Hoogenboom (May 2016-January 2018). Mechanisms of solute transport in the gut of the spiny dogfish, *Squalus acanthias*. (transferred to PhD)
Rex Yoon (2017). Metabolic activity and swimming performance in larval and juvenile Lake Sturgeon raised in differing environments
Forrest Bjornson (2017). Influence of rearing environment on predator response in larval Lake Sturgeon, *Acipenser fulvescens*
Randi Anderson (2016). The effects of body condition on stress hormone levels in Canadian arctic Ringed seals (*Phoca hispida*): Implications on a subsistence hunting staple. (co-supervised with Dr. G. Tomy)
Bailey Rankine (2015). Examining fate and effects of polyoxy-ethyleneamine (POEA) in an Experimental Lakes Area Lake using a mesocosm approach (co-supervised with Dr. V. Palace)
Ben Carriere (2015). Validation and evaluation of the stable isotope marking technique in the Lake Sturgeon, *Acipenser fulvescens*, *Acipenser fulvescens*
Elisa Van Wallegham (2015). The Detection and Characterisation of the Namao Virus in Lake Sturgeon (*Acipenser fulvescens*) (co-supervised with Dr. S. Clouthier)
Duncan Burnett (2014). Thyroid development in Lake Sturgeon (*Acipenser fulvescens*) and the potential thyroid disruption associated with exposure to the organophosphate pesticide chlorpyrifos (co-supervised with Dr. V. Palace)
Craig MacDougall. (2011) Investigating downstream passage of lake sturgeon, *Acipenser fulvescens*, through a Winnipeg River generating station.
Ahmed Waheed, MSc (2011). The influence of social and environmental factors on the stress response and development in juvenile and larval lake sturgeon, *Acipenser fulvescens*
Patricia Dasiewicz, MSc (2010). NSERC PGS. The role of the Kallikrein kinin system in the regulation of the cardiovascular system in the little skate, *Raja erinacea*.
Sadaf Zubair, MSc (2009). Ontogeny of the cortisol stress response in lake sturgeon, *Acipenser fulvescens*, as influenced by substrate and temperature during early development.
Christopher R. Singh, MSc (Zoology), 2005 – voluntary withdrawal in 2006

Undergraduate student supervision
Hons
Jessica MacPherson (2021) Examining nitrogen cycling in an elasmobranch fish, the North Pacific spiny dogfish, *Squalus acanthias suckleyi*
Ryan Wahl (2021) Tracking the steroidogenic pathway in the interreal gland of the North Pacific spiny dogfish, *Squalus acanthias suckleyi*
Ashley Soloway (2013) The effect of Selenium on developmental deformaties in cutthroat trout (co-supervised with Dr. V. Palace)

Lauren Shute (2013) The role of various cell types in calcium regulation in larval lake sturgeon *Acipenser fulvescens*
Catherine Brandt (2013) The influence of chlorpyrifos on sex steroid synthesis in adult lake sturgeon *Acipenser fulvescens* (co-supervised with Dr. V. Palace)
Alex Hare (2013) Sociality and the acute stress response in lake sturgeon, *Acipenser fulvescens*
Christopher McCabe (2012). Welcome Trust fellowship. Urea uptake across the intestine of the spiny dogfish, *Squalus acanthias sucklyei*
Ben Carriere (2012) The roles of calcium concentration on calcium flux in the spiral valve of the lake sturgeon, *Acipenser fulvescens*
Ryan Ho (2012). NSERC USRA. Characterisation of tissue bacteria in the little skate, *Leucoraja erinacea*. (co-supervised with Dr. K. Brassinga)
Murtaza Kapasi (2011) NSERC USRA. The effect of PTH and PTHrP on the rate of calcium excretion in Lake Sturgeon, *Acipenser fulvescens*
Marina Beaudry (2011) Oxidative stress and growth in Alligator gar *Altractosteus spatula*, exposed to environmentally relevant concentrations of the herbicide, Diquat (co-supervised with Dr. V. Palace)
Calen Ryan (2010). NSERC USRA. Struggling Mother Strong sons: The adaptive sex allocation in Richardson's squirrels, *Spermophilus richardsonii* (co-supervised with Dr. J. Hare)
Vanessa Grandmaison (2010): The effects of environmental calcium on calcium flux rates across the intestine of juvenila lake sturgeon, *Acipenser fulvescens*
Laura Gardiner (2010): The relationship between social status and the stress response in Richardson's ground squirrels, *Spermophilus richardsonii* (co-supervised with Dr. J. Hare)
Patricia Daseiwicz (2007): NSERC USRA. The effects of environmental calcium on calcium flux rates in juvenile lake sturgeon, *Acipenser fulvescens* calcium flux rates in lake sturgeon.
Taylor Sando (2007) Does the Stress axis in Lake Sturgeon undergo Habituation?

Summer students
Saleena Khinda (2024). Molecular identification of satiety signals in the Lake Sturgeon intestine and olfactory system
Emma Hodgson (2024). Molecular identification of satiety signals in the Lake Sturgeon intestine and olfactory system
Jess MacPherson (2022). Lake Sturgeon development.
Liam Eori (2022). HPLC separation of steroids
Ameera Kingra (2022) Vasoactivity of arginine vasotocin in isolated blood vessels of the spiny dogfish, *Squalus acanthias*
Corinne Kuo (2022) Microscopy examination of gastrointestinal development in lake Sturgeon.
Ryan Wahl (2020). Development of eDNA assays in Lake Sturgeon
Jessica MacPherson (2020). Development of the GI tract in Lake Sturgeon
Andrew Laluk (2019). Ontogeny of metabolic rates in developing Lake Sturgeon
Jessica MacPherson (2019). Effects of the microbiome on nitrogen uptake in the elasmobranch intestine (University USRA)

Cobi Wiwchar (2018). Molecular expression of stress related genes in early developing Lake Sturgeon (VP UG award)
Jordan Kroeker (2018). Development of cortisol response in Lake Sturgeon (FoS student award)
Jessica MacPherson (2018). Staining techniques in skeletal muscle of Lake Sturgeon
Michael Yusishen (2018). Science Co-op student/NSERC USRA. Examination of critical thermal maxima in solitary and grouped Lake Sturgeon.
Michael Yusishen (2017). NSERC USRA. Development of an environmental DNA assay for the detection of Lake Sturgeon
Thomas Roberts (2017). NSERC USRA. Intestinal movement of nitrogen in elasmobranch fishes
Catherine Long (2016). Faculty of Science Award. Metabolic rate measurements in young of the year Lake Sturgeon, *Acipenser fulvescens*
Justin Feilberg (2016) NSERC USRA. Urea transport across the intestine of the spiny dogfish, *Squalus acanthias suckleyi*
Alex Borecky (2015/2016) Rearing larval Lake Sturgeon
Nick Czehryn (2014/2015) NSERC USRA Lake trout physiological and behavioural plasticity to different salinities
Julia Wiens (2013/2014/2015) NSERC USRA The role of bacteria in steroid synthesis in the little skate, *Leucoraja erinacea*. (co-supervised with Dr. Karen Brassinga)
Kirstin Dangerfield (2013). Thyroid development in larval Lake Sturgeon
Lianne Arcinas (2012) NSERC USRA Egg and sperm quality in spawning Lake Sturgeon, *Acipenser fulvescens*
Shivani Khetoo (2011) Egg and sperm quality in spawning Lake Sturgeon, *Acipenser fulvescens*
Angela Wall (2007) Faculty of Science award. Using microscopy to determine sex in the Lake sturgeon, *Acipenser fulvescens*
Suadi Liban (2007) Faculty of Science award. Gut function in the little skate, *Leucoraja erinacea*
Natalie Nikkel (2006) NSERC USRA Determination of bullshark life history using vertebrae microchemistry
Patricia Daseiwicz (2006) NSERC USRA Blood volume measurement of the little skate, *Leucoraja erinacea*

Research assistants and technicians
Anthony Oladipo (May 2024 – present) Grade 2 technician
Frauke Fehrmann (July 2020 – present) Grade 3 technician
Ikechukwu Isinguzo (November 2018 – April 2020) Grade 3 technician
Hamza Amjad (November 2018 – April 2020) Grade 3 technician
James Tansley (May 2010-Sept 2010) Grade 3 Technician
Calen Ryan (May 2013-Dec 2013) Research assistant (co-supervised with Dr. J. Hare)
Darcy Childs (May 2015 – February 2017) Grade 4 technician
Jennifer Ali (April 2017 – 2018) Grade 3 technician
Forrest Bjornson (Septmber 2017 – December 2017) Grade 2 technician

Graduate student Advisory committees

PhD

Hossein Haghighi (2021-20??). The effects of thermal stress during the early developmental stages of freshwater fish. Supervisor: Dr. Ken Jeffries

Tammana Yasmin (2017-2023) Reproductive endocrinology of Lamprey. Supervisor: Margaret Docker

Garett Allen (2015-2022) Acid Base Regulation of Stenohaline Osmoconforming Decapod Crustaceans. Supervisor: Dirk Weihrauch

Alex Quijada-Rodriguez (2015-2022) Supervised by Dr. Dirk Weihrauch

Ala'a Eideh (2014-present) Studying the potential protective effects of the main antioxidant component in the olive tree “Oleuropein” against doxorubicin cardiotoxicity-induced inflammation. Supervised by Dr. Peter Eck

Nasibeh Daneshvar (2015-2021) Exploring the role of a neuro-repellent protein, Semaphorin3A, in functional muscle regeneration using pre-treatment with an NO-donor drug. Supervised by Dr. J. Anderson

Sandra Fehsenfeld (2015) Effects of elevated pCO2 on acid-base balance, ion regulation, and nitrogen household in crustaceans. Supervised by Dr. D. Weihrauch

Karen Dunmall (2011-2016) Salmon in the Arctic: Indicators of Change. Supervised by Drs. M. Docker and J. Reist.

Tracey Loewen (2009-2015). Otolith micro-chemical techniques to reveal insights into Char biodiversity: migration patterns of Arctic Char (*Salvelinus alpinus erythrinus; S. alpinus oquassa*) and stock discrimination in Dolly Varden Char (*S. malma malma*) in the Canadian Polar North. Supervised by Dr. J. Reist.

Lisa Peters (2014) Reproductive hormone disruptors in the aquatic environment. Supervised by Dr. M. Hanson.

Johnathan Hare (2008-2014) Aquatic contamination and toxicology of atrazine, glyphosate, clopyralid and chlorpyrifos to fish. Supervised by Dr. V. Palace

Melissa Pink (2010) The abiotic environment and predator-prey interactions: direct and indirect effects within aquatic environments with a specific look at temperature. Supervised by Dr. M. Abrahams

Lisa Friedrichs (2009) Otolith Microchemistry: The Geochemical Link between Environment and Biomineralization in Fish. Supervised by Dr. N. Halden

MSc

Sierra Schlief, MSc student, Department og Biological Sciences. Supervisor – Dr. Gail Davoren. Conectivity of Newfoundland forage fish using otolith microchemistry.

Jenna Williams, MSc student, Department of Biological Sciences. Supervisor – Dr. Jane Waterman. Abiotic and biotic impacts on Cape Ground Squirrels.

Baoyue Zhang, MSc student, Department of Biological Sciences. Supervisor – Dr. Dirk Weihrauch. Determination of cellular signaling pathways involved in ammonia excretion in the gills of the European shore crab, *Carcinus maenas*, and the American lobster, *Homarus americanus*

Mina Amiri, MSc student, Department of Biological Sciences. Supervisor – Dr. Dirk Weihrauch. Identification and function of the tight junction complex in crustacean gills.

Krista Robertson, MSc student, Department of Biological Sciences. Supervisor – Dr. Ken Jeffries. Using mucous to assess gene and protein expression in fathead minnows

(*Pimephales promelas*)

Amber Hiebert (2016-present) Lake Sturgeon (*Acipenser fulvescens*) Myotome Development: The Proliferation of Satellite Cells in the Developing Sturgeon. Supervisor: Judy Anderson

Gabrielle Grenier (2016-present) Seasonal patterns of growth and appetite regulation in Arctic Charr (*Salvelinus alpinus* L.); differences between morphs in wild and farmed populations. Supervisor: Ross Tallman

Alex Heathcote (2016-present) Effects of oil activities on stress development in prairie songbirds. Supervisor: Nicola Koper

Thomas Wood (2015-2018) Neighbourhood of fear: does location within a colony correlate with Richardson's ground squirrel (*Urocitellus richardsonii*) stress and fitness? Supervised by James Hare

Alex Yeo (2015-2018) Do glucose, glucocorticoid and dihydrotestosterone affect Richardson's ground squirrel, *Urocitellus richardsonii,* adaptive sex allocation. Supervised by James Hare

Lauren Shute (2017) The effects of neuropeptide Y on dissociated subfornical organ neurons. Supervised by Dr. Mark Fry

Lilian Wiens (2015-2019) Mitochondria Respiration Capacity and ROS Production with Changing Temperature in the Heart of *Oncorhyncus mykiss*, *Cyprinus carpio and Acipenser fulvescens*. Supervised by Dr. Jason Treberg

Stephanie Hans (2016) Acid-base regulation in the American horseshoe crab, *Limulus Polyphemus*. Supervised by Dr. Dirk Weihrauch

Alison Loeppky (2016). Determining the natal origin of beach versus demersally reared larval capelin, *Mallotus villosus*, off the northeast Newfoundland coast using otolith chemical signatures. Supervisor: Gail Davoren

Lisa Kalkhoven (2014- student dropped out of program). The smell of sex: Does olfactory contact with breeding conspecifics promote harmful barbering in C57BL6 mice? Supervised by Dr. James Hare

Michele Ewacha (2016) Stress response of caribou, moose, and wolves to industrial activity in Manitoba. Supervised by Dr. J. Roth

Deanna Gigliotti (2015) Cell and molecular analysis of pre-operative supraspinatus muscle from patients with rotator cuff injury. Supervised by Dr. J. Anderson

Kelsey O'Brien (2015) Eco-Immunology: Trade-offs between immunity, hormones and other life history traits of male Cape ground squirrels. Supervised by Dr. J. Waterman

Marci Trana (2014) Variation in blubber cortisol in stress in beluga whales of the Canadian Arctic. Supervised by Dr. J. Roth.

Helia Zhang (2013) Satellite cell activation in adult zebrafish (*Danio rerio*) single muscle fibre culture. Supervised by Dr. J. Anderson.

Ryan MacDonald (2013) Impact of prey availability and diet on stress in arctic foxes. Supervised by Dr. J. Roth

Matthew Martens (2013) The comparative growth and survival of a naturalized and aquaculture strain of rainbow trout (*Oncorhynchus mykiss*) in laboratory and whole-ecosystem experiments. Supervised by Dr. P. Blanchfield.

Molly Phillips (2012) Fecal steroid hormones in ground squirrels. Supervised by Dr. J. Waterman

Bethany Schroeder (2011) Using morphological and microsatellite analysis to investigate post-glacial diversity in an isolated population of threespine stickleback, (*Gasterosteus aculeatus*) in Nueltin Lake, Manitoba. Supervised by Dr. Randy Mooi.

Invited External Thesis Examiner

Katherine Ollerhead (2023).The impacts of acute environmental changes on the physiology of critically endangered school sharks (Galeorhinus galeus) in southeast Tasmania, University of Tasmania.

Cale Babey (2022) fate of hatchery reared juvenile Nechako White Sturgeon (*Acipenser transmontanus*): assessment of predation by river otters (*Lontra canadensis*), Dr. Mark Shrimpton, Department of Natural Resources and Environmental Studies; University of Northern British Columbia.

Wesley Didier (2019) Characterization of a Novel Androgen Membrane Receptor in Lampreys that might Regulate Sexual Development, Dr. Colin Brauner, Department of Zoology, University of British Columbia

James Burchfield (2018) Lake Sturgeon recruitment is limited by population density in the juvenile stage. PhD thesis, supervisor, Dr. Brian McLaren, Department of Biology, Lakehead University

Kady Lyons (2017) Physiological consequences of environmental contamination in an elasmobranch with matrotrophic histotrophy, the Round Stingray (*Urobatis halleri*) PhD thesis, supervisor Dr. Katharine Wynne-Edwards Department of Biology, University of Calgary

Megan Zak (2017) Effects of temperature and thyroid hormone on oxidative and lipid metabolism in juvenile Lake Whitefish (*Coregonus clupeaformis*). MSc thesis, supervisor Dr. Richard Manzon. Department of Biological Sciences, University of Regina

Edgar Zhipeng Liu (2011) Cyclic GMP signaling systems in lower vertebrates. MSc thesis, supervisor-Dr. John Donald, Deakin University, Australia

Josi Taylor (2009). Intestinal HCO3- secretion in fish: A widespread mechanism with newly recognized physiological functions. PhD thesis, supervisor-Dr. M. Grosell, University of Miami.

Jason Thiem (2013) Behaviour and energetics of sturgeon fishway passage. PhD thesis, supervisor-Dr. S. Cooke, Carletion University

Michael Donaldson (2012) Understanding the consequences of fisheries related stressors on adult migrating Pacific Salmonids. PhD thesis, supervisor-Dr. S. Hinch, University of British Columbia

FUNDING

Research grants applied for

ArcticNet – Phase four 2015-2018; $343.75
Title: Marine habitat usage and occupancy by coastal fishes: insights from linking otolith isotope and trace element parameters with oceanographic determinants (unsuccessful)

Canadian Foundation for Innovation Major Science Initiative Fund 2014; $2,462,889
Title: Bamfield Marine Science Centre. PI: Dr. Brad Anholt, Bamfield Marine Science centre. I was one of six participants invited to join the application (unsuccessful)

Research Grants currently held
Faculty of Science Field Work support program. Regulation of Nitrogen and Energy Balance in the Elasmobranch fish, *Squalus suckleyi*. May-September 2023 $6,562
Small equipment grant – Department of Biological Sciences, University of Manitoba Oct 2021 $10,000
Title: Replacement microtome

Small Research Equipment Grant (SREF) University of Manitoba Oct 2021; $17,769
Title: Data acquisition system

NSERC Associate Industrial Research Chair 2020-2025; $1,887,469
Title: Conservation aquaculture: Understanding the role of the environment in shaping the future of stocked Lake Sturgeon, *Acipenser fulvescens*.

NSERC Discovery 2020-2025; $275,000
Title: Endocrine regulation of metabolism in ancient fishes

Project Lead, Dr. K. Jeffries. Whole Genome sequencing of the tetraplod genome of Lake Sturgeon ($3,000 Canada's Genomic Enterprise (CGEN) – CanSeq 150; 2018-2019)

Fisheries and Wildlife Enhancement Fund 2018-2020; $57,500
Physiological effects of catch and release on adult Lake Sturgeon

NSERC Associate Industrial Research Chair 2015-2019; $2,150,000
Title: Conservation aquaculture: Understanding the role of the environment in shaping the future of stocked Lake Sturgeon, *Acipenser fulvescens*.

NSERC Engage 2016; $25,000
Title: A pilot study to evaluate the effects of variable flow on Arctic Char growth rate in a Myera tank system

NSERC Engage Plus December 2016 – May 2017; $25,000
Title: A pilot study to evaluate the effects of variable flow on Arctic Char growth rate in Myera tank system – phase 2

Research Grants previously held
Japan Society for the Promotion of Science long term fellowship September 1st – November 30th 2016; $15,000 CAD

Faculty of Science Field Work Support Program May – September 2016 $3,380
Faculty of Science Field Work Support Program May – September 2017 $4,350
Faculty of Science Field Work Support Program May – September 2019 $5,037
Faculty of Science Field Work Support Program May – September 2020 $4,875

NSERC Discovery 2010-2015; $135,000

Title: Regulation of Solute and Water Balance in Primitive Fishes

Manitoba Hydro research and Development Grant 2012-2014; $115,950
Title: Lost and Found: Tagging techniques for young of the year Lake Sturgeon

DFO contaminants Advisory group 2012-2013; $9,950
Title: Histological and enzymatic effects of the surfactant POEA on fish

Department of Indian Affairs and Northern development 2012-2013; $13,500
Title: Evaluation of hydro-climatic drivers of contaminant transfer in aquatic food webs in the Husky Lakes watershed. PI: Dr. Niklaus Gantner. I was co-applicant with one other participant.

Manitoba Hydro Research and Development Grant 2011-2013; $203,800
Title: Using Ovaprim as a conservation tool for Lake Sturgeon, *Acipenser fulvescens*: the short and long term effects of endocrine manipulation during the reproductive cycle

NSERC RTI 2011; $13,196
Title: Centrifuge for Bamfield Marine Science Centre. PI: Dr. T Allison I was one of seven applicants invited to participate

French Embassy in Canada Programme de mobilite en science and technologie 2010
Title: Central and renal actions of bradykinin in the control of cardiovascular, ventilator and kidney function in the trout, *Onchorhynchus mykiss*

NSERC Discovery 2005-2010; $157,910
Title: The Kallikrein-kinin system in an elasmobranch fish, characterization and physiological function

CFI-leaders opportunity fund 2007-2008; $255,290
Title: Endocrine control of ion and water balance in primitive fish

NSERC Collaborative Research and Development grant 2005-2009; $136,790
Title: An evaluation of current strategies to mitigate the impact of hydroelectric activity on Lake Sturgeon, *Acipenser fulvescens*. PI: Dr. Stephan Peake, University of New Brunswick, Fredericton. I was co-investigator with one other.

University of Manitoba research grant 2005-2006; $7,500
Title: Growth rate and life history determination of Bullsharks

NSERC RTI, 2005-2006: $57,756
Title: Physiological equipment and data acquisition

Natural Environment Research Council, UK, 2001-2004: $528,185
Title: Investigation of osmoregulatory plasticity in the euryhaline bullshark, *C. leucas* PI: N. Hazon, myself as a named post-doc

Research Contract, client Abitibi consolidated 1998
Title: Assessment of fish guidance efficiency of a louver array in a power canal at Grand Falls, Exploits River, Newfoundland, Canada

Research Contract, client Alberta Department of Environmental Protection Natural Resources Service 1997
Title: Design and testing of a louver system for the diversion of trout from irrigation intakes

Research contract: Client Ontario Hydro 1996-1998
Title; Investigation of a physical/perceptual barrier for diverting the free swimming movement of lake sturgeon, *Acipenser fulvescens*

European Union (research training grant) Host institution: University Autonoma Barcelona 1996-1998.
Title: The adaptational capacity of primary and secondary stress responses to chronic, repeated acute and novel stressors in aquacultured, *Sparus aurata,* Declined. PI: Dr. L. Tort I was named post-doctoral fellow

COLLABORATIONS

The collaborations listed below range from myself or my collaborator providing significant time, advice and/or resources to students to further their research, to active participation in formulation of research hypotheses and experimental design to address those hypotheses and conducting of experiments that have resulted in peer-reviewed publication. I have included only those people that I have actively collaborated with in the last six years.

Departmental collaborations

Dr. Margaret Docker – environmental DNA of Lake Sturgeon
Dr. Darren Gillis –quantitative analysis of Lake trout life history types
Dr. James Hare – endocrine correlates of life history in ground squirrels
Dr. Erwin Huebner – Microscopy examination of Lake Sturgeon larvae
Dr. Ken Jeffries – Environment genotype interactions in developing Lake Sturgeon
Dr. Jim Roth – endocrine correlates of life history in wolves, foxes and beluga whales
Dr. Jason Treberg – elasmobranch metabolism and endocrinology
Dr. Jane Waterman – endocrine correlates of life history in cape ground squirrels
Dr. Dirk Weihrauch – nitrogen metabolism and transport in elasmobranch fish

Inter-departmental collaborations

Dr. Karen Brassinga (Microbiology) – bacteria in elasmobranch fish
Dr. Norm Halden (Environment) – microchemistry of otoliths and fin rays of fishes
Dr. Gregg Tomy (Chemistry) – environmental contaminants and endocrine disruption

External collaborations – Department of Fisheries and Oceans Freshwater Institute

Dr. Sharon Clouthier – immunology in Lake Sturgeon

Dr. Eva Enders – swimming and behaviour in Lake Sturgeon
Dr. Steve Ferguson – endocrine correlates of life history in arctic sea mammals
D. Jim Reist – adaptive radiation of Lake Trout in the arctic

External collaborations – national and international
Dr. Mark Abrahams – behaviour and stress physiology of Lake Sturgeon
Dr. Peter Allen – trace element and isotope marking in fish hard structures
Dr. Ron Bruch – Lake Sturgeon life history and conservation
Dr. Carol Bucking – York University, gut physiology
Dr. Bryan Chakoumakos – Oakridge National Labs, otolith microchemistry
Dr. Suzie Currie – Acadia University, Stress and sociality
Dr. Robert Dores – Elasmobranch Endocrinology
Dr. Andrew Evans – elasmobranch endocrinology and metabolism
Dr. Craig Franklin – elasmobranch osmoregulation
Dr. Greg Goss – elasmobranch ion transport and physiology
Dr. Martin Grosell – elasmobranch gut function and osmoregulation
Dr. Susumu Hyodo – elasmobranch osmoregulation and endocrinology
Dr. Jean Claude Le-Mevel – Rainbow Trout endocrinology and renal physiology
Dr. Vince Palace – Thyroid hormone and endocrine disruption in Lake Sturgeon
Dr. Brenda Pracheil – Oakridge National Laboratories, otolith microchemistry
Dr. Stephan Peake – Juvenile life history of Lake Sturgeon
Dr. Ciaran Shaughnessey – Elasmobranch and hagfish endocrinology
Dr. Molly Webb – Sturgeon endocrinology
Dr. Amy Welsh – Population genetics of Lake Sturgeon
Dr. Chris Wood – Elasmobranch intestinal physiology

PUBLICATIONS

147. Bouyoucos, I.A., Weinrauch, A.M., Eastham, T.M., Eori, L., MacPherson, J., Porter, D., Schoen, A.R., Wahl R.C., Anderson W.G. (2024). Physiological assessment of the effects of experimental capture and transport in Pacific spiny dogfish. *Can. J. Fish. Aqua. Sci.* (in revision)
146. Bouyoucos, I.A., Anderson, W.G. (2024). Evidence for corticotrophin releasing factor genes in elasmobranch fishes. *Gen. Comp. Endocrinol.* (in revision)

Accepted or published peer reviewed papers
2024

145. Macpherson, J., Weinrauch, A.M., Shipley, O.N., Busquets-Vas, G., Newsome, S.D. and Anderson W.G. (2024). Absence of a functional gut microbiome impairs host amino acid metabolism in the Pacific spiny dogfish (*Squalus suckleyi*). *Macpherson featured as an ECR spotlight J. Exp. Biol.* (accepted)
144. Taylor, A.A., Larson, D.L., Scribner, K.T., Baker, E.A., Halden, N.M. and Anderson, W.G. (2024). Using fin ray elemental signatures and growth zone width to estimate onset of sexual maturity in Lake Sturgeon, *Acipenser fulvescens*. *Can. J. Fish. Aquatic Sci.* (accepted).
143. Belding, L.D., Thorstensen, M.J., Quijada-Rodriguez, A.R., Bugg, W.S., Yoon, G.R., Loeppky, A.R., Allen, G.J.P., Schoen, A.N., Earhart, M.L., Brandt, C., Ali,

J.L., Weihrauch, D., Jeffries, K.M., Anderson, W.G. (2024). Integrated responses induced by ecologically relevant pCO2 and temperature exposures in developing Lake Sturgeon, *Acipenser fulvescens*. *Mol. Ecol.* **33**, e17432 https://doi.org/10.1111/mec.17432

142. Schoen, A.N., Weinrauch, A.M., Bouyoucos, I.A., Treberg, J.R. and Anderson W.G. (2024) Hormonal effects of glucose and ketone metabolism in a perfused liver of an Elasmobranchs species, the North Pacific Spiny dogfish, *Squalus suckleyi Gen. Comp. Endocrinol*. **352**, 114514 https://doi.org/10.1016/j.ygcen.2024.114514
141. Taylor, A.A., Loeppky, A.R., Stadig, M., O'Connell, A. and Anderson W.G. (2024). Using Seasonal Oscillations in Fin Ray microchemistry to chemically age Lake Sturgeon, *Acipenser fulvescens*. *Trans. Am. Fisheries Soc. 00 1-1* https://doi.org/10.1002/tafs.10470
140. Weinrauch, A.M., Bouyoucos, I.A., Conlon, J.M. and Anderson, W.G. (2024). The chondrichthyan glucagon-like peptide 3 regulates hepatic ketone metabolism in the Pacific Spiny dogfish *Squalus acanthias Gen. Comp. Endocrinol.* **350** 114470 https://doi.org/10.1016/j.ygcen.2024.114470
139. Edwards, T., Bouyoucos, I.A., Hasler, C., Fry, M. and Anderson W.G. (2024). Understanding olfactory and behavioural responses to dietary cues in age-1 lake sturgeon *Acipenser fulvescens*. *Comp. Biochem. Physiol*. **288A**, 111560 https://doi.org/10.1016/j.cbpa.2023.111560

2023

138. Weisgerber, K.A. and Anderson, W.G. (2023). Comparing the incidence of spontaneous autopolyploidy in wild and hatchery Lake Sturgeon. *North American Journal of Aquaculture*, **86**, 95-109 https://doi.org/10.1002/naaq.10320.
137. Thorstensen, M.J., Weinrauch, A.M., Bugg, W.S., Jeffries, K.M. and Anderson, W.G. (2023). Tissue-specific transcriptomes reveal potential mechanisms of microbiome heterogeneity in an ancient fish. *Database*, 2023 baad055 https://doi.org/10.1093/database/baad055
136. Bouyoucos, I.A., Weinrauch, A.M. Jeffries, K.M. and Anderson W. G. (2023). Physiological responses to acute warming at the agitation temperature in a temperate shark, the Pacific Spiny dogfish (*Squalus suckleyi*). *Bouyoucos featured as ECR spotlight and paper selected as Editors choice J. Exp. Biol.* **226**, jeb246304 https://doi.org/10.1242/jeb.246304
135. Weinrauch, A.M. and Anderson, W.G. (2023). *In situ* method for the determination of nutrient acquisition and its hormonal regulation in the spiral valve of two chondrichthyan fishes. *Am. J. Physiol. Reg. Int. Comp. Physiol.* **325**, R546-R555 https://doi.org/10.1152/ajpregu.00109.2023
134. Bouyoucos, I., Shaughnessey, C., Anderson, W.G. and Dores, R. (2023). Molecular and pharmacological characterization of the melanocortin-2 receptor and its accessory proteins Mrap1 and Mrap2 in a Squalomorph shark, the Pacific spiny dogfish. *General and Comparative Endocrinology*, **342**, 114342 https://doi.org/10.1016/j.ygcen.2023.114342
133. Schoen, A.R., Weinrauch, A.R., Bouyoucos, I.A. and Anderson, W.G. (2023). An adapted liver perfusion in a shark species, *Squalus suckleyi*: investigation of energy

mobilization. *Am. J. Physiol. Reg. Int. Comp. Physiol.* **325** , R534-R545 https://doi.org/10.1152/ajpregu.00132.2023

132. Yoon, G.R., Thorstensen, M.J., Bugg, W.S., Bouyoucos, I.A., Deslauriers, D. and Anderson W.G. (2023). Comparison of metabolic rate between two genetically distinct populations of lake sturgeon. *Ecology and Evolution* **13**, 10470 https://doi.org/10.1002/ece3.10470
131. Deslauriers, D., Yoon, G.R., McClellan, K.J., Klassen, C.N. and Anderson, W.G. (2023). Assessment of family-derived metabolic traits for the conservation of an ancient fish. *Can. J. Zool.* **101**, 1052-1062 https://doi.org/10.1139/cjz-2023-004
130. Hoogenboom, J.L. and Anderson, W.G. (2023). Using ^{15}N to determine the metabolic fate of dietary nitrogen in North Pacific spiny dogfish (*Squalus acanthias suckleyi*). *J. Exp. Biol.* 226, jeb244921 *Hoogenboom featured as an ECR spotlight*
129. Bugg, W.S., Thorstensen, M.J., Marshall, K.E., Anderson, W.G. and Jeffries, K.M. (2023). Elevated temperatures reduce population-specific transcriptional plasticity in developing lake sturgeon (*Acipenser fulvescens*). *Molecular Ecology,* 32, 4044-4062 https://doi.org/10.1111/mec.16967
128. Bugg, W.S., Yoon, G.R., Schoen, A.N., Weinrauch, A.M., Jeffries, K.M. and Anderson W.G. (2023). Elevated temperatures dampen the innate immune capacity of developing lake sturgeon (*Acipenser fulvescens*). *Featured in Inside JEB. J. Exp. Biol.* **226**, jeb245335. doi:10.1242/jeb.245335
127. Hoogenboom, J.L. and Anderson, W.G. (2023). Investigating nitrogen movement in North Pacific spiny dogfish (*Squalus acanthias suckleyi*), with focus on UT, Rhp2, and Rhbg mRNA expression. *J. Comp. Physiol.* **193B**, 439-451. https://doi.org/10.1007/s00360-023-01487-4
126. Weinrauch, A.R., Bouyoucos, I.A. and Anderson, W.G. (2023). Exogenous tri-iodothyronine application increases survivorship in larval lake sturgeon (*Acipenser fulvescens*): molecular and endocrine regulation of appetite, growth, and stress axes. *Aquaculture*, 571, 739454. https://doi.org/10.1016/j.aquaculture.2023.739454
125. Hoogenboom, J.L., Wong, M. K-S., Hyodo, S., and Anderson, W.G. (2023). Nitrogen transporters along the intestinal spiral valve of cloudy catshark (*Scyliorhinus torazame*): Rhp2, Rhbg, UT. *Comparative Biochemistry and Physiology,* **280A** 111418 https://doi.org/10.1016/j.cbpa.2023.111418

2022

124. Kissinger, B.C., Enders, E.C. and Anderson, W.G. (2022). A salt on your senses: influences of rearing environment on salinity preference and sensing in lake trout, *Salvelinus namaycush*. *Env. Biol. Fish.* **106**, 933-940 https://doi.org/10.1007/s10641-022-01286-w
123. MacPherson, J., Weinrauch, A.M., Anderson, W.G. and Bucking C. (2022). The gut microbiome may influence post-prandial nitrogen handling in an elasmobranch, the Pacific spiny dogfish (*Squalus suckleyi*) *Comp. Biochem. Physiol.* **272**:111269 doi: 10.1016/j.cbpa.2022.111269.
122. Kucheravy, C.E., Trana, M.R., Watt, C.A., Roth, J.D., Tomy, G.T., Anderson, W. G. and Ferguson, S.H. (2022) Blubber cortisol in four Canadian beluga whale populations is unrelated to diet. *Mar. Ecol. Prog. Ser.* **698**, 171-189 https://doi.org/10.3354/meps14147

121. Ogloff, W.R., Anderson, R.A., Yurkowski, D.J., Debets, C.D., Anderson, W.G. and Ferguson, S.H. (2022) Spatio-temporal variation of ringed seal blubber cortisol levels in the Canadian Arctic. *J. Mammology* **103**, 1208-1220 https://doi.org/10.1093/jmammal/gyac047
120. Weinrauch, A.M, Fehrmann, F. and Anderson W.G. (2022). Sustained endocrine and exocrine function in the pancreas of the Pacific spiny dogfish post-feeding. *Fish Physiol. Biochem.* **48**, 645-657. https://doi.org/10.1007/s10695-022-01070-8
119. Yoon, G.R., Bugg, W.S., Fehrmann, F., Yusishen, M.E., Suh, M. and Anderson, W.G. (2022). Long-term effects of temperature during early life on growth and fatty acid metabolism in age-0 Lake Sturgeon. *J. Thermal Biol.* **105**, 103210 https://doi.org/10.1016/j.jtherbio.2022.103210
118. Brandt, C., Groening, L., Klassen, C. and Anderson, W.G. (2022). Effects of rearing temperature on yolksac volume and growth rate in Lake Sturgeon, *Acipenser fulvescens*, from hatch to age -1. *Aquaculture*, **546**, 737352. https://doi.org/10.1016/j.aquaculture.2021.737352
117. Yoon, G.R., Groening, L., Brandt, C., Klassen, C. and Anderson, W.G. (2022) Long-term effects of temperature on growth, energy density, whole-body composition and aerobic scope of age-0 Lake sturgeon (*Acipenser fulvescens*). *Aquaculture*, **547**, 737505 https://doi.org/10.1016/j.aquaculture.2021.737505
116. Yoon, G.R., Laluk, A., Bouyoucos, I., & Anderson, W.G. (2022) Effects of dietary shifts on ontogenetic development of metabolic rates in age-0 Lake Sturgeon (*Acipenser fulvescens)*. *Physiol. Biochem. Zool.* **95**, 135-151, https://doi.org/10.1086/718211

2021

115. Bugg, W.S., Yoon, G.R., Brandt, C., Earhart, M.L., Anderson, W.G., Jeffries, K.M. (2021). The effects of population and thermal acclimation on the growth, condition, and cold responsive mRNA expression of age-0-lake sturgeon (*Acipenser fulvescnes*). *J. Fish Biology.* **99**, 1912-1927 https://doi.org/10.1111/jfb.14897
114. Yoon, G.R., Earhart, M., Wang, Y., Suh, M. and Anderson, W.G. (2021). Effects of temperature and food availability on liver fatty acid composition and plasma cortisol concentration in age-0 lake sturgeon: Support for homeoviscous adaptation. *Comp. Biochem. Physiol A*, **261**, 111056 https://doi.org/10.1016/j.cbpa.2021.111056
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Non peer-reviewed articles

3. McDougall, C.A., Welsh, A.B., Gosselin, T., Anderson, W.G. and Nelson, P.A. (2017). How do dams affect fish populations? *Env. Sci. J. for Teens.* Science Journal for kids.org
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1. Altimiras, J.D. and Anderson W.G. (2016). Ecophysiology methods: refining the old, validating the new and developing for the future. *Comp. Biochem. Physiol.* **202A**, 1-2

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Anderson, W.G. (1998) Instruction manual for Lotek's telemetry reciever the SRX_400. Prepared for Lotek Engineering, Newmarket, Ontario, Canada. 55 p

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Anderson, W. G. (1997). Evaluation of antenna wire on gastrically inserted smolt tags. Prepared for Lotek Engineering, Newmarket, Ontario. 12 p

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Anderson, W.G., McKinley, R.S. and Deary, C. (1997). In-stream migration of Atlantic Salmon (*Salmo salar*) in the Northwest River, Newfoundland. Prepared for Genergy, St. John's Newfoundland. 28 p

Anderson W.G. and McKinley, R.S. (1997). Evaluating the effectiveness of a physical/perceptual barrier in guiding the natural migration of adult lake sturgeon, *Acipenser fulvescens*. Prepared for Ontario Hydro, Toronto, Ontario. 26 p

Anderson, W.G., Shepherd, D., Katopodis, C., McKinley, R.S. and Rajaratnam, N. (1997). Laboratory and Field-Testing of a Louver array for the guidance of juvenile rainbow trout. Prepared for, Alberta Department of Environmental Protection. 46 p

Invited presentations

Conference presentations are too numerous to be listed (over 200 including all HQP involved in Dr. Anderson's research program)

28. Anderson, W.G. April 2024. University of California Davis, Department of Animal Sciences The Physiology of ancient fishes from fundamentals to application and back again.
27. Anderson, W.G. February 2020. University of Alberta, Biological Sciences Department seminar. Comparative gastrointestinal physiology of elasmobranchs and sturgeon.
26. Anderson, W.G. February 2020. Disney World, Florida. Stress Physiology in Elasmobranch fishes

25. Anderson, W.G. February 2019. University of British Columbia, Zoology Department seminar. Understanding early rearing environment and phenotypic development in Lake Sturgeon toward improved success in stock enhancement.
24. Anderson, W.G. May 2019. Department of Fisheries and Oceans, Freshwater Institute, Winnipeg, Canada. Conservation aquaculture of Lake Sturgeon, what and how can we improve?
23. Earhart, M.E. and Anderson W.G. July 2018. International Congress for the Biology of Fishes, Calgary, Alberta, Canada. Development of the cortisol stress response in larval Lake Sturgeon.
22. Belding, L., Quijada-Rodriguez, A.R., Yoon, G.R., Ali, J., McPherson, J., Weihrauch, D. and Anderson, W.G. July 2018. International Congress for the Biology of Fishes, Calgary, Alberta, Canada. The effect of over-wintering and freshwater acidification on behaviour and physiology of Age-0 Lake Sturgeon (*Acipenser fulvescen*s)
21. Anderson, W.G. January 2018, Faculty of Natural Resources Management, Lakehead University, Thunder Bay, Ontario. Understanding early rearing environment and phenotypic development in Lake Sturgeon toward improved success in stock enhancement.
20. Anderson, W.G. September 2016, Atmospeheric and Ocean Sciences Research Institute Symposium, University of Tokyo, Tokyo. Functional evolution of osmoregulatory hormones in vertebrates – an elasmobranch perspective
19. Anderson, W.G., McCabe, C. and Wood, C.M. July 2014, Society of Experimental Biology annual meeting, Manchester UK. The role of the elasmobranch intestine regulating nitrogen balance.
18. Anderson, W. G. November 2013, Department of Biology, Carleton University. Physiological Ecology of the Lake Sturgeon, *Acipenser fulvescens*
17. Anderson, W.G. June 2013, Manitoba Hydro; Conservation Aquaculture, Understanding the role of the Environment in shaping the future of stocked Lake Sturgeon
16. Anderson, W.G. October 2012, Nature Manitoba Winnipeg; Ecology and physiology of a cultural icon, the Lake Sturgeon, Acipenser fulvescens
15. Anderson, W. G. February 2012, Manitoba Hydro, Lost and Found, tagging techniques for youong of the year Lake Sturgeon
14. Anderson, W.G. June 2011, Department of Biology, University of Winnipeg. Waste not want not; intestinal handling of water and ions in elasmobranch fish
13. Anderson, W.G. February 2011, Manitoba Hydro. Using Ovaprim as a conservation tool for Lake Sturgeon
12. Anderson, W.G. June 2010, The American Elasmobranch Society, annual meeting, Providence, RI, USA. Probing the depths, What can the endocrine stress response in teleost fish tell us about the stress response in elasmobranch fish
11. Anderson, W.G. April 2010, Strathhendrick Rotary Club, Killearn, Scotland. A case study in an academic career
10. Anderson, W.G. April 2010, Dunstaffnage Marine Lab, University of the Highlands and Islands, Oban Scotland. The role of the intestine in osmoregulation in elasmobranch fish

9. Anderson, W.G. February 2010, Department of Biology, The Universite de Bretagne, Occidentale, Brest, France. Physiological Ecology of the Euryhaline Bullshark
8. Anderson, W.G. June 2009, Society of Experimental Biology, Glasgow, UK. Waste not want not, intestinal handling of solutes and water in elasmobranchs.
7. Anderson W.G. November 2007, Department of Zoology, University of British Columbia. The Euryhaline Bullshark, how does it do it and why?
6. Anderson, W.G. November 2006, School of Life Sciences University of Queensland; Physiological regulation during acute transfer in the euryhaline bullshark from freshwater to saltwater
5. Anderson W.G. September 2006, Department of Biology University of New Brunswick (Fredericton). Euryhalinity in an Elasmobranch Fish, the Bullshark, *Carcharhinus leucas*.
4. Anderson, W.G. October 2006, Department of Biology, University of Regina; Salt and water balance in the Euryhaline Bullshark.
3. Anderson, W.G., Taylor, J.R., Grosell, M. and Hazon, N. April 2006, Society of Experimental Biology, Canterbury, UK. Water metabolism in Elasmobranch fish
2. Anderson, W.G. December 2005. Rosenstiel School of Marine and Atmospheric Sciences, University of Miami, Florida, USA. Euryhaline bullshark physiological ecology in a changing salinity.
1. Anderson, W.G. November 2005, Department of Biological Sciences, University of Alberta. Hormonal regulation of salt and water balance in the euryhaline bullshark, *Carcharhinus leucas.*

4. TEACHING

Philosophy

At the undergraduate level I have 4 principle objectives in teaching.

1. As a research scientist one learns to question and evaluate theories and principles presented in the primary and textbook literature. As a consequence I feel it is important to instill a level of critical thinking in students, a skill that is transferable to any future employment they may wish to pursue.
2. The development of techniques and methodology allow for integration of a broad knowledge base and application to ones personal area of interest. However, application requires continual learning and refining of personal skills and this is the second of my teaching objectives.
3. Continual learning of techniques and methodologies related to my research allow me to examine my research objectives from a variety of angles. This aspect basically relates to problem solving at the level of the "big picture" and is the third of my teaching objectives.
4. The final objective I have whilst teaching is to determine the level of individual ability. Course work, although set, must also be fluid enough to encompass all the students.

These philosophies are not fixed, indeed it is important that they are fluid and respond to the changing horizons in how I teach and how material will likely be learned and delivered in the future. In my short time as a University Professor I have recognized an increasing reliance for internet and on-line based materials. These have been introduced to the lower level classes I teach in but I have yet to implement them in the more senior classes I teach in. However, I am constantly evaluating my teaching materials and how these are delivered in response to both self and student assessment to ensure that the material delivered is not 'stale' and is as up to date as possible. This last point is particularly relevant for the 4000 and graduate student course I am involved with.

Courses taught

BIOL 2410 – Human Physiology I

This is a large class taught to >260 students in the fall term. I typically teach the endocrinology and reproductive sections in this class (13 lectures). Dr. M. Fry teaches the remainder of the course and typically administers the course. I have taught the course in its entirety when Dr. Fry was on sabbatical in the Fall term of 2011.

BIOL 2420 – Human Physiology II

This is the companion course to the above course with >220 students taught in the winter term. I typically have a small involvement in this course with teaching only the renal section (6 lectures). The course is co-taught usually with Dr. K. Campbell, Dr. K. Scott and Dr. D. Weihrauch and Dr. Campbell normally administers the course. I have taught Dr. Campbell's section when he was on sabbatical in 2012.

We are largely restricted to the textbook for both these courses as it acts as a service course for the Faculty of Kinesiology and is largely populated by general science students. I do, however, strive to introduce non-human examples which allows for not only demonstration of physiology in the broader context but evolutionary principles at the same time.

BIOL 3470 – Environmental physiology of animals I

This is a third year course with a moderate enrollment of 35-45 students taught in the fall term. My role in this course is small as I teach only 5 classes in comparative cardiovascular physiology. The course is administered by Dr. K. Campbell.

BIOL 3472 – Environmental physiology of animals II

This course acts as the companion course to BIOL 3470 and is taught in the winter term. The enrollment is usually around 30 students nad it is administered by Dr. D. Weihrauch. I do not normally teach in this class, however, I took over Dr. Weihracuh's role when he was on sabbatical in the winter term of 2013.

Lectures in BIOL 3470 and 3472 are loosely based on a recommended textbook, however, this is a third year class and as a consequence lecture material will be drawn from additional sources including the primary literature. There is a strong lab component to these courses so the combination of primary literature in the lecture material and the laboratory exercises instructs students in critical thinking and problem solving alongside hypothesis testing and presentation of scientific data.

BIOL 4480 – Comparative Endocrinology

I am the sole instructor for this 4th year course taught in the winter term. The class is on average 20 students. While the framework of my lecture notes are loosely based on a textbook that acts as suggested reading for the students the vast majority of content is drawn from the primary literature. I am in constant dialogue with the students in class and as the course progresses it moves away from the single unit approach in the 2000 level classes to the broader context. I incorporate methodology into the lectures so students learn not only the facts but how those facts are obtained. I see this 4th year class as an opportunity to test students on big picture ideas and concepts.

BIOL 7220 – critical thinking in Biological Sciences
In the former Department of Zoology I co-taught this course with Dr. M. Docker. When Zoology, Botany and the Biology unit merged the template for this course was used to develop a core PhD course in the Department of Biological Sciences. I teach this with Dr. Docker every second year (once with Dr. Piercey-Normore in 2010) and the course spans the fall and winter term. Enrollment varies but has been a maximum of 12 when we first taught the course to 6 students in 2012/13. Both Dr. Docker and myself developed the delivery and assessment methods used in the course. Students are required to write either a mini proposal or critique of a research area that they may not be familiar with.

5. ADMINISTRATION

Philosophy

I never expected when starting my academic post in 2004 that the administrative aspects of my job would be so important to my colleagues, the Department and the University community. As Associate Head between 2007 – 2012 I learned that acting on administrative issues quickly allows me to manage my time effectively and balance my research endeavours with the necessary administrative role that I play in the Department. Providing people a voice and avenue to discuss concerns or problems they may have is critical in the management of individuals.

Duties

As associate department head I was primarily concerned with the organization, implementation and running of the Undergraduate programs in the Department of Biological Sciences. These duties include:

- In consultation with the Department Head timetabling of classes and appointment of teaching duties for all teaching instructors in the department
- Review of courses taken by students in other institutions for equivalency to courses in the Biological and Genetics programs
- Discipline matters associated with academic dishonesty, class disruption, etc associated with term papers as outlined in the Universities student discipline bylaw
- Conflict resolution between instructors and students under the University Respectful workplace and learning environment policy
- Advising students on course selection and program specific requirements in Biological Sciences and Genetics programs to ensure graduation requirements will be met
- Approval of students to register for courses in our programs in the absence of pre-requisites or appropriate grades
- Approval for students to use courses outside of the Biological Sciences or Genetics programs as part of their requirements in Biological Sciences or Genetics.
- Liasing between the Faculty of Science and the Department on proposed course and program changes made in the Department of Biological Sciences.

- Review of applications and appointment of sessional instructors for courses offered in the Department of Biological Sciences
- Regular meetings with the Department Head and Associate Head to discuss all aspects of running the largest Department in the Faculty of Science at the University of Manitoba
- Promoting the Department to high schools during ‘evening of excellence’, ‘Info days’ and Manitoba Science Teachers events.
- Monitoring impact of changes in instructional methods, eg: Supplemental Instruction in BIOL 1410 and 1412
- Act as Acting Head of the Department of Biological Sciences when required.

Standing Committee membership
University

- Senate committee on Animal Care (member 2007-2010); Reviewed policies and procedures related to animal care at the University of Manitoba
- Protocol management review committee (member 2007-2009); Reviewed animal care protocols as required under the guidelines of the Canadian Council for Animal Care
- Elected member of University Senate from the Faculty of Science (2012-2019); Recommend changes in university policies and procedures associated with academic matters. Senate reports to the University Board of Governors.
- Elected member of the Senate Committee on Admissions (2014- 2018); Recommends to senate matters related to admissions for undergraduate programs leading to a degree.

Faculty

- Faculty of Science Committee on Student Standing (member 2010-present). This committee reviews academic appeals for student standing in the Faculty of Science. The committee reports to the Faculty of Science, although students may also appeal to the University Discipline committee if denied at the Science committee.
- Committee on Course and Academic Programs Faculty of Science (member 2008-present). Represent the Department of Biological Sciences, regarding Faculty of Science course and program changes. This committee reports to the University Senate
- Faculty of Science Endowment fund committee three-year term (member 2010-2013). This committee is responsible for allocation of Faculty of Science Endowment funds based on applications submitted by each of the administrative units within the Faculty of Science
- Faculty of Science Local Animal Care Committee (Chair 2006-2009)

Department

- Undergraduate curriculum committee (Chair 2008-present); this committee discusses proposed course and program changes and reports to the Department of Biological Sciences
- Recruitment and retention (member 2011-present); this committee coordinates the presence of Biological Sciences at recruitment events organised by the Faculty of Science and the University

- Graduate Studies committee (member 2009-present); this committee discusses admission to the graduate program and is responsible for recommending to department council any changes in graduate studies regulations and procedures
- Physiology teaching committee (Chair 2006-present); this committee discussing teaching responsibilities associated with the physiology theme courses in the Department of Biological Sciences and reports to the Undergraduate curriculum committee.

Ad Hoc committee membership

- Faculty of Science Internationalisation committee (member 2012-2014); This committee was established to determine the level of internationalization in the Faculty of Science and recommend strategies to improve international ties.
- Faculty of Science Local Disciplinary Committee (member on request 2008-present); I have been asked to attend these committee meetings irregularly based on my standing on the Faculty of Science committee on Student Standing.
- Search committee for the Department Head in the Physics Department (2014); Requested to serve on this committee by the Dean of the Faculty of Science
- Search committee for new faculty member in the Department of Statistics (2010); requested to serve on this committee as the external member to the Department by the Dean of the Faculty of Science
- Elected member from the Department of Biological Sciences for the promotion and tenure committees of Dr. Margaret Docker and Dana Schroeder and the promotion committee for Gail Davoren

Department

- Elected member to be on the Search committee for two animal physiology positions in the Department of Zoology (2007) and for the search committee for the Departments equipment technician (2012)

<u>6. Service to the community</u>

I am asked to review, on average 2 manuscripts a month by scientific journals. I have acted as a reviewer for National Science and Engineering Research Council Discovery, and Stacie research applications; National Science Foundation (USA) and Natural Environment Research Council (UK) research grants. I am a member of the Canadian Society of Zoologists (CSZ) and the Society for Experimental Biologists and served as the Comparative Physiology and Biochemistry section chair for the CSZ in 2012.

- Elected member of the Board of Governors for the Canadian Society of Zoologists (2nd Vice President) 2019 for 4 year term
- Elected member (Secretary) of the Board of Governors for the North American Sturgeon and Paddlefish Society 2017 – 2022; 2 years as a member at large followed by 3 years as Secretary
- Dec 2014 – 2025: Associate Editor, Comparative Biochemistry and Physiology A
- June 2015 – 2021: Associate Editor, Canadian Journal of Fisheries and Aquatic Sciences

CURRICULUM VITAE – JULY 2024

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POST-SECONDARY EDUCATION

1992 PhD (Fisheries and Aquatic Sciences), University of Guelph, Ontario
1985 BSc (Marine Biology, Honours), University of Guelph, Ontario. Graduated with Distinction

ACADEMIC POSITIONS

03/2017 – present	Professor Department of Biological Sciences, University of Manitoba
03/2011 – 03/2017	Associate Professor Department of Biological Sciences, University of Manitoba
07/2006 – 03/2011	Assistant Professor Department of Biological Sciences, University of Manitoba
07/2000 – 01/2004	Postdoctoral Fellow Great Lakes Institute for Environmental, University of Windsor
09/1997 – 04/2000	Instructor and Research Associate Biology Program, University of Northern British Columbia
12/1995 – 03/1997	Visting Scientist Department of Zoology, University of New Hampshire
02/1992 – 11/1995	Visiting Fellow Fisheries and Oceans Canada, Pacific Biological Station & West Vancouver Laboratory

ACADEMIC AWARDS

1984	University of Guelph Alma Mater BSc Scholarship
1984	University of Guelph Biological Science Students' Council Scholarship
1984, 1985	NSERC Undergraduate Summer Research Awards
1985–1989	NSERC Postgraduate Scholarships
1985	Keith Ronald Graduate Scholarship
1986	College of Biological Science Alumni Association Alma Mater Graduate Scholarship
2017	UM/UMFA Merit Award (Research and Service)
2019–2022	Faculty of Science Research Chair in Fundamental Science (Life Sciences)
2021	Fellow, American Fisheries Society

PUBLICATIONS

>100 peer-reviewed publications
Plus 120 seminars and oral conference presentations and 35 poster presentations.

Books:

1. **Docker, M.F.** 2015. *Lampreys: Biology, Conservation and Control, Vol. 1*. Springer, Dordrecht, Netherlands (editor), 439 pp.
2. **Docker, M.F.** 2019. *Lampreys: Biology, Conservation and Control, Vol. 2*. Springer, Dordrecht, Netherlands (editor), 570 pp.

Invited Book Preface:

3. **Docker M.F.** 2016. *In* Orlov A., and R.J. Beamish (eds.), *Jawless Fishes of the World, Vol. 1.* Cambridge Scholars Publishing, Newcastle Upon Tyne.

Refereed Book Chapters: Highly Qualified Personnel (HQP)

4. **Docker, M.F.** 2024. Reproduction in extant agnathan fishes: lampreys and hagfishes. Invited chapter in Norris, D.O. and Lopez, K.H (eds.), *Hormones and Reproduction of Vertebrates, Volume 1, Fishes.* 2nd Edition. Elsevier, Amsterdam. pp. 317–344.
5. Wilkie, M.P., N.S. Johnson, and **M.F. Docker.** 2022. Invasive species control and management: the sea lamprey story. Invited chapter in Fangue, N., Cooke, S., Farrell, A., Brauner, C., and Eliason, E. (eds.), *Conservation Physiology for the Anthropocene – A Systems Approach, Part B*. Elsevier, Amsterdam. pp. 489–579.
6. **Docker, M.F.**, F.W.H. Beamish, T. Yasmin, M.B. Bryan, and A. Khan. 2019. The lamprey gonad. *In* Docker, M.F. (ed.), *Lampreys: Biology, Conservation and Control, Vol. 2.* Springer, Dordrecht, Netherlands. pp. 1–186.
7. **Docker, M.F.** and I.C. Potter. 2019. Life history evolution in lampreys: alternative migratory and feeding types. *In* Docker, M.F. (ed.), *Lampreys: Biology, Conservation and Control, Vol. 2.* Springer, Dordrecht, Netherlands. pp. 287–409.
8. **Docker, M.F.** and J.B. Hume. 2019. There and back again: lampreys in the 21st century and beyond. *In* Docker, M.F. (ed.), *Lampreys: Biology, Conservation and Control, Vol. 2.* Springer, Dordrecht, Netherlands. pp. 527–570.
9. **Docker, M.F.**, J.B. Hume, and B.J. Clemens. 2015. Introduction: A surfeit of lampreys. *In* Docker, M.F. (ed.), *Lampreys: Biology, Conservation and Control, Vol. 1.* Springer, Dordrecht, Netherlands. pp. 1–34.
10. Maitland, P.S., C.B. Renaud, B.R. Quintella, D.A. Close, and **M.F. Docker**. 2015. Conservation of native lampreys. *In* Docker, M.F. (ed.), *Lampreys: Biology, Conservation and Control, Vol. 1*. Springer, Dordrecht, Netherlands. pp. 375–428.
11. Dunmall, K.M., J.M. Reist, E.C. Carmack, J.A. Babaluk, M.P. Heide-Jørgensen, and **M.F. Docker**. 2013. Pacific salmon in the Arctic: harbingers of change. *In* F.J. Mueter, D.M.S. Dickson, H.P. Huntington, J.R. Irvine, E.A. Logerwell, S.A. MacLean, L.T. Quakenbush, and C. Rosa (eds.) *Responses of Arctic Marine Ecosystems to Climate Change*. Alaska Sea Grant, University of Alaska Fairbanks. 23 pp. 0141-0163 doi: 10.4027/ramecc.2013.07.
12. **Docker, M.F.** 2009. A review of the evolution of nonparasitism in lampreys and an update of the paired species concept. *In* L.R. Brown, S.D. Chase, P.B. Moyle, R.J. Beamish, and M.G. Mesa (eds.), *Biology, management, and conservation of lampreys in North America*. American Fisheries Society, Symposium 72, Bethesda, Maryland, pp. 71–114.
13. Goodman, D.H., A.P. Kinziger, S.B. Reid, and **M.F. Docker**. 2009. Morphological diagnosis of *Entosphenus* and *Lampetra* ammocoetes (Petromyzontidae) in Washington, Oregon, and California. *In* L.R. Brown, S.D. Chase, P.B. Moyle, R.J. Beamish, and M.G. Mesa (eds.), *Biology, management, and conservation of lampreys in North America*. American Fisheries Society, Symposium 72, Bethesda, Maryland, pp. 223–232.
14. Renaud, C.B., **M.F. Docker**, and N.E. Mandrak. 2009. Taxonomy, distribution, and conservation of lampreys in Canada. *In* L.R. Brown, S.D. Chase, P.B. Moyle, R.J. Beamish, and M.G. Mesa (eds), *Biology, management, and conservation of lampreys in North America*. American Fisheries Society, Symposium 72, Bethesda, Maryland, pp. 293–309.

Refereed Articles in Academic Journals:

15. Hume, J.B., S. Bennis, T. Bruning, M.F. Docker, S. Good, R. Lampman, J. Rinchard, T. Searcy, M.P. Wilkie, and N.S. Johnson. 2024. Evaluation of larval sea lamprey *Petromyzon marinus* growth in the laboratory: Influence of temperature and diet. Aquaculture Research 2024: 547340.
16. Lawrence, M.J., P. Grayson, J.D. Jeffrey, **M.F. Docker**, C.J. Garroway, J.M. Wilson, R.G. Manzon, M.P. Wilkie, and K.M. Jeffries. 2023. Transcriptomic impacts and potential routes of

detoxification in a lampricide-tolerant teleost exposed to TFM and niclosamide. Comparative Biochemistry and Physiology - Part D: Genomics and Proteomics 46: 101074.

17. Carim, K.J., D.C. Larson, J.M. Helstab, M.K. Young, and **M.F. Docker**. 2023. A revised taxonomy and estimate of species diversity for western North American *Lampetra*. Environmental Biology of Fishes 106: 817–836.
18. Mochnacz, N.J., M.K. Taylor, **M.F. Docker**, and D.J. Isaak. 2023. An ecothermal paradox: bull trout populations diverge in response to thermal landscapes across a broad latitudinal gradient. Environmental Biology of Fishes 106: 979–999.
19. Bernos, T.A., M.C. Yates, R. Young, A. Imrit, E. Myler, S. Sharma, **M.F. Docker**, A. Fitzgerald, R. Hanner, D. Heath, J. Livernois, and N.E. Mandrak. 2023. Environmental DNA (eDNA) applications in freshwater fisheries management and conservation in Canada: overview of current challenges and opportunities. Canadian Journal of Fisheries and Aquatic Sciences 80: 1170–1186.
20. Klimley, A.P., K.M. Cogliati, M. Kuroki, and **M.F. Docker**. 2022. A review of molecular, physiological, behavioral, and ecological studies in a Special Issue devoted to the movement ecology of fishes. Environmental Biology of Fishes 105: 1683–1695.
21. Cooke, S.J., **M.F. Docker**, N.E. Mandrak, N. Young, D.D. Heath, K.M. Jeffries, A. Howarth, J.W. Brownscombe, J. Livernois, C.A.D. Semeniuk, P.A. Venturelli, A.J. Danylchuk, R.J. Lennox, I. Jarić, A.T. Fiske, C.S. Vandergoot, J.R. Britton, and A.M. Muir. 2022. Technoscience and the modernization of freshwater fisheries assessment and management. Environmental Technology & Innovation 28: 102865.
22. Yasmin, T., P. Grayson, **M.F. Docker**, and S.V. Good. 2022. Pervasive male-biased expression throughout the germline-specific regions of the sea lamprey genome supports key roles in sex differentiation and spermatogenesis. Communications Biology 5: 434.
23. Lawrence, M.J., P. Grayson, J.D. Jeffrey, **M.F. Docker**, C.J. Garroway, J.M. Wilson, R.G. Manzon, M.P. Wilkie, and K.M. Jeffries. 2022. Variation in the transcriptome response and detoxification gene diversity drives pesticide tolerance in fishes. Environmental Science & Technology 56: 12137–12147.
24. Grayson, P.D., A. Wright, C.J. Garroway, and **M.F. Docker**. 2022. SexFindR: A computational workflow to identify young and old sex chromosomes. bioRxiv 2022.02.21.481346. https://doi.org/10.1101/2022.02.21.481346
25. Lantz, S.R., R.A. Adair, J.J. Amberg, R. Bergstedt, M.A. Boogaard, U. Bussy, **M.F. Docker**, E.S. Dunlop, A. Gonzalez, T.D. Hubert, M.J. Siefkes, W.P. Sullivan, S. Whyard, M.P. Wilkie, B. Young, and A. Muir. 2022. Next generation lampricides: a three-stage process to develop improved control tools for invasive sea lamprey. Canadian Journal of Fisheries and Aquatic Sciences 79: 692–702.
26. McLaughlin, R., J.V. Adams, P.R. Almeida, J. Barber, D.P. Burkett, M.F. Docker, N.S. Johnson, M.L. Moser, A.M. Muir, D.L. Pereira, M.J. Siefkes, T.B. Steeves, and M.P. Wilkie. 2021. Foreword: Control and conservation of lampreys beyond 2020 - Proceedings from the 3rd Sea Lamprey International Symposium (SLIS III). Journal of Great Lakes Research 47 (Supplement 1): S1–S10.
27. Mateus, C.S., **M.F. Docker**, G. Evanno, J.E. Hess, J.B. Hume, I. Oliviera, A. Souissi, and T.M. Sutton. 2021. Population structure in anadromous lampreys: Patterns and processes. Journal of Great Lakes Research 47 (Supplement 1): S38–S58.
28. **Docker, M.F.**, G.A. Bravener, C.J. Garroway, P.J. Hrodey, J.B. Hume, N.S. Johnson, S.A. Lewandoski, J.L. Ogden, and E.C. Zollweg-Horan. 2021. A review of sea lamprey dispersal and population structure in the Great Lakes and the implications for control. Journal of Great Lakes Research 47 (Supplement 1): S549–S569.
29. Borowiec, B.G., **M.F. Docker,** N.S. Johnson, M.L. Moser, B. Zielinski, and M.P. Wilkie. 2021. Exploiting the unique physiology of lampreys to refine methods of control and conservation. Journal of Great Lakes Research 47 (Supplement 1): S723–S741.

30. Ferreira-Martins, D., J. Champer, D.W. McCauley, Z. Zhang, and **M.F. Docker.** 2021. Genetic control of invasive sea lamprey in the Great Lakes. Journal of Great Lakes Research 47 (Supplement 1): S753–S763.
31. Dey, C., A.I. Rego. M.J. Bradford, and 71 other co-authors. 2021. Research priorities for the management of freshwater fish habitat in Canada. Canadian Journal of Fisheries and Aquatic Sciences 78: 1744–1754.
32. Lawrence, M.J., D. Mitrovic, D. Foubister, L.M. Bragg, J. Sutherby, **M.F. Docker**, M.R. Servos, M.P. Wilkie, and K.M. Jeffries. 2021. Contrasting physiological responses between invasive sea lamprey and non-target bluegill in response to acute lampricide exposure. Aquatic Toxicology 237: 105484.
33. <u>Ajmani, N.</u>, <u>T. Yasmin</u>, **M.F. Docker**, and S.V. Good. 2021. Transcriptomic analysis of gonadal development in parasitic and non-parasitic lampreys (*Ichthyomyzon* spp.), with a comparison of genomic resources in these non-model species. Genes Genomes Genetics 11: jkab030.
34. <u>Mochnacz, N.J.</u>, D.I. MacKenzie, N. Koper, **M.F. Docker**, and D.J. Isaak. 2021. Fringe effects: detecting bull trout (*Salvelinus confluentus*) at distributional boundaries in a montane watershed. Canadian Journal of Fisheries and Aquatic Sciences 78: 1030–1044.
35. Larson, D., M. Helstab, **M.F. Docker**, B. Bangs, and B.J. Clemens. 2020. Landlocked Pacific lamprey *Entosphenus tridentatus* in the Middle Fork Willamette River, Oregon. Environmental Biology of Fishes 103: 291–298.
36. <u>Yusishen, M.E.</u>, <u>F.C. Eichorn</u>, W.G. Anderson, and **M.F. Docker.** 2020. Development of quantitative PCR assays for the detection and quantification of lake sturgeon (*Acipenser fulvescens*) environmental DNA. Conservation Genetics Resources 12: 17–19.
37. Anderson, J.E., A. Cunha, and **M.F. Docker.** 2019. Novel "omega fibers" in superficial body-wall myotomes during metamorphosis in the northern brook lamprey, *Ichthyomyzon fossor*. Canadian Journal of Zoology 97: 1218–1224.
38. <u>Spice, E.K.</u>, T.A. Whitesel, G.S. Silver, and **M.F. Docker**. 2019. Contemporary and historical river connectivity influence population structure in western brook lamprey in the Columbia River Basin. Conservation Genetics 20: 299–314.
39. Neave, F.B., T.B. Steeves, T.C. Pratt, R.L. McLaughlin, J.V. Adams, and **M.F. Docker.** 2019. Stream characteristics associated with feeding type in silver (*Ichthyomyzon unicuspis*) and northern brook (*I. fossor*) lampreys and tests for phenotypic plasticity. Environmental Biology of Fishes 102: 615–627.
40. Evans, T.M., P. Janvier, and **M.F. Docker.** 2018. The evolution of lamprey (Petromyzontida) life history and the origin of metamorphosis. Reviews in Fish Biology and Fisheries 28: 825–838.
41. Schloesser, N.A., C.M. Merkes, C.B. Rees, J.J. Amberg, T.B. Steeves, and **M.F. Docker.** 2018. Correlating sea lamprey density with environmental DNA detections in the lab. Management of Biological Invasions 9: 483–495.
42. Aman, J., **M.F. Docker**, and K.W. Grimes. 2017. New England range extension of American Brook Lamprey (*Lethenteron appendix*) as confirmed by genetic analysis. Northeastern Naturalist 24: 536–543.
43. <u>Mochnacz, N.J.</u>, B.C. Kissinger, D. Deslauriers, M.M. Guzzo, E.C. Enders, W.G. Anderson, **M.F. Docker**, D. Isaak, and J.R. Treberg. 2017. Development and testing of a simple field-based intermittent-flow respirometry system for riverine fishes. Conservation Physiology 5: cox048;doi:10.1093/conphys/cox048.
44. Bartels, H., C. Wrede, M. Przybylski, I.C. Potter, and **M.F. Docker**. 2017. Implications of absence of seawater-type mitochondria-rich cells and results of molecular analyses for derivation of the non-parasitic Ukrainian brook lamprey *Eudontomyzon mariae*. Environmental Biology of Fishes 100: 509–518.
45. Clemens, B.J., L. Wyss, R. McCoun, I. Courter, L. Schwabe, C. Peery, C.B. Schreck, <u>E.K. Spice</u>, and **M.F. Docker**. 2017. Temporal genetic population structure and interannual variation in migration behavior of Pacific lamprey *Entosphenus tridentatus*. Hydrobiologia 794: 223–240.

46. Clemens, B.J., R.J. Beamish, K.C. Coates, **M.F. Docker**, and 17 others. Conservation challenges and research needs for Pacific Lamprey in the Columbia River Basin. Fisheries 42: 268-280.
47. Gingera, T.D., R. Bajno, **M.F. Docker**, and J.D. Reist. 2017. Environmental DNA as a detection tool for zebra mussels *Dreissena polymorpha* (Pallas, 1771) at the forefront of an invasion event in Lake Winnipeg, Manitoba, Canada. Management of Biological Invasions 8: 287–300.
48. Kissinger, B.C. L.N. Harris, D. Swainson, W.G. Anderson, **M.F. Docker**, and J.D. Reist. 2017. Fine-scale population structure in lake trout (*Salvelinus namaycush*) influenced by life history variation in the Husky Lakes drainage basin, NT Canada. Canadian Journal of Fisheries and Aquatic Sciences 75: 1070–1081.
49. **Docker, M.F.**, G.S. Silver, J.C. Jolley, and E.K. Spice. 2016. Simple genetic assay distinguishes lamprey genera *Entosphenus* and *Lampetra*: comparison with existing genetic and morphological identification methods. North American Journal of Fisheries Management 36: 780–787.
50. Jolley, J.C. G. Kovalchuk, and **M.F. Docker**. 2016. River lamprey *Lampetra ayresii* outmigrant upstream of the John Day Dam in the Mid-Columbia River. Northwestern Naturalist 97: 48–52.
51. Gingera, T.D., T.B. Steeves, D.A. Boguski, S. Whyard, W. Li, and **M.F. Docker**. 2016. Detection and identification of lampreys in Great Lakes streams using environmental DNA. Journal of Great Lakes Research 42: 649–659. Winner of the 2016 Undergraduate Paper Award from the Canadian Council of University Biology Chairs.
52. Rohlfing, K., Stuhlmann, F., **M.F. Docker**, and T. Burmester. 2016. Convergent evolution of hemoglobin switching in jawed and jawless vertebrates. BMC Evolutionary Biology 16:30.
53. McCauley, D.W., **M.F. Docker**, S. Whyard, and W. Li. 2015. Lampreys as diverse model organisms in the genomics era. Cover article for BioScience 65: 1046–1056.
54. Blanchfield P.J., K.A. Kidd, **M.F. Docker**, V.P. Palace, B.J. Park, and L.D. Postma. 2015. Recovery of a wild fish population from whole-lake additions of a synthetic estrogen. Environmental Science and Technology 49: 3136–3144.
55. Bartels, H., **M.F. Docker**, M. Krappe, M.M. White, C. Wrede, and I.C. Potter. 2015. Variations in the presence of chloride cells in the gills of lampreys and their evolutionary implications. Journal of Fish Biology 86: 1421–1428.
56. Hess, J.E., N.R. Campbell, **M.F. Docker**, C. Baker, A. Jackson, R. Lampman, B. McIlraith, M.L. Moser, D.P. Statler, W.P. Young, A.J. Wildbill, and S.R. Narum. 2015. Use of genotyping-by-sequencing data to develop a high-throughput and multi-functional SNP panel for conservation applications in Pacific lamprey. Molecular Ecology Resources 15: 187–202.
57. Heath, G., D. Childs, **M.F. Docker**, D.W McCauley, and S. Whyard, S. 2014. RNA interference technology to control pest sea lampreys - a proof-of-concept. PLoS ONE 9 (2): e88387.
58. Penton, P.M., C.T. McFarlane, E.K. Spice, **M.F. Docker**, and G.K. Davoren. 2014. Lack of genetic divergence in capelin (*Mallotus villosus*) spawning at beach versus subtidal habitats in coastal embayments of Newfoundland. Canadian Journal of Zoology 92: 377–382.
59. Spice, E.K. and **M.F. Docker**. 2014. Reduced fecundity in non-parasitic lampreys may not be due to heterochronic shift in ovarian differentiation. Journal of Zoology 294: 50–58.
60. Spice, E.K., S. Whyard, and **M.F. Docker**. 2014. Gene expression during ovarian differentiation in parasitic and non-parasitic lampreys: implications for fecundity and life history types. General and Comparative Endocrinology 208: 116–125.
61. Hess, J.E., N.R. Campbell, D.A. Close, **M.F. Docker**, and S.R. Narum. 2013. Population genomics of Pacific lamprey: adaptive variation in a highly dispersive species. Molecular Ecology 22: 2898–2896.
62. Backhouse-James, S.M. and **M.F. Docker**. 2012. Microsatellite and mitochondrial DNA markers show no evidence of population structure in walleye (*Sander vitreus*) in Lake Winnipeg. Journal of Great Lakes Research 38: 47–57.
63. Bartels, H., **M.F. Docker**, U. Fazekas, and I.C. Potter. 2012. Functional and evolutionary implications of the cellular composition of the gill epithelium of feeding adults of a freshwater

parasitic species of lamprey, *Ichthyomyzon unicuspis*. Selected as an "Editors' Choice" article for Canadian Journal of Zoology 90: 1278–1283.

64. Boguski, D.A., S.B. Reid, D.H. Goodman, and **M.F. Docker**. 2012. Genetic diversity, endemism, and phylogeny of lampreys within the genus *Lampetra sensu stricto* (Petromyzontiformes: Petromyzontidae) in western North America. Journal of Fish Biology 81: 1891–1914.
65. **Docker, M.F.**, N.E. Mandrak, and D.D. Heath. 2012. Contemporary gene flow between "paired" silver (*Ichthyomyzon unicuspis*) and northern brook (*I. fossor*) lampreys: implications for conservation. Conservation Genetics 13: 823–835.
66. Spice, E.K., D.H. Goodman, S.B. Reid, and **M.F. Docker**. 2012. Neither philopatric nor panmictic: microsatellite and mtDNA evidence suggest lack of natal homing but limits to dispersal in Pacific lamprey. Molecular Ecology 21: 2916–2930.
67. Taylor, E.B., L.N. Harris, E.K. Spice, and **M.F. Docker**. 2012. Microsatellite DNA analysis of parapatric lamprey (*Entosphenus* spp.) populations: implications for evolution, taxonomy and conservation of a Canadian endemic. Canadian Journal of Zoology 90: 291–303.
68. Reid, S.B., Boguski, D.A., D.H. Goodman, and **M.F. Docker**. 2011. Validity of *Lampetra pacifica* (Petromyzontiformes: Petromyzontidae), a brook lamprey described from the lower Columbia River Basin. Zootaxa 3091: 42–50.
69. Spice, E.K., T.A. Whitesel, C.T. McFarlane, and **M.F. Docker**. 2011. Characterization of 12 microsatellite loci for the Pacific lamprey (*Entosphenus tridentatus*) and cross amplification in five other lamprey species. Genetics and Molecular Research 10: 3246–3250.
70. Clemens, B.J., T.R. Binder, **M.F. Docker**, M.L. Moser, and S.A. Sower. 2010. Similarities, differences, and unknowns in biology and management of three parasitic lampreys of North America. Fisheries 35: 580–594.
71. Luzier, C.W., **M.F. Docker**, and T.A. Whitesel. 2009. Characterization of ten microsatellite loci for western brook lamprey *Lampetra richardsoni*. Conservation Genetic Resources 2: 71–74.
72. McFarlane, C.T. and **M.F. Docker**. 2009. Characterization of 14 microsatellite loci in the paired lamprey species *Ichthyomyzon unicuspis* and *I. fossor* and cross amplification in four other *Ichthyomyzon* species. Conservation Genetic Resources 1: 377–380.
73. Goodman, D.H., S.B. Reid, **M.F. Docker**, G.R. Haas, and A.P. Kinziger. 2008. Mitochondrial DNA evidence for high levels of gene flow among populations of a widely distributed anadromous lamprey *Entosphenus tridentatus* (Petromyzontidae). Journal of Fish Biology 72: 400–417.
74. Heath, D.D., S. Jamieson, I. Stasiak, C.M. Bettles, and **M.F. Docker**. 2008. Genetic differentiation among sympatric migratory and resident life-history forms of *Oncorhynchus mykiss* in British Columbia. Transactions of the American Fisheries Society 137: 1268–1277
75. **Docker, M.F.**, G.R. Haas, D.H. Goodman, S.B. Reid, and D.D. Heath. 2007. PCR-RFLP markers detect 29 mitochondrial haplotypes in Pacific lamprey (*Entosphenus tridentatus*). Molecular Ecology Notes 7: 350–353.
76. Neave, F.B., N.E. Mandrak, **M.F. Docker**, and D.L. Noakes. 2007. An attempt to differentiate sympatric *Ichthyomyzon* ammocoetes using meristic, morphological, pigmentation and gonad analyses. Canadian Journal of Zoology 85: 549–560.
77. Roy, D., **M.F. Docker**, G.D. Haffner, and D.D. Heath. 2007. Body shape vs. colour associated initial divergence in the *Telmatherina* radiation in Lake Matano, Sulawesi, Indonesia. Journal of Evolutionary Biology 20: 1126–1137.
78. **Docker, M.F.** 2006. Bill Beamish's contributions to lamprey research and recent advances in the field. Guelph Ichthyology Reviews 7:1–52.
79. Neave, F.B., N.E. Mandrak, **M.F. Docker**, and D.L. Noakes. 2006. Effects of preservation on pigmentation and length measurements in larval lampreys. Journal of Fish Biology 68: 991–1001.
80. Heath, D.D., J.M. Shrimpton, R.I. Hepburn, S.K. Jamieson, S.K. Brode, and **M.F. Docker**. 2006. Population structure and divergence using microsatellite and gene locus markers in

Chinook salmon (*Oncorhynchus tshawytscha*) populations. Canadian Journal of Fisheries and Aquatic Sciences 63: 1370–1383.

81. Bettles, C.M., **M.F. Docker**, B. Dufour, and D.D. Heath. 2005. Hybridization dynamics between sympatric species of trout: loss of reproductive isolation. Journal of Evolutionary Biology 18: 1220–1233.
82. Therriault, T.W., M.I. Orlova, **M.F. Docker**, H.J. MacIsaac, and D.D. Heath. 2005. Invasion genetics of a freshwater mussel (*Dreissena rostriformis bugensis*)) in Eastern Europe: high gene flow and multiple introductions. Heredity 95: 16–23.
83. Roy, D., **M.F. Docker**, P. Hehanussa, D.D. Heath, and G.D. Haffner. 2004. Genetic and morphological data supporting the hypothesis of adaptive radiation in the endemic fish of Lake Matano. Journal of Evolutionary Biology 17: 1268–1276.
84. Maeva, E., I. Bruno, B.S. Zielinski, **M.F. Docker**, F.M. Severin, and R.G. Maev. 2004. The use of pulse-echo acoustic microscopy to non-invasively determine sex of living larval sea lamprey, *Petromyzon marinus*. Journal of Fish Biology 65: 148–156.
85. Therriault, T.W., **M.F. Docker**, M.I. Orlova, D.D. Heath, and H.J. MacIsaac. 2004. Molecular resolution of the family Dreissenidae (Mollusca: Bivalvia) with emphasis on Ponto-Caspian species, including first report of *Mytilopsis leucophaeata* in the Black Sea basin. Molecular Phylogenetics and Evolution 30: 479–489.
86. **Docker, M.F.**, A. Dale, and D.D. Heath. 2003. Erosion of interspecific reproductive barriers resulting from hatchery supplementation of rainbow trout sympatric with cutthroat trout. Molecular Ecology 12: 3515–3521.
87. **Docker, M.F.**, S.A. Sower, J.H. Youson, and F.W.H. Beamish. 2003. Future sea lamprey control through regulation of metamorphosis and reproduction: A report from the SLIS II New Science and Control workgroup. Journal of Great Lakes Research 29 (Supplement 1): 801–809.
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90. Lorion, C.M., D.F. Markle, S.B. Reid, and **M.F. Docker.** 2000. Re-description of the presumed-extinct Miller Lake lamprey, *Lampetra minima*. Copeia 2000: 1019–1028.
91. **Docker, M.F.**, J.H. Youson, R.J. Beamish, and R.H. Devlin. 1999. Phylogeny of the lamprey genus *Lampetra* inferred from mitochondrial cytochrome *b* and ND3 gene sequences. Canadian Journal of Fisheries and Aquatic Sciences 56: 2340–2349.
92. Kent, M.L., **M. Docker**, J. Khattra, C.R. Vossbrinck, D.J. Speare, and R.H. Devlin. 1999. A new *Microsporidium* sp. (Microsporidia) from the musculature of the mountain whitefish *Prosopium williamsoni* from British Columbia: Morphology and phylogeny. Journal of Parasitology 85: 1114–1119.
93. **Docker, M.F.**, M.L. Kent, D.M.L. Hervio, J.S. Khattra, L.M. Weiss, A. Cali, and R.H. Devlin. 1997. Ribosomal DNA sequence of *Nucleospora salmonis* Hedrick, Groff and Baxa, 1991 (Microsporea: Enterocytozooidae): Implications for phylogeny and nomenclature. Journal of Eukaryotic Microbiology 44: 55–60.
94. **Docker, M.F.**, R.H. Devlin, J. Richard, and M.L. Kent. 1997. Sensitive and specific polymerase chain reaction assay for detection of *Loma salmonae* (Microsporea). Diseases of Aquatic Organisms 29: 41–48.
95. Shaw, R.W., M.L. Kent, **M.F. Docker**, A.M.V. Brown, R.H. Devlin, and M.L. Adamson. 1997. A new species of *Loma* (Microsporea) in shiner perch (*Cymatogaster aggregata*). Journal of Parasitology 83: 296–301.
96. Kent, M.L., D.M.L. Hervio, **M.F. Docker**, and R.H. Devlin. 1996. Taxonomy studies and diagnostic tests for myxosporean and microsporidian pathogens of salmonid fishes utilising ribosomal DNA sequence. Journal of Eukaryotic Microbiology 43: S98–99.

97. **Docker, M.F.**, and F.W.H. Beamish. 1994. Age, growth, and sex ratio among populations of least brook lamprey, *Lampetra aepyptera*, larvae: an argument for environmental sex determination. Environmental Biology of Fishes 41: 191–204.
98. Murdoch, S.P., **M.F. Docker**, and F.W.H. Beamish. 1992. Effect of density and individual variation on growth in sea lamprey (*Petromyzon marinus*) larvae in the laboratory. Canadian Journal of Zoology 70: 184–188.
99. Murdoch, S.P., F.W.H. Beamish, and **M.F. Docker**. 1991. Laboratory study of growth and interspecific competition in larval lampreys. Transactions of the American Fisheries Society 120: 653–656.
100. **Docker, M.F.**, and F.W.H. Beamish. 1991. Growth, fecundity, and egg size of least brook lamprey, *Lampetra aepyptera*. Environmental Biology of Fishes 31: 219–227.
101. **Docker, M.F.**, T.E. Medland, and F.W.H. Beamish. 1986. Energy requirements and survival in embryo mottled sculpin (*Cottus bairdi*). Canadian Journal of Zoology 64: 1104–1109.
102. Wong, P.T.S., Y.K. Chau, J.S. Rhamey, and **M. Docker**. 1984. Relationship between water solubility of chlorobenzenes and their effects on a freshwater green alga. Chemosphere 13: 991–996.

Invited Book Reviews:

103. **Docker, M.F.** 2020. Book review: Great Lakes Sea Lamprey: The 70 Year War on a Biological Invader. Fisheries 45: 380.
104. **Docker, M.F.** 2008. Book critique: Hardisty shares his final thoughts on lampreys. Environmental Biology of Fishes 82: 11–15.

Editorials:

105. **Docker, M.F.** 2021. Continuity and changes: expanding the Editorial Board. Environmental Biology of Fishes 104: 735–736.
106. **Docker, M.F.** 2021. Picking up the mantle. Environmental Biology of Fishes 104: 211–212.

SELECT LIST OF RECENT RESEARCH FUNDING

Career total to date = $19.7 million

1. Good, S.V. and **M.F Docker**. The role of epigenetic control of the germline specific region of the sea lamprey genome in sex determination and differentiation (2023 – 2025) Great Lakes Fishery Commission (Sea Lamprey Research Program). $236,815.
2. Hume, J.B., **M.F. Docker**, S.V. Good, K.M. Jeffries, N.S. Johnson, R. Lampman, J. Rinchard, C.M. Wagner, and M.P. Wilkie. Sea Lamprey Aquaculture and Procurement (SLAP) Initiative (2022–2025) Great Lakes Fishery Commission (Great Lakes Restoration Initiative). $1,190,510 USD.
3. **Docker, M.**, R. Hanner, M. Steeves, and R. Philipps. Field-ready environmental (eDNA) protocols and tools for sea lamprey assessment (2021–2022) Great Lakes Fishery Commission (Sea Lamprey Research Program). $343,277.
4. **Docker, M.** Can environmental DNA (eDNA) cost-effectively and non-invasively monitor fish stocks in Lake Winnipeg? (2021–2023) Manitoba Fish and Wildlife Enhancement Fund. $36,410.
5. Semeniuk, C.A.D., B.D.T. Neff, N.E. Mandrak, S.J. Cooke, D.D. Heath, T.E. Pitcher, B. Dixon, C. Audet, **M. Docker**, C. Febria, and B. Zielinski. Fisheries management and conservation careers in science and technology, FishCAST (2020 – 2026) NSERC Collaborative Research and Training Experience (CREATE) Program. $1,720,000.
6. Heath, D.D., **M. Docker**, S. Cooke and 21 co-investigators. Environmental DNA ("eDNA"), meta-barcoding and transcriptional profiling to improve sustainability of freshwater fisheries and fish culture (2019 – 2023) Genome Canada Large-Scale Applied Research Project Competition (LSARP). $9,077,272.
7. **Docker, M.F.** Mechanisms of life history evolution in an ancient vertebrate (2019 – 2024)

NSERC Discovery Grant Program. $200,000.

8. Garroway, C.J., **M.F. Docker**, and K.M. Jeffries. Population genomic analysis to test for broad-scale patterns of genetic variation and selection in Great Lakes sea lamprey (2019 – 2021) Great Lakes Fishery Commission (Sea Lamprey Research Program). $300,335
9. **Docker, M.F.**, C.J. Garroway, and A.E. Wright. Genetic basis of sex determination in sea lamprey (2018 – 2020) Great Lakes Fishery Commission (Sea Lamprey Research Program). $275,000.
10. Jeffries, K.M., **M.F. Docker**, M.P. Wilkie, J.M. Wilson, C.J. Garroway, and R.G. Manzon Using a comparative transcriptomics approach to increase potency and specificity of lampricide treatments (2018 – 2020) Great Lakes Fishery Commission (Sea Lamprey Research Program). $366,000.
11. Hume, J.B., C.M. Wagner, **M.F. Docker**, H. Dawson, and N. Dobiesz. Reducing uncertainty in the sea lamprey operating model with life-stage specific empirical evidence: a methodological approach and model-based evaluation (2018 – 2020) Great Lakes Fishery Commission (Sea Lamprey Research Program). $220,000 USD.

SUMMARY OF TEACHING AND STUDENT SUPERVISION

Undergraduate Courses:
University of Manitoba:

- BIOL 2210 Chordate Zoology (2008 – present)
- BIOL 3300 Evolutionary Biology (2006 – 2015)
- BIOL 4212 Systematics and Biogeography of Fishes (2008 – present)
- BIOL 4890 Special Topics in Biology: Cell and Molecular Aspects of Lamprey Development (2010), Causes and Treatment of Avoidable Blindness (2017), Using Environmental DNA to Monitor Aquatic Organisms (2020)
- ENVR 4000 Multidisciplinary Topics in Environmental Science 2 (2016)

University of Northern British Columbia:

- BIOL 100 Introduction to Biology (1998 – 2000); named 1 of 5 “Popular Profs” in the 1999 *Maclean’s Guide to Canadian Universities*
- BIOL 307 Ichthyology and Herpetology (1997)
- BIOL 311 Cell and Molecular Biology (1998)
- BIOL 406 Fisheries Ecology (1997 – 1998)
- BIOL 411 Conservation Biology (1999)

Graduate Courses: University of Manitoba

- ZOOL 7220 Advanced Topics in Zoology: Aquatic Biology (2008 – 2009)
- BIOL 7220 Critical Thinking in Biological Sciences (2010 – 2016)
- BIOL 7600 Special Topics in Biology: Cell and Molecular Aspects of Lamprey Development (2010), Advanced Fish Systematics (2012), Advanced Evolutionary Biology (2014)

Student and Other Trainee Supervision: University of Manitoba

- Honours thesis students (10 students)
- Undergraduate Student Research Award (USRA) supervision (12 students)
- Other undergraduate research assistants (33 students)
- MSc students (20)
- PhD students (6)
- Postdoctoral fellows (4)

Recent High School Outreach

- IISD-Experimental Lakes Area (ELA) Youth Outreach program (Monitoring eDNA and Learning

Ecology with Youth, MeDLEY), Peguis First Nation Science and Technology Symposium, Discover Your Future in Science, Girls in Science

SELECT PROFESSIONAL SERVICE

University Leadership Roles:

- Acting Head, Department of Biological Sciences, University of Manitoba (2016)
- Associate Head (Undergraduate), Department of Biological Sciences, University of Manitoba (2016–2017)
- University of Manitoba Senate, Faculty of Science academic representative (2023–2026)

Journal Editorial Boards:

- Environmental Biology of Fishes (Advisory Editor 2019–2021; Editor-in-Chief 2021–present)
- Journal of Great Lakes Research (Guest Editor 2019–2021)
- Journal of Great Lakes Research (Associate Editor 2023–present)
- Journal of Ichthyology (2016–present)

Other Leadership Roles:

- Co-chair of the Freshwater Fishes Species Specialist Subcommittee of COSEWIC (Committee on the Status of Endangered Wildlife in Canada) (2021–present)
- Secretary–Treasurer of the Mid-Canada Chapter (MCC) of the American Fisheries Society (2009–2023)
- Canadian Conference for Fisheries Research (CCFFR) Board of Directors (2015–2022); President (2019)
- Canadian Conference for Fisheries Research-Society of Canadian Limnologists (CCFFR-SCL*)* Justice, Equity, Diversity, and Inclusion (JEDI) Committee member (2020–2022)
- Organizing Committee, Third Sea Lamprey International Symposium (SLIS III), Detroit (2019)
- Chair of the Organizing Committee, Canadian Conference for Fisheries Research-Society of Canadian Limnologists (CCFFR-SCL), Virtual Meeting (2021)

Reviewer / Examiner:

- Peer review for >70 scientific journals (e.g., Canadian Journal of Fisheries and Aquatic Sciences, Ecology and Evolution, Evolutionary Ecology, Journal of Fish Biology, Molecular Ecology, Proceedings of the Royal Society B: Biological Sciences Transactions of the American Fisheries Society) and books (e.g., Arctic Marine Fishes of Canada, Fish Physiology)
- Grant proposal reviewer for >25 national and international funding agencies (e.g., Alberta Conservation Association, Canada Foundation for Innovation, French National Research Agency, FWF Der Wissenschaftsfonds (Austrian Science Fund), Leverhulme Trust (UK), Mitacs, NSERC, Portuguese Science Foundation, Washington Sea Grant)
- External MSc examiner at other Canadian universities (6) and PhD thesis examiner internationally (5), including University of Otago (New Zealand), Rennes University (France), and Vilnius University (Lithuania)

Invited Expert:

- On national and international science advisory boards (e.g., Great Lakes Fishery Commission Sea Lamprey Research Board, Manitoba Aquatic Invasive Species Advisory Forum)
- Participant and reviewer at national and international assessment meetings (e.g., Fisheries and Oceans Canada pre-COSEWIC meetings, expert reviewer for Canadian Science Advisory Secretariat (CSAS), technical reviewer for U.S. Geological Survey, Integrating eDNA Data into the Nonindigenous Aquatic Species (NAS) Database)

Curriculum Vitae
Cale A.C. Gushulak, Ph.D.

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Research Gate: https://www.researchgate.net/profile/Cale_Gushulak
LinkedIn: https://www.linkedin.com/in/cale-gushulak-b286a0296/

Work experience

Postdoctoral Research Associate, Center for Limnology, University of Wisconsin–Madison, Madison, Wisconsin: Dec. 2023 – June 2024

> Project(s): *Investigating the impacts of waves on the formation, movement, sustainment, and degradation of harmful algal and cyanobacterial blooms.*
> Supervisor: Dr. Grace Wilkinson

Postdoctoral Researcher, Institute of Environmental Change and Society (IECS) and Biology Department, University of Regina, Regina, Saskatchewan: Sept. 2020 – Nov. 2023

> Project(s): *Examination of anthropogenic impacts of land use, hydrological, and climate changes on the biogeochemistry, eutrophication, and ecology of lakes and wetlands at the landscape scale and over multiple time-scales in the Prairie region of Canada.*
> Supervisor: Dr. Peter R. Leavitt

Education

Ph.D. Biology (Paleolimnology), Queen's University, Kingston, Ontario, 2016-2020

> Thesis: *Changes in climate and catchment processes over the middle and late Holocene in the boreal region of northeastern Ontario, Canada*
> Supervisor: Dr. Brian F. Cumming

M.Sc. Geology, University of Western Ontario, London, Ontario, 2014-2016

Thesis: *First major appearance of brachiopod-dominated benthic shelly communities in the reef ecosystem during the early Silurian*
Supervisor: Dr. Jisuo Jin

B.Sc. Hons. Biology, Brandon University, Brandon, Manitoba, 2010-2014

Thesis: *Paleoclimate of the Early Eocene McAbee Macroflora, British Columbia, Canada*
Supervisor: Dr. David Greenwood

Honours and Awards (CAD$)

- Society of Canadian Aquatic Science (SCAS) Outstanding Service Award, 2024
- Canadian Association of Palynologists Student Research Award, Queen's University, 2020 - **$500**
- Natural Sciences and Engineering Research Council of Canada Post-Graduate Doctoral Scholarship (NSERC PGS-D 3), Queen's University, 2017-2020 - **$63,000**
- Queen's University Graduate Dean's Award for Doctoral Field Research, Queen's University, 2018 - **$3000**
- Wildlife Conservation Society of Canada W. Garfield Weston Fellowship, Queen's University, 2018 - **$8000**
- E.G. Bauman Fellowship, Queen's University, 2016-2017 - **$15,000**
- Ontario Graduate Scholarship (OGS), University of Western Ontario, 2015-2016 - **$15,000**
- Western Science Entrance Scholarship, University of Western Ontario, 2014-2015 - **$8000**
- H. Stewart Perdue Memorial Scholarship, Brandon University, 2014 - **$530**
- J.Y. Tsukamoto Scholarship in Plant Biology, Brandon University, 2013 - **$250**

Research

Accepted publications

N=17, Citations=137, h-index=6

***Indicates co-lead author**

Gushulak, C.A.C., Chegoonian, A.M., Wolfe, J., Gray, K., Mezzini, S., Wissel, B., Hann, B., Baulch, H., Finlay, K., and Leavitt, P.R. (2024) Impacts of hydrologic management on the eutrophication of shallow lakes in an intensive agricultural landscape (Saskatchewan, Canada). *Freshwater Biology*. https://doi.org/10.1111/fwb.14260

Chan, C.N., **Gushulak, C.A.C.,** Leavitt, P.R., Logozzo, L.A., Finlay, K., and Bogard, M. (2024) Experimental ecosystem eutrophication causes offsetting effects on emissions of CO_2, CH_4, and N_2O from agricultural reservoirs. *Environmental Science & Technology* 58: 7045-7055. https://pubs.acs.org/doi/10.1021/acs.est.3c07520

Gushulak, C.A.C., Mezzini S., Moir, K.E., Simpson, G.L., Bunting, L., Wissel, B., Engstrom, D.R., Laird, K.R., St. Amand, A., Cumming, B.F., and Leavitt, P.R. (2024) Impacts of century of land-use change on the eutrophication of large, shallow, prairie Lake Manitoba in relation to adjacent Lake Winnipeg (Manitoba, Canada). *Freshwater Biology* 69: 47-63. https://doi.org/10.1111/fwb.14192

Laird, K.R., Li, S., **Gushulak, C.A.C.,** Moir, K.E., Wang, Y., Leavitt, P.R., and Cumming B.F. (2023) Influence of cultural eutrophication, climate, and landscape connectivity on 3 Kawartha lakes (Ontario, Canada) since the early 1800s. *Lake and Reservoir Management* 39: 120-140. https://doi.org/10.1080/10402381.2023.2204061

McCarthy, F.M.G., Patterson R.T., Head, M.J., Riddick, N., Lafond, K., Cumming, B.F., Hamilton, P.B., Pisaric, M., **Gushulak C.A.C.,** Leavitt, P.R. and others. (2023) The varved succession of Crawford Lake, Milton, Ontario, Canada, as a candidate Global Boundary Stratotype Section and Point for the Anthropocene Series. *The Anthropocene Review* 10: 146-176. https://doi.org/10.1177/20530196221149281

Bjorndahl, J.A., **Gushulak, C.A.C.,*** Mezzini, S., Simpson, G.L., Haig, H.A., Leavitt, P.R., and Finlay, K. (2022) Abrupt changes in the physical and biological structure of endorheic upland lakes due to 8-m lake-level variation during the 20th century. *Limnology and Oceanography* 67: 1022-1039. https://doi.org/10.1002/lno.12054

Danesh, D.C., **Gushulak, C.A.C.,** Moos, M.T, Karmakar, M., and Cumming, B.F. (2022) Changes in the prairie-forest ecotone in northwest Ontario (Canada) over the Holocene. *Quaternary Research* 46: 44-55. https://doi.org/10.1017/qua.2021.52

Gushulak, C.A.C., Marshall M., Cumming, B.F., Llew-Williams, B., Patterson, R.T., and McCarthy, F.M.G. (2022) Siliceous algae response to the 'Great Acceleration' of the mid-twentieth century in Crawford Lake (Ontario, Canada): a potential candidate for the Anthropocene GSSP. *The Anthropocene Review* 9: 571-590. https://doi.org/10.1177/20530196211046036

Gushulak, C.A.C., Haig, H.A., Kingsbury, M.V., Wissel, B., Cumming, B.F., and Leavitt, P.R. (2021) Effects of variation in benthic phototrophs along a depth gradient on assessments

of whole-lake processes. *Freshwater Biology* 66: 2118-2132. http://doi.org/10.1111/fwb.13820

Gushulak, C.A.C., Reinhardt, E.G., and Cumming, B.F. (2021) Climate driven declines in terrestrial input over the middle and late Holocene of perched boreal lakes in northeast Ontario (Canada) and teleconnections to the North Atlantic. *Quaternary Science Reviews* 265: 107056. https://doi.org/10.1016/j.quascirev.2021.107056

Gushulak, C.A.C., Leavitt, P.R., and Cumming, B.F. (2021) Basin-specific records of lake oligotrophication during the middle-to-late Holocene in boreal northeast Ontario, Canada. *The Holocene* 31: 1539-1554. https://doi.org/10.1177%2F09596836211025972

Gushulak, C.A.C., and Cumming, B.F. (2020) Diatom assemblages are controlled by light in oligotrophic and mesotrophic lakes in northern Ontario (Canada). *Journal of Paleolimnology* 64: 419-433. https://doi.org/10.1007/s10933-020-00146-w

Elmslie, B.G., **Gushulak, C.A.C.,** Boreux, M.P., Lamoureux, S.F., Leavitt, P.R., and Cumming, B.F. (2020) Complex responses of phototrophic communities to climate warming during the Holocene of northeastern Ontario. *The Holocene* 30: 272-288. https://doi.org/10.1177/0959683619883014

Gushulak, C.A.C., Laird, K.R., Bennett, J.R., and Cumming, B.F. (2017) Water depth is a strong driver of intra-lake diatom distributions in a small boreal lake. *Journal of Paleolimnology* 58: 231-241. https://doi.org/10.1007/s10933-017-9974-y

Gushulak, C.A.C., and Jin, J. (2017) Post-extinction recovery and diversification of reef-dwelling brachiopod communities: Examples from the lower Silurian of Hudson Bay. *Palaeogeography, Palaeoclimatology, Palaeoecology* 485: 605-621. https://doi.org/10.1016/j.palaeo.2017.07.016

Gushulak, C.A.C., Jin, J., and Rudkin, D.M. (2016) Paleolatitudinal morpho-gradient of the early Silurian brachiopod *Pentameroides* in Laurentia. *Canadian Journal of Earth Sciences* 53: 680-694. https://doi.org/10.1139/cjes-2015-0183

Gushulak, C.A.C., West, C.K., and Greenwood, D.R. (2016) Paleoclimate and precipitation seasonality of the Early Eocene McAbee megaflora, Kamloops Group, British Columbia. *Canadian Journal of Earth Sciences* 53: 591-604. https://doi.org/10.1139/cjes-2015-0160

Manuscripts in review and revision

Gushulak, C.A.C., Bertram, T.H, Dugan, H.A., Franck, J.A., Pujara, N., Rogers, M.N., Salemink-Harry, S., Smith, B.J., Wagner, T.J.W., Zoet, L.K., and Wilkinson, G.M. The role of surface water waves on driving cyanobacterial blooms in lakes. *Limnology and Oceanography Letters.* Submitted. LOL2-24-0083.

Communications

Gushulak, C.A.C., Bodmer, P., Carvalho, C.R., Gladstone-Gallagher, R.V., Lee, Y.P., Lowman, H.E., Oguguah, N.M., Meinikmann, K., Rii., Y.M., Rodriguez-Cardona, B.M., and Bizic, M. (2023) The silent mental health and well-being crisis of early career researchers in aquatic sciences. *Limnology and Oceanography Bulletin.* https://doi.org/10.1002/lob.10539

Ghosh, A., Bizic, M., **Gushulak, C.A.C.,** Lee, Y.P., Meinikmann, K., Luis, K., and Grossart H-P. (2022) Bridging gaps in Aquatic Sciences: a conscious effort toward unbiased scientific presentations through Amplifying Voices. *Limnology and Oceanography Bulletin*. https://doi.org/10.1002/lob.10505

Meinikmann, K., **Gushulak, C.A.C.,** Ghosh, A., Bizic, M., Lee, Y.P., and Grossart, H-P. (2022) ASLO's Early Career Committee Amplifies Voices of Underrepresented Groups in Aquatic Sciences. *Limnology and Oceanography Bulletin* 31: 18-20. https://doi.org/10.1002/lob.10484

Invited presentations

Gushulak, C.A.C. (2024) There are back again: a postdoc's tale through the academic job market. Keynote presentation, Ontario-Quebec Paleolimnology Symposium (PALS), Kingston, Ontario.

Gushulak, C.A.C., Bjorndahl, J.A., Mezzini, S, Bunting, L, Simpson, G.L., Moir, K.E., Haig, H.A., Wissel, B., Engstrom, D.R., Laird, K.R., Cumming, B.F., Finlay, K., and Leavitt., P.R. (2021) Mechanisms of ecological state change across prairie lakes: eutrophication, lake-level variation, and climate change. Society of Canadian Limnologists LimnoSeminar series, Virtual Seminar.

Conference presentations

Gushulak, C.A.C., Numrich, L., Chegoonian, A.M., Mezzini, S., Laird, K.R., Cumming, B.F., Finlay, K., and Leavitt, P.R. (2024) Multiple mechanisms drive widespread eutrophication of Canadian prairie lakes along broad environmental gradients and spatial and temporal scales. Association for the Sciences of Limnology and Oceanography (ASLO) 2024 Meeting, Madison, Wisconsin, USA.

Gushulak, C.A.C., Mezzini, S., Moir, K.E., Shah, V., Bunting, L., Simpson, G.L., Wissel, B., Engstrom, D.R., Laird, K.R., St. Amand, A., Cumming, B.F., and Leavitt, P.R. (2023) Canada's forgotten Great Lakes: patterns of eutrophication across hydrologically connected large, shallow, lakes in an agricultural landscape (Manitoba, Canada). Association for the Sciences of Limnology and Oceanography (ASLO) 2023 Aquatic Sciences Meeting, Palma de Mallorca, Spain.

Gushulak, C.A.C., Bateson, D., Lerminiaux, J., and Leavitt, P. R. (2022) Experimental eutrophication of agricultural wetlands through direct additions of nitrogenous fertilizer urea. Joint Aquatic Sciences Meeting (JASM), Grand Rapids, Michigan, USA.

Gushulak, C.A.C., Bateson, D., Mezzini, S., and Leavitt, P. R. (2022) Eutrophication of agricultural wetlands through direct additions of nitrogenous fertilizer urea: Implications for regional water quality. Canadian Conference for Fisheries Research – Society of Canadian Limnologists Symposium (CCFFR-SCL), Vancouver, British Columbia.

Gushulak, C.A.C., Mezzini, S., Simpson, G.L., Wissel, B., Bunting, L., Engstrom. D.R., Laird, K.R., Cumming, B.F., and Leavitt, P.R. (2021) Local catchment alterations drive eutrophication in prairie Great Lakes (Manitoba, Canada): Evidence from lakes with and without large river inputs. Association for the Sciences of Limnology of Oceanography (ASLO) 2021 Aquatic Sciences Meeting, Virtual.

Gushulak, C.A.C. and Cumming, B.F. (2019) Limnological responses to Holocene climate change in northeastern Ontario: a preliminary study. Ontario-Quebec Paleolimnology Symposium, Waterloo, Ontario.

Gushulak, C.A.C. and Cumming, B.F. (2019) Diatom community assemblages are controlled by light availability in deep, clear lakes in northeastern Ontario. Society of Canadian Limnologists (SCL) Symposium-Canadian Conference for Fisheries Research, London, Ontario.

Gushulak, C.A.C. and Cumming, B.F. (2018) East vs West: differing precipitation regimes cause a climatic dipole during the Holocene Thermal Maximum in northern Ontario, Canada. International Paleolimnology Association-International Association of Limnogeology (IPA-IAL) Conference, Stockholm, Sweden.

Gushulak, C.A.C., Laird, K.R., Bennett, J.R., and Cumming, B.F. (2017) Spatial statistics and diatom community organization: An argument against dispersal. Ontario-Quebec Paleolimnology Symposium, St. Catharines, Ontario.

Gushulak, C.A.C. and Jin. J. (2017) Community organization of equatorial reef-dwelling brachiopods from the early Silurian (late Telychian) Attawapiskat Formation, Hudson Bay, Canada. Geological Association of Canada/Mineralogical Association of Canada (GAC/MAC) annual meeting, Kingston, Ontario.

Gushulak, C.A.C., Jin, J., and Rudkin, D.M. (2015) Paleolatitudinal morpho-gradient of the early Silurian brachiopod *Pentameroides* in Laurentia. International Geoscience Programme Project No. 591 annual meeting, Quebec City, Quebec.

Gushulak, C.A.C., Archibald, S.B., and Greenwood, D.R. (2014) Climate of the Early Eocene McAbee macroflora, British Columbia. Geological Society of America (GSA) annual meeting, Vancouver, British Columbia.

Other Presentations

Gushulak, C.A.C., Reinhardt, E.G., Leavitt, P.R., and Cumming, B.F. (2019) Millennial-scale lake-water production history of a small boreal lake in northeast Ontario, Canada. Beaty Water Research Centre Symposium, Kingston Ontario.

Ongoing Collaborations

Eutrophication histories of shallow prairie Great Lakes (Winnipeg, Manitoba, Dauphin) in Manitoba, Canada

- Dr. Nicole Armstrong, Manitoba Agriculture and Resource Development

Greenhouse gas fluxes in relation to fertilizer-induced eutrophication in natural and agricultural wetland ponds across the prairie pothole region (Saskatchewan, Alberta) of Canada.

- Dr. Matthew Bogard, University of Lethbridge

Paleolimnological assessment of anthropogenic development, climate change, and fire history on montane lakes in Glacier National Park (Montana, USA).

- Dr. Jim Elser, University of Montana

Responses of urban-impacted Lake Washington (Washington, USA) to diversion of effluent on lake production and eutrophication

- Dr. Curtis DeGasperi, King County Water and Land Resources, Washington

Mentorship and Instruction

Mentorship

BIOL: 498/499 – B.Sc. Thesis Research, Biology Department, University of Regina

- Liam Numrich, 2023-2024
  Lake eutrophication response to shoreline and agricultural development of prairie-parkland catchments in western Saskatchewan

- Masan Lueke, 2022-2023
  Relative importance of sediment release and river influx to the nitrogen (N) budget of an N-limited hypereutrophic lake

BIOL: 490 – Selected Topics in Biology, Biology Department, University of Regina

- Viraj Shah, 2023
  Eutrophication trends in agriculturally impacted Dauphin Lake, Manitoba Canada

BIOL: 396 – Independent Research in Biology, Biology Department, University of Regina

- Jay G. Vavadia, 2023
  Assessments of cyanobacterial toxins in the Qu'Appelle River system and agricultural reservoirs throughout southern Saskatchewan, Canada

- Viraj Shah, 2022
  Analysis of sedimentary pigments from seven agricultural reservoirs using high performance liquid chromatography

- Jess Lerminiaux, 2022
  Analysis of cyanobacterial toxins in agricultural wetlands throughout southern Saskatchewan, Canada

BIOL: 537 – Undergraduate theses, Biology Department, Queen's University

- Jaedyn Smith, 2019-2020
  Recent limnological history of Hogsback Lake, northeastern Ontario, Canada

- Matthew Marshall, 2019-2020
  Defining the Holocene-Anthropocene boundary with chrysophyte scales in Crawford Lake, southern Ontario

Instruction

Co-instructor, Biology Department, University of Regina, 2021

- Biology 335: Limnology
- Biology 276: Environmental Biology

Graduate teaching assistant, Biology Department, Queen's University, 2016-2020

- BIOL 103: Introductory Biology of Organisms
- BIOL 433: History and Philosophy of Biology
- BIOL 350: Evolution and Human Affairs
- BIOL 335: Limnology

Graduate teaching assistant, Department of Earth Sciences, University of Western Ontario, 2014-2015

- ES 2265A: Paleobiology and Paleoecology
- ES 2266G: Dinosaur & Other Vertebrate Evolution
- ES 2240F: Catastrophic Events in Earth History
- ES 1083F: Life on Planet Earth

Teaching assistant, Geology Department, Brandon University, 2014

- GEOL 161: Historical Geology
- GEOL 374: Invertebrate Paleontology

Academic Service

Peer review

Scientific publications, **N=9**

- Canadian Journal of Fisheries and Aquatic Sciences (1)
- Hydrobiologia (1)
- Journal of Contemporary Water Research and Education (1)
- Journal of Phycology (1)
- Limnology and Oceanography (1)
- Quaternary Science Reviews (2)
- Science of the Total Environment (1)
- Scientific Data (1)

Professional organizations

Past Global Changes (**PAGES**), Early Career Network – 2020-present

Association for the Sciences of Limnology and Oceanography (**ASLO**) – 2020-present

Society for Canadian Aquatic Sciences (**SCAS**) – 2019-present

Canadian Quaternary Association (**CANQUA**) – 2018-present

International Paleolimnology Association (**IPA**) – 2017-present

Professional service

Chair, SCAS Communications Committee – 2023-present

- I set committee agendas and meetings, facilitate committee discussions and projects, and delegate tasks to members.

Member, SCAS Communications Committee – 2022

- I communicate opportunities, events, and news to the community through listserve emails and social media.

Member, ASLO Early Career Committee – 2021-2024

- I organize opportunities and events for early career researchers in aquatic sciences including hosting webinars, leading professional development workshops, distributing travel awards, and advancing Equity, Diversity, Inclusivity, and Justice initiatives within the society.

Conference organization

- ASLO 2024 Meeting
  - Lead workshop organizer: Maintaining positive well-being during periods of change.
  - Session organizer: Amplifying voices in a changing world.
  - Organizer: Early career mixer.
- ASLO 2023 Aquatic Sciences Meeting
  - Lead workshop organizer: Putting the ‘Fun’ back in Funding: advice for early career aquatic scientists on acquiring research funding.
  - Workshop organizer: Managing one’s own mental health in academia.
  - Organizer: Early career mixer.

University service

Sustainability committee member, Center for Limnology, University of Wisconsin-Madison, 2024

- I worked with faculty, staff, and students of the Center for Limnology to improve the sustainability of the Center's events, labs, and procedures.

Chair, Biology Graduate Student Council (BGSC), Biology Department, Queen's University, 2018-2020

- I led departmental graduate student committee which organized opportunities and events for graduate students. I worked with faculty leadership to improve graduate student wellbeing and move towards long-term objectives of the department.

Coordinator, Limnology seminar series, Biology Department, Queen's University, 2018-2019

- I organized and coordinated weekly freshwater science seminar series with both internal and invited external presenters.

Founder and Chair, Biology Graduate Research Symposium (BGRS), Queen's University, 2016-2018

- I organized and led a committee which hosted a departmental symposium for graduate students to present their research.

Academic Coordinator, Biology Graduate Society Council (BGSC), Biology Department, Queen's University, 2016-2018

- I organized opportunities and awards for biology graduate students (e.g., TAing award), and worked with faculty leadership regarding graduate student academic issues (e.g., thesis defense requirements, course offerings).

Volunteer teaching assistant for field courses, Geology Department, Queen's University, 2017

- I volunteered for sedimentological/paleontological international field courses.

Department of Earth Sciences open-house volunteer, University of Western Ontario, 2014-2016

- I spoke with prospective students about Department of Earth Sciences courses, opportunities, and experiences.

Academic Representative, Biological Society on Campus, Brandon University, 2013-2014

- I acted as liaison between undergraduates and faculty regarding academic issues (e.g., course selection, grading issues, research, and volunteering opportunities).

External service

Invited member, Technical Table on Lake Diefenbaker Irrigation Expansion Project, Federation of Sovereign Indigenous Nations (FSIN), Saskatoon, Saskatchewan, 2021.

- I provided scientific expertise and interpretation of data for Chiefs and Councils of FSIN member Indigenous nations.

Science Communication and Outreach

Volunteer – Skype-a-Scientist, 2022-present

- I discuss lake and environmental science topics with elementary school classes.

Special guest – The Doctor and The Dumbass Podcast, Episodes 13, 14: Dinosaurs I, II

- I was interviewed about dinosaur paleontology, ecology, and phylogeny.

Completed Courses

Indigenous Canada – University of Alberta (Online)

Additional Certification

BOATSMART Exam - Pleasure Craft Operator Card

Standard First Aid and CPR ‘C’ – Updated April 2021

WHMIS (Workplace Hazardous Materials Information System) – Updated September 2020

Biosafety Awareness training – September 2020

Curriculum Vitae

Caleb T. Hasler (he/him)

Associate Professor
Department of Biology
The University of Winnipeg
Richardson College for the Environment, Room 2RC045
Winnipeg, Manitoba, R3B 2E9
+1 204 803 2896
c.hasler@uwinnipeg.ca

Academic Appointments

2021–present: **Tenured, Associate Professor**, Biology, The University of Winnipeg

2023–present: **Adjunct Professor**, Biological Sciences, University of Manitoba

2022–present: **Adjunct Professor**, Food and Human Nutritional Sciences, University of Manitoba

2020–present: **Adjunct Professor**, Biology, Queen's University

2021–2024: **Chancellor's Research Chair**, The University of Winnipeg

2017–2021: **Assistant Professor**, Biology, The University of Winnipeg

2015–2017: **Lecturer**, Department of Natural Resources and Environmental Sciences, University of Illinois, Urbana IL

2014–2017: **Postdoctoral Research Associate**, Natural Resources and Environmental Sciences, University of Illinois (PI: Cory Suski)

2014: **Lecturer**, Environmental Sciences, Carleton University, Ottawa ON

Work Experience

2011–2014: **Research Scientist and Project Manager**, Dillon Consulting Limited, Ottawa ON

2005: **Research Intern** for Lotek Wireless, Newmarket ON under the supervision of Dr. George Niezgoda (deceased)

2005: **Field Assistant** for Dr. David P. Philipp, University of Illinois, Urbana IL

2004: **GPS/GIS Technician** for Queen's University Biological Station, Elgin ON

Current Professional Service Appointments

- **Member** of the American Fisheries Society Executive Direction Search Committee
- **Chair** of the Awards Committee of the Society of Canadian Aquatic Sciences (also a member of the nominations committee)
- **Associate Editor** of *Transactions of the American Fisheries Society* (since 2017)
- **Associate Editor** of *Conservation Physiology* (since 2023)
- **Peer reviewer** for many journals, I average 4 per year on top of other editorial duties
- **Member** of the Lake Winnipeg Foundation's Science Advisory Committee

Educational Background

Ph.D. Carleton University, Ottawa, Canada
Department of Biology
Dissertation Title: A Conservation Physiology Approach to Understanding the Migration Biology of an Imperiled Stock of Summer-run Chinook salmon *(Oncorhynchus tshawytscha)* in a Regulated River
Supervisor: Dr. Steven J. Cooke
May 2011

M.Sc. Queen's University, Kingston, Canada
Department of Biology
Dissertation Title: Measuring the influence of winter conditions on largemouth bass behaviour using both biotelemetry and laboratory studies
Supervisor: Dr. Bruce L. Tufts
August 2007

B.Sc. Queen's University, Kingston, Canada
Department of Biology / Geographic Information Management Studies Medial
Dissertation Title: Associations among acoustically-tagged largemouth bass during the winter as revealed by a 3-D whole lake telemetry observatory
Supervisor: Dr. Roly Tinline
April 2005

Grants and other Funding Support

- Canadian Foundation of Innovation, John R. Evans Leaders Fund – Establishment of the Center for Research in Interdisciplinary Sciences (2024–26; selected by university to move to national competition, $425K, co-principal investigator)
- Fisheries and Wildlife Enhancement Fund (Manitoba) – Enhancing recreational fisheries management in Manitoba by incorporating image pattern recognition software (2024, two years, $73K, principal investigator)
- Fisheries and Wildlife Enhancement Fund (Manitoba) – Scientific study to inform recreational angling regulations of spawning Walleye and Lake Trout (2022, two years, $148K, principal investigator)
- NSERC Alliance – Quantifying consequences of recreational angling on lake trout and development best practices to promote survival (2021, two years, $30K per year, principal investigator, Manitoba Agriculture and Resource Development and Travel Manitoba [partners])
- University of Winnipeg - Chancellor's Research Chair in Freshwater Fisheries Ecology and Management (2021, three years, $7.5K per year, principal investigator)
- Fisheries and Wildlife Enhancement Fund (Manitoba) – Lake trout population assessment and catch and release study (2021, two years, $77K, principal investigator)
- Fisheries and Oceans Canada – Biological synopsis of Chinese mystery snail (2020, 9K, principal investigator)
- Fisheries and Oceans Canada – An exploration of walleye spawning and recruitment in the Hamilton Harbour AOC (2020, $10K, principal investigator
- Fisheries and Oceans Canada – Assessment of spawning behaviour of walleye in Hamilton Harbour (2019, $10K, principal investigator)
- Fisheries and Oceans Canada – YOY white bass stomach content analysis (2019, $2.7K, principal investigator)
- Fisheries and Wildlife Enhancement Fund (Manitoba) – Conservation genetics of sauger (2019, 2 years, $69K total, principal investigator)
- NSERC – Discovery Launch Supplement (2019, $12, principal investigator)
- NSERC – Discovery Grant – Organismal responses of freshwater fish to elevated carbon dioxide (2019 to present, 5 years, $140K total, principal investigator)
- Indigenous and Northern Affairs Canada – Community-based climate monitoring program, Integrating traditional and technical environmental knowledge to increase educational and professional opportunities for Ebb and Flow youth (2018 to present, $10K, co-investigator)
- Research Manitoba – New Investigator Grant, Can parental exposure and transgenerational acclimation mediate negative consequences of exposure to elevated carbon dioxide in a freshwater fish?, (2018 to present, $50K, principal investigator)
- Fisheries and Oceans Canada, Summary of temperature metrics for aquatic invasive species in the Prairie Region (2019, $9.2K, principal investigator)
- The University of Winnipeg – Major Research Grant, Wood frog (*Lithobates sylvaticus*) behaviour in response to diluted bitumen exposure (2018, $6.5K, principal investigator)

- Institute for Sustainable Development – Experimental Lakes Area HQP Grant, Wood frog (*Lithobates sylvaticus*) behaviour in response to diluted bitumen exposure (2018, $3.5K, principal investigator)
- Fisheries and Oceans Canada, Dreissenid Risk Assessment - Water Velocity (2018, $8.1K, principal investigator)
- US Army Corp of Engineers/United States Geological Survey, Effectiveness of Carbon Dioxide Fish Barriers in Flowing Water (2015–present, $200K, postdoctoral researcher)
- Illinois Department of Natural Resources, Non-target Impacts of Using Carbon Dioxide as a Fish Barrier (2014–16, $200K, postdoctoral researcher)
- Canadian Solar, Blanding's Turtle Mitigation Plan (2014, $35K, lead scientist and project manager)
- Enbridge Renewable Energy, Bat habitat-use and mortality assessment (2013–14, $120K, principal investigator)
- City of Ottawa, Blanding's Turtle Conservation Needs Assessment (2012–13; $45K, principal investigator)

Scholarships and Awards

- Society of Canadian Aquatic Sciences Outstanding Service Award (February 2024; 0K)
- The University of Winnipeg, 2018, 2020, 2021, 2022 & 2023 Merit Award (0K; award abolished in 2024)
- Natural Sciences and Engineering Research Council (NSERC) Visiting Fellowship (February 2013; Successful Applicant; 43.5K – declined)
- NSERC Postdoctoral Fellow (June 2011; Successful Applicant; 80K-declined)
- NSERC Sir Alexander Graham Bell Canada Graduate Scholarship (Summer 2008-Summer 2011; 105K)
- Ontario Graduate Scholarship (2008-09; 15K-declined)
- Ontario Graduate Scholarship- Science and Technology (2007-08; 15K)
- Dean of Graduate Studies Academic Excellence Scholarship for Domestic Students (2007-11; 24K)
- Carleton Graduate Scholarship (2007-11; 16.1K)
- Donald R. Wiles Prize for first year lab demonstrators and teaching assistants (April 2010; .23K)
- Carleton University Travel Award (August 2009; 1.2K)
- Peter A. Larkin Travel Award (August 2009; declined value; 0.5K)
- American Fisheries Society- Skinner Memorial Award (August 2009; 0.8K)
- American Fisheries Society-Physiology Section Travel Award (July 2008; 0.5K)
- Clemens-Rigler travel award (0.2K)
- Queen's Graduate Award (2005-2006) (4.3 K)
- Queen's University Work Study Entitlement with Dr. R. Robertson (2004-05) (2.0 K)
- The Mildred K. Walters Awards, Queen's University (1.0 K)

Books

1) Midway, S., **C. Hasler**, and P. Chakrabarty, editors. 2022. Methods for fish biology, 2nd edition. American Fisheries Society, Bethesda, Maryland.

2) **Hasler, C.T.**, J.G. Imhoff, N.J. Mandrak, and S.J. Cooke, editors. 2023. Freshwater fisheries in Canada: historical and contemporary perspectives on the resources and their management. American Fisheries Society, Bethesda, Maryland.

Refereed Publications (^Undergraduate Advisee, *Graduate Mentee, [S]Shared Supervisory Duties)

Google Scholar Statistics: total citations = 2225; h-index = 26; i10-index = 57

89) Howell, B.E.UWG, Navarroli, G.UWG, DePasquale, S.W.UW, Cooke, S.J., and **C.T.Hasler**. In press. Sex and season influence behaviour and physiology of lake trout following angling. Conservation Physiology 00:000.

88) Fleet, J.L.[UWG], Mackey, T.E., Jeffrey, J.D., Good, S.V., Jeffries, K.M., and **C.T. Hasler**. 2024. Interindividual behavioural variation in response to elevated CO_2 predicts mRNA transcript abundance of genes related to acid-base regulation in medaka (*Oryzias latipes*). Aquatic Toxicology 270: 106885.

87) Edwards, T., Bouyoucos, I., **Hasler, C.T.**, Fry, M., and, Gary Anderson. 2024. Understanding olfactory and behavioural responses to dietary cues in age-1 lake sturgeon Acipenser fulvescens. Comparative Biochemistry and Physiology Part A: Molecular & Integrative Physiology. 111560.

86) Reynolds, J., Elvidge, C., Vander Meulen, I., **Hasler, C.T.**, Frank, R., Headley, J., Hewitt, L., and D. Orihel. 2024. Naphthenic acid fraction compounds, produced by the extraction of bitumen from oil sands, alters survival and behaviour of juvenile yellow perch (*Perca flavescens*). Facets 9:1–12.

85) Auge, A.C., Blouin-Demer, G., **Hasler, C.T.**, D. Murray. 2024. Demographic evidence that development is not compatible with sustainability in semi-urban freshwater turtles. Animal Conservation 27:253–266.

84) Traynor, E.M.[UWG], DePasquale, S.W.[UW], and **C.T. Hasler**. 2023. Short-term exposure of near-future CO_2 has limited influence on the energetics and behaviour of young-of-year salmonids. Canadian Journal of Zoology 101:991–1003.

83) Howell, B.E.[UWG], Navarroli, G.[UWG], Mullen, E.J., Cooke, S.J., and **C.T. Hasler**. 2023. Lake trout reflex impairment and physiological status following ice-angling. Canadian Journal of Fisheries and Aquatic Sciences 80:1547–1561.

82) Cooke, S.J., Chapman, J.M., Jeanson, A.L., Klein, G., Kroeker, D., Pegg, M.A., and **C.T. Hasler**. 2023. The intersection between diverse small-scale fisheries and the recreational fishing sector in the inland waters of Canada. Pages xxx–xxx *in* E.J. Andrews & C. Knott, editors.

Thinking Big about Small-Scale Fisheries in Canada. TBTI Global Publication Series, St. John's, NL, Canada.

81) DePasquale, S.W.[UW], Howell, B.E.,[UWG], Navarroli, G.[UWG], Jeffries, K.M., Cooke, S.J., Wijenayake, S., Jeffrey, J.D., and **C.T. Hasler**. 2023. Are the effects of catch-and-release angling evident in changes to mRNA abundances related to metabolism, acid-base regulation and stress in lake trout (*Salvelinus namaycush*) gills? Conservation Physiology 11, coad065.

80) Traynor, E.M.[UWG], and **C.T. Hasler**. 2023. Elevated CO_2 levels did not induce species- or tissue-specific damage in young-of-year salmonids. Journal of Aquatic Animal Health 35:78–87.

79) Toavs, T.R., **Hasler, C.T.**, Suski, C.D., and S.R. Midway. 2023. A 30-year dataset of CO_2 in flowing freshwaters in the United States. Scientific Data 10:20.

78) Franzin, W.G., Dunn, C.L., Klein, G.M., Long, J.M., Lumb, C.E., Merkowsky, J.J., Tyree, M., **Hasler, C.T.** and D.A. Watkinson. 2023. Status and management of fisheries resources in Manitoba and Saskatchewan. Pages 205–228 in **C. Hasler**, J. Imhof, N. Mandrak, and S. Cooke, editors. Freshwater fisheries in Canada: historical and contemporary perspectives on the resources and their management. American Fisheries Society, Bethesda, Maryland.

77) Cooke, S.J., Castaneda, R.A., Reid, A.J., Duncan, A., **Hasler, C.T.**, Brownscombe, J., Howarth, A., Piczak, M.L., Kerr, S.J., Jones, M.L., Casselman, J.M., Imhof, J.G., and N.E. Mandrak. 2023. Freshwater fisheries resources and management: Canadian contexts. Pages 57–90 in **C. Hasler**, J. Imhof, N. Mandrak, and S. Cooke, editors. Freshwater fisheries in Canada: historical and contemporary perspectives on the resources and their management. American Fisheries Society, Bethesda, Maryland.

76) Donaldson, M.R., Landovskis, S., Deveau, G.S., Eliason, E.J., Jeffries, K.M., Poesch, M.S., Drake, D.A.R., Braun, D., Nguyen, V.M., Raby, G.D., Lennox, R.J., Swanson, H., Favaro, B., Bower, S.D., Lapointe, N.W., **Hasler, C.T.**, and S.J. Cooke. 2023. On the future of freshwater fisheries science, management, and policy in Canada. Pages 563–587 in **C. Hasler**, J. Imhof, N. Mandrak, and S. Cooke, editors. Freshwater fisheries in Canada: historical and contemporary perspectives on the resources and their management. American Fisheries Society, Bethesda, Maryland.

75) Chakrabarty, P., Midway, S.R., and **C.T. Hasler**. 2022. Methods in fish biology: the modern toolbox. Pages 1–5 in S. Midway, **C. Hasler**, and P. Chakrabarty, editors. Methods for fish biology, 2nd edition. American Fisheries Society, Bethesda, Maryland.

74) Card, J.T.[*], Beiber, J., Louison, M.J., Suski, C.D., and C.T. Hasler. 2022. An examination of freezing in yellow perch (*Perca flavescens*) following ice fishing using a histological approach. Journal of Applied Ichthyology 38:285–292.

73) Reynolds, J.S., Jackson, B.L., Madison, B.N., Elvidge, C.K., Frank, R.A., **Hasler, C.T.**, Headley, J.V., Hewitt, M.L., Peru, K.M., Yakimowski, S.B., and D.M. Orihel. 2022. Fathead minnows exposed to organic compounds from oil sands tailings as embryos have reduced survival, impaired development, and altered behaviors that persist into larval stages. Environmental Toxicology and Chemistry 41:1319–1332.

72) Patterson, S.A., Denton, D.T.J.[^], **Hasler, C.T.**[S], Blais, J.M., Hanson, M.L., Hollebone, B.P., Rodriguez-Gil, J.L., Langlois, V.S., Patey, G., Yang, Z. and D.M. Orihel[S]. 2022. Resilience of larval wood frogs (*Rana sylvatica*) to hydrocarbons and other compounds released from naturally weathered diluted bitumen in a boreal lake. Aquatic Toxicology 245:106128.

71) Lawrence, M.J., Jeffries, K.M., Cooke, S.J., Enders, E.C., **Hasler, C.T.**, Somers, C.M., Suski, C.D., and M.J. Louison. 2022. Catch and release ice fishing: Status, issues, and research needs. Transactions of the American Fisheries Society 00:000–000. 0.1002/tafs.10349.

70) Bzonek, P.A., Edwards, P.D., **Hasler, C.T.**, Suski, C.D., Boonstra, R., and N.E. Mandrak. 2022. Deterring movement of an invasive fish: individual variation in Common Carp responses to acoustic and stroboscopic stimuli. Transactions of the American Fisheries Society 151:112–123.

69) Dey, C.J., A.I. Rego, M.J. Bradford, K.D. Clarke, K. McKercher, N.J. Mochnacz, A. de Paiva, K. Ponader, L. Robichaud, A.K. Winegardner, C. Berryman, P.J. Blanchfield, C.M. Boston, D. Braun, J.W. Brownscombe, C. Burbidge, S. Campbell, A. Cassidy, C. Chu, S.J. Cooke, D. Coombs, J. Cooper, A. Curry, M. Cvetkovic, A. Demers, M. Docker, A. Doherty, S.E. Doka, K. Dunmall, B. Edwards, E.C. Enders, N. Fisher, Gauthier-Ouellet, W. Glass, L.N. Harris, **C.T. Hasler**, J. Hill, S.G. Hinch, E.E. Hodgson, J. Hwang, K.M. Jeffries, L. King, R. Kiriluk, R. Knight, A. Levy, J. MacDonald, R. Mackereth, R. McLaughlin, C.K. Minns, J.W. Moore, K. Nantel, C. Nessman, C. Normand, C.M. O'Connor, J. Paulic, L. Phalen, J. Post, T.C. Pratt, S.M. Reid, A. Rose, J. Rosenfeld, K.E. Smokorowski, D. Sooley, M.K. Taylor, J. Treberg, J. Trottier, T.D. Tunney, M-P. Veilleux, D.A. Watkinson, D. Watts, K. Winfield, J.P. Ziegler, J.D. Midwood and M.A. Koops. 2021. Research priorities for the management of freshwater fish habitat in Canada. Canadian Journal of Fisheries and Aquatic Sciences. 78:1744–1754.

68) [*]Mackey, T.E., **Hasler, C.T**.[S], Durhack, T., Jeffrey, J.D., Macnaughton, C.J., Ta, K., Enders, E.C., and K.M. Jeffries[S]. 2021. Molecular and physiological responses predict acclimation limits in juvenile brook trout (*Salvelinus fontinalis*). Journal of Experimental Biology 224:jeb241885.

67) Imhof, J.G., Lapointe, N.W., Metikosh, S., and **C.T. Hasler**. 2021. Regaining lost protections: status of the revisions to the Canadian Fisheries Act. Fisheries 00:000–000.

66) Wong, C.H.^, Enders, E.C., and **C.T. Hasler**. 2021. Limited evidence of zebra mussel (Dreissena polymorpha) consumption by freshwater drum (*Aplodinotus grunniens*) in Lake Winnipeg. Journal of Great Lakes Research 47:592–602.

65) Card, J.T.*, and **C.T. Hasler**. 2021. Physiological effects of catch-and-release angling on freshwater drum (*Aplodinotus grunniens*). Fisheries Research 237:105881.

64) Card, J.T.*, **Hasler, C.T.**, Ruppert, J.L.W., Donadt, C., and M.S. Poesch. 2020. A three-pass electrofishing removal strategy is not effective for eradication of Prussian Carp in a North American stream network. Journal of Fish and Wildlife Management 11:485–493.

63) Morrison, S.M., Mackey, T.E.*, Durhack, T., Jeffrey, J.D., Wiens, L.M., Mochnacz, N.J., **Hasler, C.T.**, Enders, E.C., Treberg, J.R., and K.M. Jeffries. 2020. Sub-lethal temperature thresholds indicate acclimation and physiological limits in brook trout *Salvelinus fontinalis*. Journal of Fish Biology 00:000–000.

62) Castañeda, R.A., Burliuk, C.MM., Casselman, J.M., Cooke, S.J., Dunmall, K.M., Forbes, L.S., **Hasler, C.T.**, Howland, K.L., Hutchings, J.A., Klein, G.M., Nguyen, V.M., Price, M.H.H., Reid, A.J., Reist, J.D., Reynolds, J.D., Van Nynatten, A., and N.E. Mandrak. 2020. A brief history of fisheries in Canada. Fisheries 00: 00–00.

61) Lawrence, M.J., Raby, G.D., Teffer, A.K., Jeffries, K.M., Danylchuk, A.J., Eliason, E.J., **Hasler, C.T.**, Clark, T.D., and S.J. Cooke. 2020. Best practices for non-lethal blood sampling of fish via the caudal vasculature. Journal of Fish Biology 00:000-000.

60) Raby, G.D., Chapman, J.M., de Bruijn, R., Eliason, E.J., Elvidge, C..K., **Hasler, C.T.**, Madliger, C.L., Nyboer, E.A., Reid, A.J., Roche, D.G., Rytwinski, T., Ward, T.D., Wilson, A.D.M., and S.J. Cooke. 2020. Teaching post-secondary students in ecology and evolution: Strategies for early-career researchers. Ideas in Ecology and Evolution 13: 14–24.

59) Althoff, A., **Hasler, C.T.**, and M. Louison. 2020. Impact of retrieval time and hook type on hooking depth in ice-angled northern pike caught on tip-ups. Fisheries Research 225: 105502.

58) Hasler, C.T., Raby, G.D., Chretien, E., Stockwell, M., Cooke, S.J., Rechisky, E., Welch, D., Sopinka, N., and N. Mandrak. 2019. Reflections on the legends of Canadian fisheries science and management. Fisheries 44: 534–538.

57) Suski, C.D., Philipp, M., and **C.T. Hasler**. 2019. Influence of nutritional status on carbon dioxide tolerance and avoidance behavior in a freshwater teleost. Transaction of the American Fisheries Society 148: 914925.

56) Hechter, D.^, and **C.T. Hasler**. 2019. Repeatability of burst swimming performance in Medaka (*Oryzias latipes*). Fish Physiology and Biochemistry 45: 1299–1307.

55) Hasler, C.T., Leathers, J.^, Ducharme, A.*, and N.J. Casson. 2019. Biological effects of water velocity and other hydrodynamic characteristics of flow on Dreissenid mussels. Hydrobiologia 837: 1–14.

54) Tucker, E.K.*, Suski, C.D., Philipp, M.A., Jeffrey, J.D. and **C.T. Hasler.** 2019. Glucocorticoid and behavioral variation in relation to carbon dioxide avoidance across two experiments in freshwater teleost fishes. Biological Invasions 21: 505–517.

53) Hasler, C.T., Woodley, C., Schneider, E.V.C., Hixson, B.K., Fowler, C.J., Midway, S.R., Suski, C.D., and D. Smith. 2019. Avoidance of carbon dioxide in flowing water by bighead carp. Canadian Journal of Fisheries and Aquatic Sciences 76: 961–969.

52) Schneider, E.V.C.*, **Hasler, C.T.**, and C.D. Suski. 2019. Swimming performance of a freshwater fish during exposure to high carbon dioxide, Environmental Science and Pollution Research 26: 3447–3454.

51) Jeffrey, J.D., Hannan, K.D., **Hasler, C.T.**, and C.D. Suski. 2018. Hot and bothered: The effects of elevated pCO_2 and temperature on juvenile freshwater mussels. American Journal of Physiology— Regulatory, Integrative, and Comparative Physiology 315: R115–R127.

50) Robertson, M.D., Hernandez, M.F., Midway, S.R., **Hasler, C.T.,** and C. D. Suski. 2018. Shelter seeking behavior of crayfish, *Procambarus clarkii*, in elevated carbon dioxide. Aquatic Ecology 52: 225–233.

49) Schneider, E.V.C.*, **Hasler, C.T.**, and C.D. Suski. 2018. Fish behavior in elevated CO_2: implications for a movement barrier in flowing water. Biological Invasions 20: 1899–1911.

48) Jeffrey, J.D., Hannan, K.D., **Hasler, C.T**., and C.D. Suski. 2018. Chronic exposure of a freshwater mussel to elevated pCO_2: Effects on the control of biomineralization and ion-regulatory responses. Environmental Toxicology and Chemistry 37: 538–550

47) Hasler, C.T., Jeffrey, J.D., Schneider, E.V.C., Hannan, K.D., Tix, J.A., and C.D. Suski. 2018. Biological consequences of weak acidification caused by elevated carbon dioxide in freshwater ecosystems. Hydrobiologia 806: 1–12.

46) Louison, M., **Hasler, C.T.**, Raby, G., Suski, C.D., and J. Stein. 2017. Chill out: Physiological responses to winter ice-angling in two temperate freshwater fishes. Conservation Physiology 5:cox027

45) Hasler, C.T., Hannan, K.D., Jeffrey, J.D., Suski, C.D. 2017. Valve gaping behaviour of three species of freshwater mussels exposed to elevated carbon dioxide. Environmental Science and Pollution Research 24: 15567–15575.

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14) O'Connor, C.M., Gilmour, K.M., Arlinghaus, R., **Hasler, C.T.**, Philipp, D.P., S.J. Cooke. 2010. Seasonal carryover effects of an experimental stressor in a wild teleost fish. Physiological and Biochemical Zoology 83:950–957.

13) Gillis, N.C.^, Rapp, T., **Hasler, C.T.**, Wachelka, H., and S.J. Cooke. 2010. Spatial ecology of adult muskellunge (*Esox masquinongy*) in the urban Ottawa reach of the historic Rideau Canal, Canada. Aquatic Living Resources 23:225–230.

12) Hanson, K.C., **Hasler, C.T.,** Donaldson, M.R., and S.J. Cooke. 2010. Stability of swimming performance and activity hierarchies among wild largemouth bass (*Micropterus salmoides*) at multiple temporal scales. Canadian Journal of Zoology 88:324–333.

11) Donaldson, M.R., **Hasler, C.T.**, Hanson, K.C., Clarke, T.D., S.G. Hinch, and S.J. Cooke. 2010. Injecting youth into peer-review to increase its sustainability: a case study of ecology journals. Ideas in Ecology and Evolution 3:1–7.

10) Hasler, C.T., Pon, L.B., Roscoe, D.W., Mossop, B., Patterson, D.A., Hinch S.G., and S.J. Cooke. 2009. Expanding the 'toolbox' for studying the response of fish to hydropower infrastructure and operating strategies: linking individual physiological status, energetics, behaviour, and fate. Environmental Reviews 17:179–197.

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8) Caputo, M., O'Connor, C.M., **Hasler, C.T.**, Hanson, K.C., and S.J. Cooke. 2009. Do surgically implanted telemetry transmitters have long-term consequences on the nutritional physiology and condition of wild fish? Diseases of Aquatic Organisms 84:35–41.

7) Hasler, C.T., Suski, C.D., Hanson, K.C., Cooke, S.J., and B.L. Tufts. 2009. The influence of dissolved oxygen on winter habitat selection by largemouth bass: an integration of field biotelemetry studies and laboratory experiments. Physiological and Biochemical Zoology 82: 143–152.

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5) Hanson, K.C., **Hasler, C.T.,** Cooke, S.J., Suski, C.D., and D.P.Philipp. 2008. Behaviour, activity, and depth distribution of largemouth bass as revealed by a 3D whole-lake telemetry array. Canadian Journal of Zoology 86:801–811.

4) Hasler, C.T., Donaldson, M.R., Gingerich, A.J., and K.C. Hanson. 2007. Looking beyond the border: Advantages and challenges of moving between Canada and the United States for graduate studies in fisheries science. Fisheries 32: 502–503.

3) Hanson, K. C., **Hasler, C. T.**, Suski, C. D., and S. J. Cooke. 2007. Morphological correlates of wild largemouth bass (*Micropterus salmoides)* swimming performance in the natural environment. Comparative Biochemistry and Physiology (A) 148:913–920.

2) Gingerich, A. J., Cooke, S. J., Hanson, K. C., Donaldson, M. R., **Hasler, C. T.,** Suski, C.D., and R. Arlinghaus. (2007) Evaluation of the interactive effects of air exposure duration and water temperature on the condition and survival of angled and released fish. Fisheries Research 86:169–178.

1) Hasler, C. T., Cooke, S. J., Tinline R., Hanson, K. C., Suski, C. D., Niezgoda, G., Phelan, F. J. S., and D. P. Philipp. (2007) Frequency, composition and stability among individual largemouth bass (*Micropterus salmoidae*) at diel, daily and seasonal scales. Ecology of Freshwater Fish 16:417–424.

Non-refereed Publications

Hasler, C.T., Howell, B., Navarroli, G., and S. DePasquale. 2023. Lake trout population assessments and catch and release study. Final Report submitted to Fisheries and Wildlife Enhancement Fund. 17 pp + appendices.

Hasler, C.T. and C. Wong. 2023. Sauger Conservation Biology. Final Report submitted to Fisheries and Wildlife Enhancement Fund. 8 pp + appendices.

Hasler, C.T., Burke, L., Cawker, M., Depasquale, S., Fennell, C., Ilagan, B., Kaur, S., Klymchuk, J., Kopp, S., Kumar, Q., Lecours, J., Leppelmann, M., Malchuk, G., Mayes, G., Prive, M., Samborski, I., Sobkowich, A., Versluis, R., and T. Mackey. 2022. Screening of invasive species using the NAISC prioritization process. Submitted to Fisheries and Oceans Canada, March 23, 2022. i + 57pp. (note, all authors other than myself and T. Mackey were undergraduates in my Fish Biology and Conservation course)

Edgar, M.R., Poesch, M.S., and **C.T. Hasler**. 2021. Biological synopsis of the Chinese Mystery Snail (*Cipangopaludina chinensis*). Submitted to Fisheries and Oceans Canada. 34 pp.

Mackey, T.*, Enders, E., and **C.T. Hasler**. 2019. Summary of temperature metrics for aquatic invasive species in the Prairie Region. Canadian Technical Report of Fisheries and Aquatic Sciences 3308: vii + 62 p.

Hasler, C.T., Leathers J^, Ducharme A*, N.J. Casson. 2018. Biological effects of water velocity and other hydrodynamic characteristics of flow on Dreissenid mussels. Fisheries and Oceans Canada. 38 pp.

Hasler, C.T., Sullivan, C., and C.D. Suski. 2016. Quantification of 'behavior' of carbon dioxide in a field setting. Suski Lab Technical Report Series No. 2016-002. Submitted to Illinois Department of Natural Resources. 16 pp.

Tix, J.A.*, **Hasler, C.T.,** Sullivan, C., and C.D. Suski. 2016. Physiological and behavioral responses of exposure to elevated ozone in bluegill. Suski Lab Technical Report Series No. 2016-001. Submitted to Illinois Department of Natural Resources. 24 pp.

Hasler, C.T., Sullivan C., Hannan, K.*, Tix, J.*, Jeffrey, J.D., and C.D. Suski. 2015. A comparison of methods to measure CO_2 concentration in freshwater. Suski Lab Technical Report Series No. 2015-001. Submitted to Illinois Department of Natural Resources. 14 pp.

Hasler, C.T., Patraquin, K., Liu, H., Borassa, D. and M. Enright (Dillon Consulting Limited). 2015. Talbot Wind Farm – Bat mortality predictors. Enbridge Renewable Energy.

Hasler, C.T. and S. Taylor (Dillon Consulting Limited). 2013. South March Highlands Blanding's Turtle Conservation Needs Assessment. City of Ottawa.

Hasler, C.T. and S. Taylor (Dillon Consulting Limited). 2012. Population estimate and movement study, Year 3 of 4 Annual Report. City of Ottawa.

Hasler, **C.T.** (Dillon Consulting Limited). 2011. Restoring salmonid spawning habitat using gravel replenishment. CP Rail.

Hasler, C.T. and S. Taylor (Dillon Consulting Limited). 2011. Population estimate and movement study, Year 2 of 4 Annual Report. City of Ottawa.

Cooke, S.J., Hatry, C., **Hasler, C.T.**, and K.E. Smokorowski. 2011. Literature Review, Synthesis and Proposed Guidelines Related to the Biological Evaluation of "Fish Friendly" Very Low Head Turbine Technology in Canada. Canadian Technical Report of Fisheries and Aquatic Sciences 2931.

Hasler, C.T., and S.J. Cooke. 2010. Puntledge River 2007-2009 pulse flow assessment: Final Report. For BC Hydro. 108 Pages. Fish Ecology and Conservation Physiology Laboratory Research Report Series 10-08

Hasler, C.T., Cooke, S.J., and E. Guimond. 2009. Puntledge River 2008 summer run Chinook radio and electromyography telemetry study: Interim report. For BC Hydro. 42 pages, Fish Ecology and Conservation Physiology Laboratory Research Report Series 09-02.

Hasler, C.T., Sunder, R., Donaldson, M.R., Cooke, S.J., and E. Guimond. 2008. Puntledge River 2007 summer run Chinook radio and electromyography telemetry study: Interim report. For BC Hydro. 25 pages, Fish Ecology and Conservation Physiology Laboratory Research Report Series 08-02.

Hanson, K. C., Cooke, S. J., Suski, C. D., Niezgoda, G., Phelan, F. J. S., Tinline, R., **Hasler, C. T.** and D. P. Philipp. 2006. Monitoring bass behaviour in real time over a three year period: Implications for conservation, management, and bass fishing. B.A.S.S. Workshop. Lindsey, Ontario Canada. April 01, 2006.

Hasler, C. T., Tufts, B. L., and G. Niezgoda. 2005. Gradient Trend Analysis of Warner Lake Ecological Observatory data and optimal filter settings. Lotek Wireless Inc. (technical report)

Teaching History

Courses Taught

- Winter 2024: **Fish Biology and Conservation** (The University of Winnipeg) – lectured and led lab
- Winter 2024: Undergraduate **Directed Studies** (P. Cheema, The University of Winnipeg)
- Fall 2023: Undergraduate **Directed Studies** (M. Hutton, The University of Winnipeg)
- Winter 2023: **Ecological Animal Physiology** (The University of Winnipeg)
- Fall 2022/Winter 2023: **Graduate Seminars in Biology** (The University of Winnipeg)
- Winter 2022: **Fish Biology and Conservation** (The University of Winnipeg) – lectured and led lab.
- Fall 2021/Winter 2022: **Graduate Seminars in Biology** (The University of Winnipeg)
- Winter 2021: Graduate **Directed Studies** (J. Fleet, The University of Winnipeg)
- Winter 2021: Undergraduate **Directed Studies** (Gurveer Sidhu, The University of Winnipeg)
- Fall 2020: **Comparative Animal Physiology I** (The University of Winnipeg) – lectured and all four lab sections.
- Winter 2020: Undergraduate **Directed Studies** (M. Dolores, The University of Winnipeg)
- Winter 2020: Undergraduate **Directed Studies** (C. Phillips, The University of Winnipeg)
- Winter 2020: **Fish Biology and Conservation** (The University of Winnipeg) – lectured and led lab.
- Fall 2019: **Comparative Animal Physiology I** (The University of Winnipeg) – lectured and led a lab section.

- Winter 2019: Graduate Student **Directed Study** (J. Card and T. Mackey, The University of Winnipeg)
- Winter 2019: Undergraduate **Directed Studies** (C. Wong, The University of Winnipeg)
- Winter 2019: Undergraduate **Directed Studies** (A. Novalkowski, The University of Winnipeg)
- Fall 2018: **Freshwater Ecology** (The University of Winnipeg) – lectured and led a lab section
- Fall 2018: **Comparative Animal Physiology I** (The University of Winnipeg) – lectured and led a lab section.
- Spring/Summer 2018: **Directed Studies** (D. Hechter, The University of Winnipeg)
- Winter 2018: **Ichthyology** (The University of Winnipeg) – lectured and led a lab section
- Fall 2017: **Comparative Animal Physiology I** (The University of Winnipeg) – lectured and led a lab section.
- Winter 2017: **Wildlife Population Ecology** (University of Illinois)– co-lectured and led lab component of course that teaches the fundamentals and application of population application.
- Fall 2016: **Fisheries Techniques** (University of Illinois)– lectured and developed modules. This practical course detailed specific techniques used in the field of fisheries data collection.
- Fall 2015: **Fisheries Techniques** (University of Illinois)– co-lectured and developed modules. This practical course detailed specific techniques used in the field of fisheries data collection.
- Spring 2014: **Aquatic Conservation**, Sessional Lecturer (Carleton University)– Course developed and lectured. This course detailed issues associated with aquatic environments focusing on anthropogenic impacts and conservation.

Guest Lectures

- 2022 & 2023: The story of how vodka production might save the Great Lakes from invasive species. Fish Biology and Conservation, Department of Science, McKendree University (zoom)
- 2022: The story of how vodka production might save the Great Lakes from invasive species. Ecotoxicology, Department of Environmental Science and Studies, The University of Winnipeg.
- 2021: The physiology of pain, Comparative Animal Physiology I, Department of Biology, The University of Winnipeg
- 2018-2019: Fisheries Act, Graduate Student Policy Course, Department of Biology, The University of Winnipeg
- 2018: Environmental Assessments, Graduate Student Policy Course, Department of Biology, The University of Winnipeg
- 2018: Freshwater and carbon dioxide, Ecotoxicology Course, Department of Biological Sciences, University of Manitoba
- 2014–2016: Leader of Fish module for Freshman Field Day, Department of Natural Resources and Environmental Sciences, University of Illinois
- 2013: Grade 12 Geography class (North Addington Education Centre), Ms. Rebecca Dunphy
- 2012-13: Upper-year Environmental Science course (Carleton University), Drs. Jon Midwood and Steven Cooke (x2)
- 2012 Introduction to Biology (Carleton University), Dr. Greg Bulte
- 2011-13: Physics of Time (Carleton University), Dr. Peter Harrison (x2)

- 2010: Guest Lecture optional to students of BIOL 1103: How to write lab reports for BIOL 1103 presentation (x2)
- 2007: Grade 9 Science Class Guest Lecture, North Addington Education Centre, Rebecca Yanch and Joel Hasler
- 2006: Grade 11 Biology Class, Queen's University Biological Station, Tim Dessmond
- 2006: Animal Communications Honours Seminar Class Guest Lecture, Queen's University, Dr. Kamini Persaud
- 2004: GIS and Global Positioning System (GPS) Guest Instructor, Queen's University, Biology Program

Invited Seminars/Outreach Talks

- Manitoba Fly Fishing Association, 2024
  Title: Lake trout research in Manitoba
- Filipino-Canadian Anglers Association of Manitoba, 2024
  Title: The science of recreational angling
- USRA Research Day, The University of Winnipeg (keynote speaker), 2023
  Title: From here to…where?
- Manitoba Fly Fishing Association, 2022
  Title: Physiological and behavioural consequences of angling on fishes
- COGRaD Water Quality Workshop, 2020
  Title: Classical approaches to monitoring fish health
- Department of Physics, University of Winnipeg, 2019
  Title: Freshwater biota and rising CO_2
- Department of Biology, Brandon University, 2019
  Title: Freshwater biota and rising CO_2
- Skywalk Lecture Series, The University of Winnipeg, 2018
  Title: Your job is to fish all day? Science of catch and release angling.
- Canadian Society of Environmental Biologists, 2018
  Title: Freshwater biota and rising dissolved carbon dioxide?
- Freshwater Institute, Fisheries and Oceans Canada, 2018
  Title: Using carbon dioxide to stop the movement of bigheaded carp.
- Department of Geography, The University of Winnipeg, 2018
  Title: Freshwater biota and rising carbon dioxide
- Department of Ecology, Montana State University, March 2017
  Title: Physiology in the Anthropocene, understanding fish ecophysiology
- Department of Wildlife and Fisheries, Texas A&M University, College Station, March 2017
  Title: Conservation physiology, an emerging discipline for fish ecology and management
- Department of Biology, The University of Winnipeg, March 2017
  Title: Conservation physiology, an emerging discipline for fish ecology and management
- Department of Biology, Ball State University, January 18, 2017
  Title: Fisheries Biology, an Integrative Approach
- Ecosystem Science and Management Program, University of Northern British Columbia, January 9, 2017

Title: Fish Ecology and Management, an Integrative Approach

- Department of Natural Resources and Environmental Sciences, University of Illinois, September 30, 2016
  Title: Freshwater biota and rising pCO_2?
- Department of Forestry and Environmental Conservation, Clemson University, April 21, 2016
  Title: Fisheries Ecology and Conservation
- Department of Biological Sciences, University of Manitoba, December 7, 2015
  Title: Integrative Biology and Hydropower
- US Fish and Wildlife Co-op, University of Nebraska, November 15, 2015
  Title: Fish Biology and Human Dimensions
- Illinois Department of Resources – Asian Carp Group Meeting, January 21, 2015, Springfield IL
  Title: The effectiveness of carbon dioxide as a barrier for fish movement
- Transportation Engineering Professionals – Ottawa Chapter, June 7, 2013, Ottawa ON
  Title: Blanding's turtle and wildlife guide systems at Terry Fox Drive, Ottawa, Canada
- Limnology Seminar Series, Queen's University, April 11, 2007, Kingston ON
  Title: The effect of winter on largemouth bass movement and distribution
- Behaviour, Ecology, Evolution, Research Seminars, Queen's University, December 6, 2006, Kingston Ont. Canada
  Title: Largemouth bass and their winter environment.
- Conservationists of Frontenac Addingtion Monthly Meeting, Barrie Township Hall, Cloyne Ont. Canada
  Title: Angling Nesting Black Bass.
- Wednesday Night Seminar Series, QUBS, August 2006
  Title: Acoustic Telemetry and Largemouth bass.
- Behaviour, Ecology, Evolution, Research Seminars, Queen's University, January 18, 2006, Kingston Ont. Canada
  Title: Exploring Largemouth bass activity using a submerged hydrophone array: Ideas, Results, Issues
- Inaugural Queen's University GIS Day, Queen's University, November 16, 2005, Kingston Ont. Canada
  Title: Fishy Associations- a GIS type analysis of associations among largemouth bass
- Wednesday Night Seminar series, QUBS, August 2004
  Title: GIS and GPS in Biological Sciences

<u>Conference Presentations</u>

(^ UG student, * G student)

Note, due to global pandemic in 2020, two posters by B.Sc. students (Canadian Society of Zoologists (CSZ) Meeting, Saskatoon SK, Canada), two presentations by M.Sc. students (CSZ and International Congress on the Biology of Fishes, Montpellier, France), and two presentations by Hasler (CSZ, and International Association of Great Lakes Research, Winnipeg, MB, Canada) were cancelled.

Navarroli, G., Howell, B., Morrisette, O., Rennie, M., and **C.T. Hasler** (**presenter**). 2024. Life history characteristics of recreational lake trout fisheries in Manitoba. Great Plains Fisheries Worker Association 71st Annual General Meeting, Hecla, Manitoba, March 2024.

Schoen, A., Anderson, G., and **C.T. Hasler**. 2024. Investigating maternal stress during the lake trout spawn. Great Plains Fisheries Worker Association 71st Annual General Meeting, Hecla, Manitoba, March 2024.

Fleet, J.L.*, Mackey, T.E., Jeffrey, J.D., Jeffries, K.M., Good, S.V., and **C.T. Hasler (presenter)**. 2023. Interindividual behavioural variation in response to elevated CO2 predicts mRNA transcript abundance of genes related to acid-base regulation in medaka. Society of Experimental Biology Centenary Conference, Edinburgh, UK, July 2023.

Wallace, G.^ and **C.T. Hasler**. 2023. Effects of acute exposure to elevated carbon dioxide on early life stages of Japanese medaka (*Oryzias latipes*). Canadian Society of Ecology and Evolution Conference, Winnipeg, MB, Canada, May 2023 (poster).

DePasquale, S.W.^, B.E. Howell*, G. Navarroli*, K.M. Jeffries, S.J. Cooke, S. Wijenayake, J.D. Jeffrey, and **C.T. Hasler**. 2023. Effects of catch-and-release angling on the abundance of mRNAs related to metabolism, acid-base regulation, and stress in lake trout (*Salvelinus namaycush*) gills. American Indian Science and Engineering Society (AISES) in Canada National Gathering, Vancouver, BC, Canada.

Howell, B.E.*, G. Navarroli*, E.J. Mullen, S.J. Cooke, and **C.T. Hasler**. 2023. Lake trout reflex impairment and physiological status following ice-angling. Society of Canadian Aquatic Sciences, Montréal, QC, Canada.

Klein, A.*, Desforges, JP., Docker, M., and **C.T. Hasler**. 2023. Environmental DNA as a tool to augment gillnet sampling for fish community monitoring. Society of Canadian Aquatic Sciences, Montreal, QC, Canada. (poster)

Navarroli, G.*, B.E. Howell*, A.W.R. Klein*, E.J. Mullen, O. Morissette, and **C.T. Hasler**. 2023. Population assessments of Manitoban lake trout fisheries. Society of Canadian Aquatic Sciences, Montréal, QC, Canada.

DePasquale, S.W.^, B.E. Howell*, G. Navarroli*, K.M. Jeffries, S.J. Cooke, S. Wijenayake, J.D. Jeffrey, and **C.T. Hasler**. 2023. Effects of catch-and-release angling on the expression of mRNAs related to metabolism, ion and acid-base regulation, and stress in lake trout (*Salvelinus namaycush*) gills. Society of Canadian Aquatic Sciences, Montréal, QC, Canada.

Navarroli, G.*, B.E. Howell*, A.W.R. Klein*, E.J. Mullen, O. Morissette, and **C.T. Hasler**. 2022. Are Manitoban lake trout populations in peril?. Canadian Conference for Fisheries Research – The Society of Canadian Limnologists, Vancouver, BC, Canada. (poster)

Minns, R.*, Wood, T., and **C.T. Hasler**. 2023. Effects of various stimuli on Japanese Medaka behaviour. Society of Canadian Aquatic Sciences, Montreal, QC, Canada. (poster)

Minns, R.*, Wood, T. and **C.T. Hasler**. 2023. Effects of various stimuli on Japanese Medaka behaviour. Canadian Society of Zoologists, Saskatoon, SK, Canada. (poster)

Wallace, G. E.^, and **C.T. Hasler**. 2023. Effects of acute exposure to elevated carbon dioxide on early life stages of Japanese medaka (*Oryzias latipes*). Canadian Society of Zoologists. Saskatoon, Saskatchewan. May, 2023

Fleet, J.L.*, Mackey, T.E., Jeffrey, J.D., Jeffries, K.M., Good, S.V., and **C.T. Hasler (presenter)**. 2022. Patterns of gill transcript abundance are related to behavioural responses to acute CO_2 exposure. Canadian Ecotoxicology Workshop. Winnipeg, Manitoba. October 2022.

Lecours, J.B.^, Gene, S.M., Orihel, D.M., Katzenback, B.A., Provencher, J.F., Mallory, M.L., Rochman, C., and **C.T. Hasler**. 2022. Behavioural responses as indicators of toxicity resulting from exposure to microplastics in wood frog (*Litobates sylvaticus*) larvae. Canadian Ecotoxicology Workshop. Winnipeg, Manitoba. October 2022.

Edwards, T., Bouyoucos, I., **C.T. Hasler**, and G. Anderson. 2022. Effects of L-alaine exposure during early life stage on olfactory development and overall survival in age-0 lake sturgeon (*Acipenser fulvescens*). International Congress on the Biology of Fishes. Montpellier, France. June 2022.

Hasler, C.T., Mackey, T.E., Jeffries, K.M., Lemoine, C.M.R., Cassone, B.J., Good, S.V., and J.L. Fleet*. 2022. Effects of multigenerational exposure and phenotypic variation on a freshwater fish species exposed to elevated carbon dioxide. Canadian Society of Zoologists Annual Meeting (Remote). May 2022.

Hasler, C.T., DePasquale, S.^, and E. Traynor*. 2022. Effects of acute carbon dioxide (CO_2) exposure on juvenile salmonids. American Fisheries Society Annual General Meeting (Remote). August 2022.

Toavs, T.R., **Hasler, C.T.**, Suski, C.D., and S. Midway. 2022. CO_2 in Flowing Freshwater: What can we learn from 30-Years of Data?. American Fisheries Society Annual Meeting. Spokane, Washington. August 2022.

Toavs, T.R., **Hasler, C.T.**, Suski, C.D. and S. Midway. 2022. CDFLOW: A 30-year dataset of CO_2 in U.S. flowing freshwaters. Southern Division American Fisheries Society Annual Meeting. Charleston, South Carolina. January 2022.

Traynor, E.*, DePasquale, S.^, and **C.T. Hasler**. 2022. Effects of acute carbon dioxide (CO_2) exposure on juvenile salmonids. Canadian Society of Zoologists Annual Meeting (Remote). May 2022.

Traynor, E.*, DePasquale, S.^ and **C.T. Hasler**. 2022. Effects of acute carbon dioxide (CO_2) exposure on juvenile salmonids. Canadian Conference for Fisheries Research and Society for Canadian Limnologist. Vancouver, British Columbia, Canada. February 2022.

Wong, C.H.*, Franck, J.P.C, Good, S., Forbes, L.S., Klein, G.M., and C.T. Hasler. Evaluating genetic diversity and structure of sauger (*Stizostedion canadense*) populations in Manitoba. Canadian Conference for Fisheries Research and Society for Canadian Limnologist. Vancouver, British Columbia, Canada. February 2022.

Wong, C.H.*, Enders, E.C., **C.T. Hasler**. 2021. Limited evidence of zebra mussel (*Dreissena polymorpha*) consumption by freshwater drum (*Aplodinotus grunniens*) in Lake Winnipeg. 74th Canadian Conference for Fisheries Research/Society of Canadian Limnologists, Virtual (hosted by Winnipeg MB), February 2021.

Traynor, E.M.*, Wong, C.H.*, Brooks, J., Boston, C., Reddick, D., Cooke, S.J., Midwood, J., and **C.T. Hasler**. 2021. Potential walleye spawning activity in Hamilton Harbour revealed using integrative approaches. 74th Canadian Conference for Fisheries Research/Society of Canadian Limnologists, Virtual (hosted by Winnipeg MB), February 2021.

Mackey, T.E.*, Durhack,T., Macnaughton, C.J., Jeffrey, J.D, Enders, E.C., Jeffries, K.M., and **C.T Hasler**. 2020. Thermal Acclimation in Juvenile Brook Trout (*Salvelinus fontinalis*). 73nd Canadian Conference for Fisheries Research/Society of Canadian Limnologists, Halifax NS, January 2020.

Card, J.T.*, and **C.T. Hasler**. 2020. Physiological and behavioural effects of catch-and-release angling on freshwater drum, across seasons. 73rd Canadian Conference for Fisheries Research/Society of Canadian Limnologists, Halifax NS, January 2020.

Hasler, C.T., Card, J.T.*, Beiber, J.^, Suski, C.D., and M. Louison. 2020. Behavioural and physiological consequences of ice angling on fishes. 73nd Canadian Conference for Fisheries Research/Society of Canadian Limnologists, Halifax NS, January 2020.

Orihel, D.M., Hanson, M.L., Hollebone, B.P., Palace, V.P., Luis Rodiguez-Gil, J., Langlois, V.S., Baillon, L., Black, T.A., Cederwall, J., Denton, D.*, Greer, C.W., **Hasler, C.T.**, Lara-Jacobo, L., Layton-Matthews, D., Leybourne, M., Mason, J.J., Maynard, C., Ortmann, A.C., Paterson, M.J., Patterson, S.A., Pauli, B., Rooney, R.C., Seguiin, J., Stoyanovich, S.S., Timlick, L., and J.M. Blais. 2019. Responses of freshwater vertebrates and their food web to experimental spills of diluted bitumen. SETAC Helsinki, Finland, May 29, 2019.

Mackey, T.*, Jefferies, K., Enders, E., Jeffrey, J., Durhack, T., and **Hasler, C.T**. Basic and applied aspects of thermal acclimation in Brook Trout. Prairie University Biology Symposium, Winnipeg, Canada, February 2019. (won best five minute thesis talk)

Schultz, V.^, **Hasler, C.T.**, and Huebner, J. Impacts of waste water on daphnia and medaka. Prairie University Biology Symposium, Winnipeg, Canada, February 2019.

Denton, D.^, Patterson, S., Orihel, D., Blais, J., Hansen, M., Rodrigeuz-Gill, J., Hollebone, B., Hasler, C.T. Behavioural responses to diluted bitumen in wood frog tadpoles. Prairie University Biology Symposium, Winnipeg, Canada, February 2019.

Bzonek, P.B., Edwards, P.D., **Hasler, C.T**., Suski, C.D., Boonstra, R., and Mandrak, N.E. Investigating nonphysical barriers and the roleof inter-individual fish variation. 72nd Canadian Conference for Fisheries Research/Society of Canadian Limnologists, January 2019.

Hasler, C.T., Denton, D.^, Patterson, S.A., Blais, J.M., Palace, V., Hanson, M., Hollebone, B.P., Rodriguez-Gill, J.L.,and Orihel, D.M. Behavioural responses to diluted bitumen in wood frog tadpoles. 72nd Canadian Conference for Fisheries Research/Society of Canadian Limnologists, January 2019.

Denton, D.^, Patterson, S., Orihel, D., Blais, J., Hansen, M., Rodrigeuz-Gill, J., Hollebone, B., **Hasler, C.T.** Behavioural responses to diluted bitumen in wood frog tadpoles. 13th Annual Randy Kobes Undergraduate Science Poster Compeition, Winnipeg, Canada, September 2018.

Hechter, D.T.^, and **Hasler, C.T.** Interindividual variation of glycolytic-based swimming performance in Medaka. 13th Annual Randy Kobes Undergraduate Science Poster Competition, Winnipeg, Canada, September 2018.

Bzonek, P.B., Edwards, P.D., Hasler, C.T., Suski, C.D., Boonstra, R., and Mandrak, N.E. Investigating nonphysical barriers and the roleof inter-individual fish variation. 13th International Congress on the Biology of Fishes, Calgary, July 2018.

Hasler, C.T., Woodley, C.M., Schneider, E.V.C., Hixson, B.K., Fowler, C.J., Midway, S.R., Suski, C.D., and Smith, D. Avoidance of elevated carbon dioxide in flowing water by an invasive fish species. 13th International Congress on the Biology of Fishes, Calgary, July 2018.

Suski, C.D., **Hasler, C.T.**, Jeffrey, J.D., Tucker, E., Philipp, M., Bouyoucous, I., Dennis, C., Schneider, E. Using carbon dioxide to deter the movements of invasive fishes. 13th International Congress on the Biology of Fishes, Calgary, Canada, July 2018.

Suski, C.D., Bouyoucos, I., Hannan, K., Tix, J., Midway, S.R., Jeffrey, J.D., and **Hasler, C.T.** Carbon dioxide and freshwater fish: insights from barrier applications. 147th American Fisheries Society Annual General Meeting, Tampa Bay, United States, August 2017

Hasler, C.T., Woodley, C., Schneider, E., Hixson, B., Fowler, C., Suski, C.D., and Smith, D. Avoidance of elevated carbon dioxide in flowing water by an invasive fish species, *Hypophthalmichthys nobilis*. 147th American Fisheries Society Annual General Meeting, Tampa Bay, United States, August 2017

Smith D.L., Woodley C., Threadgill, T., **Hasler, C.T.,** Suski, C.D., Cupp, A., Urbanczyk, A., Hixson, B., Hancock, D., and Noel, M. Movement and survival of bighead carp exposed to carbon dioxide deterrent barriers. 147th American Fisheries Society Annual General Meeting, Tampa Bay, United States, August 2017.

Schneider, E., **Hasler, C.T.,** Midway, S.R., and Suski, C.D. Effectiveness of carbon dioxide fish barriers in flowing water. 146th American Fisheries Society Annual Meeting, August 20–24, 2016. Kansas City, MO.

Hasler, C.T., Midway, S.R., Tix, J.A., Jeffrey, J.D., and Suski, C.D. Exposure to elevated CO_2 alters diel movement patterns of largemouth bass over short time scales. 146th American Fisheries Society Annual Meeting, August 20–24, 2016. Kansas City, MO.

Midway, S.R., **Hasler, C.T.**, and Suski, C.D. Predation of freshwater fish in elevated carbon dioxide environments. 146th American Fisheries Society Annual Meeting, August 20–24, 2016. Kansas City, MO. (poster)

Tix, J.A., Sullivan, C., **Hasler, C.T.**, Jeffrey, J.D., and Suski C.D. The Impact of Elevated Carbon Dioxide (CO_2) on Alarm Cue Behaviors in Fathead Minnows. Illinois Chapter of the American Fisheries Society 54th Annual Meeting, February 29–March 2, 2016. Springfield, IL.

Jeffrey, J.D., Hannan, K., **Hasler, C.T.,** Wright, A. and Suski, C.D. Carbon dioxide as a barrier to Asian carp: The impact on genes associated with the stress response and shell growth in a non-target freshwater mussel. 76th Midwest Fish and Wildlife Conference, January 24-27, 2016. Grand Rapids, MI, USA. (invited)

Hannan, K., Jeffrey, J.D., Wright, A., **Hasler, C.T.** and Suski, C.D. The responses of freshwater unionid mussels to elevated CO_2 in the context of fish barriers. 76th Midwest Fish and Wildlife Conference January 24-27, 2016. Grand Rapids, MI, USA.

Hasler, C.T., Dennis, C. E. III, Wright, A., Jeffrey, J.D., Donaldson, M.R., Adhikari, S., Amberg, J. Gaikowski, M. and C.D. Suski. The effectiveness of carbon dioxide as a non-physical barrier for fish movement. 76th Midwest Fish and Wildlife Conference January 24-27, 2016. Grand Rapids, MI, USA. (invited)

Jeffrey, J.D., Hannan, K., **Hasler, C.T.**, Wright, A. and Suski, C.D. The impact of elevated carbon dioxide on genes associated with shell growth and the stress response in a freshwater mussel. Society for Integrative and Comparative Biology Annual meeting, January 3-7. Portland, OR, USA.

Hasler, C.T., Midway, S.R., Jeffrey, J.D., Tix, J.A., and Suski, C.D. Post-release behaviors of largemouth bass following exposure to elevated carbon dioxide. Society for Integrative and Comparative Biology Annual meeting, January 3-7. Portland, OR, USA.

Hannan, K., Jeffrey, J.D., Wright, A., **Hasler, C.T.** and Suski, C.D. The physiological effects of exposures to elevated CO_2 on freshwater unionid mussels. Society for Integrative and Comparative Biology Annual meeting, January 3-7. Portland, OR, USA.

Hasler, C.T., Adhikari, S., Dennis, C. E. III, Wright, A., Donaldson, M.R., Jeffrey, J.D., Amberg, J. Gaikowski, M., and C.D. Suski. The effectiveness of carbon dioxide as a non-physical barrier for fish movement. American Fisheries Society Annual General Meeting, August 16-20, 2015. Portland OR.

Hannan, K., Jeffrey, J.D., Wright, A., **Hasler, C**.T., Suski, C.D. The physiological response of freshwater mussels to elevated carbon dioxide levels. American Fisheries Society Annual General Meeting, August 16-20, 2015. Portland, OR.

Tix, J.A., Sullivan, C., **Hasler, C.T.**, Jeffrey, J.D., and C.D. Suski. The Impact of Elevated Carbon Dioxide (CO_2) on Alarm Cue Behaviors in Fathead Minnows. American Fisheries Society Annual General Meeting, August 16-20, 2015. Portland OR.

Hasler, C.T., Adhikari, S., Dennis, C. E. III, Wright, A., Donaldson, M.R., Jeffrey, J.D., Amberg, J. Gaikowski, M., and C.D. Suski. The effectiveness of carbon dioxide as a non-physical barrier for fish movement. Midwest Fish and Wildlife Conference, February 9-11, 2015. Indianapolis IN. (invited)

Suski, C.D. Jeffrey, J.D., **Hasler, C.T**., Chapman, J., and S.J. Cooke. Linking landspape-scale disturbances to stress on condition of resident fishes: implications for restoration and conservation. Society for Integrative and Comparative Biology, January 3-7, 2015, West Palm Beach, FL. (invited)

Donaldson, M.R. Adhikari, S., Amberg, J., Cupp, A., Dennis, C.E. III, **Hasler, C.T.**, Jeffrey J.D., Jensen, N., Romine, J., Wright, A.W., Gaikowski, M., and C.D. Suski. Carbon dioxide as a non-physical barrier for Asian carp movement. Canadian Conference for Fisheries Research, January 8-11, 2015, Ottawa ON.

Hasler, C.T., Hanson, K.C., Suski, C.D., and S.J. Cooke. Warner Lake Ecological Observatory – a perspective. Annual Meeting of the American Fisheries Society, August 15-21, 2014, Quebec City QC. (invited)

Hasler, C.T., Cooke, S.J., Hinch, S.G., Guimond, E., and Mossop, B. Effectiveness of pulse flows on the upstream movement of an imperiled stock of summer-run Chinook salmon. Canadian Conference for Fisheries Research, January 4-7 2011, Toronto ON.

Hasler, C.T., Cooke, S.J., Hinch, S.G., Guimond, E., Donaldson, M.R., Mossop, B., and Patterson, D.A. En route temperature use and bioenergetics of different migration strategies in a population of summer-run Chinook salmon. Annual Meeting of the American Fisheries Society, September 12-16, 2010, Pittsburgh PE.

Hasler, C.T., Cooke, S.J., Hinch, S.G., Guimond, E., Donaldson, M.R., Mossop, B., and Patterson, D.A. En route temperature use and bioenergetics of different migration strategies in a population of summer-run Chinook salmon. International Congress on the Biology of Fish, July 5-9, 2010, Barcelona, Spain.

Hasler, C.T., Sunder, R.P.B., Donaldson, M.R., Guimond, E., Patterson, D., Mossop, B., Hinch, S.G., and Cooke, S.J. The influence of circulating blood physiology on migratory behaviour and fate of an imperiled stock of Chinook salmon. Canadian Conference for Fisheries Research, January 7-9, 2010, Winnipeg MB.

Hasler, C.T., Sunder, R.P.B., Donaldson, M.R., Guimond, E., Patterson, D., Mossop, B., Hinch, S.G., and Cooke, S.J. The influence of circulating blood physiology on migratory behaviour and fate of an imperiled stock of Chinook salmon. Fish Telemetry Conference held in Europe, September 14-18, 2009, Umea Sweden.

Hasler, C.T., Sunder, R.P.B., Donaldson, M.R., Guimond, E., Patterson, D., Mossop, B., Hinch, S.G., and Cooke, S.J. The influence of circulating blood physiology on migratory behaviour and fate of an imperiled stock of Chinook salmon. 139 Annual Meeting of the American Fisheries Society, August 31-September 4, 2009, Nashville TN.

Hasler, C.T., Colotelo, A.H., Rapp, T., Jamieson, E., Bellehumeur, K., Arlinghaus, R., and S.J. Cooke. Opinions of fish researchers, managers, and anglers towards recreational fishing issues: a comparative exploratory analysis for North America. American Fisheries Society Trichapter meeting between the Minnesota, Wisconsin, and Ontario Chapters, February 2-5, 2009, Duluth MN.

Hasler, C.T., Sunder, R., Donaldson, M.R., Guimond, E., Patterson, D., Mossop, B., Hinch, S.G., Cooke, S.J. Expanding the 'toolbox' for measuring the impacts of hydropower on fish and fish habitat using individual-based techniques: a case study from the Puntledge River, British Columbia. Annual Meeting of the American Fisheries Society, August 17- 21, 2008, Ottawa ON. (invited)

Hasler, C.T., Sunder, R., Donaldson, M.R., Guimond, E., Mossop, B., Patterson, D., Hinch, S.G., Cooke, S.J. Condition, migration behaviour and energy use of an imperiled stock of Chinook salmon in a hydropower impacted river. International Congress on the Biology of Fish, July 27-August 1, 2008, Portland OR.

Hasler, C. T., Hanson, K. C., Suski, C. D., Cooke, S. J., Philipp, D. P, and Tufts, B. L. Behavioural and physiological responses of largemouth bass to winter hypoxia measured using telemetry and laboratory techniques. American Fisheries Society Ontario Chapter Annual General Meeting, March 1-3, 2007, Orillia ON.

Hasler, C. T., Hanson, K. C., Suski, C. D., Cooke, S. J., and Tufts, B. L. Distribution of largemouth bass in relation to dissolved oxygen: measured using a 3-Dimensional telemetry array. Canadian Council for Fisheries Research Annual Meeting, January 3-5, 2007, Montreal QC.

Mentoring

Postdoctoral Fellows mentored at The University of Winnipeg

- Dr. Alexandra Schoen (2023-2025)

Undergraduate and Graduate Students mentored at The University of Winnipeg

- Riley Versluis (**M.Sc. thesis**, 2023-25, co-supervised with Lee Gutowsky, Fisheries and Oceans Canada)

- Katrina Audet (**M.Sc. thesis**, 2022-24, co-supervised with Margaret Docker, University of Manitoba)
- Andrew Klein (**M.Sc. thesis,** 2022-24), Mitacs Accelerate Fellowship with Manitoba Hydro
- Rosemary Minns (**M.Sc. thesis**, 2022-24), The University of Winnipeg Graduate Scholarship holder
- Giulio Navarroli (**M.Sc. thesis,** 2021-23), NSERC CGS-M holder/ The University of Winnipeg President's Scholarship holder
- Bradley Howell (**M.Sc. thesis**, 2021-23), co-supervise with Steve Cooke, Carleton University, The University of Winnipeg Graduate Scholarship holder
- Emma Traynor (**M.Sc. thesis**, 2020-22), Research Manitoba Studentship holder
- Caleb Wong (**M.Sc. thesis**, 2020-23)
- Jenna Fleet (**M.Sc. thesis**, 2019-21), NSERC CGS-M holder
- Jamie Card (**M.Sc. thesis**, 2018-20), NSERC CGS-M holder
- Theresa Mackey (**M.Sc. thesis**, 2018-20), co-supervised with Ken Jeffries, University of Manitoba, Research Manitoba Studentship holder
- Isabella Sambroski (**B.Sc. thesis**, 2023-24)
- Simon DesPasquale (**B.Sc. thesis**, 2022-23)
- Grace Wallace (**B.Sc. thesis**, 2022-23)
- Lauren Burke (**B.Sc. thesis**, 2021-22)
- Victoria Thevenot (**B.Sc. thesis**, 2020-21)
- Chelsea Lukawy (**B.Sc. thesis,** 2019-20)
- Emily McIntosh (**B.Sc. thesis,** 2019-20)
- Caleb Wong (**B.Sc. thesis**, 2019-20)
- Daniel Denton (**B.Sc. thesis,** 2018-19)
- Vanessa Schulz (**B.Sc. thesis**, 2018-19)
- Leena Tetrault (**NSERC USRA & Indigenous Summer Scholars Program**, 2024)
- Melody Hutton (**NSERC USRA**, 2024)
- Grace Wallace (**NSERC USRA & Indigenous Summer Scholars Program**, 2023)
- Simon DePasquale (**NSERC USRA**, 2021 & 2022)
- Jessica Lecours (**NSERC USRA**, 2022)
- Erin Hare (**NSERC USRA**, 2020)
- Grace Sidhu (**NSERC USRA**, 2020)
- Parteek Cheema (**UG directed study**, 2024)
- Melody Hutton (**UG directed study**, 2023)
- Suvansh Shukla (**UG directed study**, 2023)
- Gurveer Sidhu (**UG directed study**, 2021)
- Marilen Dolores (**UG directed study**, 2020)
- Colton Phillips (**UG directed study**, 2020)
- Kimbaya Carriere (**UG directed study**, 2019)
- Aiden Novalkowski (**UG directed study**, 2019)
- Manuel Candaele (**Pathway to Graduate Studies Program**, 2021 & **Indigenous Summer Scholars Program**, 2022)
- Bailey Truss (**UG directed study**, 2019)

- Caleb Wong (**UG directed study**, 2019)
- Drake Hechter (**UG directed study**, 2018)
- Grace Wallace (**UG research assistant**, 2023)
- Melody Hutton (**UG research assistant**, 2023)
- Taylor Cangemi (**UG research assistant**, 2021& 2022)
- Izabella Samborski (**UG research assistant**, 2022)
- Aiden Novalkowski (**UG research assistant**, 2019)
- Jeremey Leathers (**UG research assistant**, 2018)
- Adrienne Ducharme (**Grad. research assistant**, 2018)
- Isaac Henderson (**Highschool co-op student**, 2019)
- Janelle Laing (**M.Sc. advisory committee,** 2022-24)
- Sophia Brown (**M.Sc. advisory committee**, 2020-23)
- Arshiya Bagheri (**M.Sc. advisory committee**, 2020-23)
- Chris Patterson (**M.Sc. advisory committee∫,** 2020-21, withdrawn)
- Kristina Muise (**M.Sc. advisory committee**, 2018-20)
- Trevor Moore (**M.Sc., advisory committee**, 2017-19, withdrawn)
- Jessica Lecours (**B.Sc., advisory committee**, 2023-24)
- Avery Keen (**B.Sc., advisory committee**, 2022-23)
- Sean Robinson (**B.Sc., advisory committee**, 2021-22)
- Tiana Tiede (**B.Sc., advisory committee**, 2021-22)
- Ian McNicol (**B.Sc., advisory committee**, 2020-21)
- Fatima Almoumen (**B.Sc., advisory committee**, 2019-20)
- Jayden Borley (**B.Sc., advisory committee**, 2019-20)
- Leanne Miele (**B.Sc., advisory committee**, 2019-20)
- Joana Salazar (**B.Sc., advisory committee**, 2018-19)
- Raelene Sawatzky-Dyck (**B.Sc., advisory committee**, 2018-19)
- Rebecca Cummer (**B.Sc., advisory committee**, 2017-18)
- Robyn Demare (**B.Sc., advisory committee**, 2017-18)
- Yousra Irshad (**B.Sc., advisory committee**, 2017-18)

Undergraduate and Graduate Students mentored at the University of Manitoba

- Tyler Edwards (Ph.D., advisory committee, 2023-2027)
- Drake Hechter (Ph.D., advisory committee, 2021-2024)
- Tyler Edwards (M.Sc. advisory committee, 2021-2023
- Adam Scott (M.Sc., advisory committee, 2010-20)
- Eric Mullen (M.Sc., advisory committee, 2018-20)
- McKenzie Hauger (M.Sc., advisory committee, 2018-20)
- Aaron Klymasz-Swartz (M.Sc. advisory committee, 2019-21)
- Scott Morrison (B.Sc. advisory committee, 2018)

Undergraduate and Graduate Students mentored at the Queen's University

- Emma Schubert (B.Sc., advisory committee, 2022-23)
- Jessie Reynolds (M.Sc., advisory committee, 2019-21)
- Julia Weder (B.Sc., advisory committee, 2018-19)

Undergraduate and Graduate Students mentored at Carleton University while a Ph.D. student:

- Mark Taylor (M.Sc., later transitioned to Ph.D.)
- Charles Hatry (B.Sc., later completed M.Sc.)
- Rana Sunder (B.Sc.)
- Nathan Gillis (B.Sc.)

Undergraduate and Graduate Students mentored at the University of Illinois Urbana-Champaign while a postdoctoral research associate:

- John Tix (M.Sc.)
- Kelly Hannan (M.Sc.)
- Eric Schneider (M.Sc. in progress)
- Lena Makdah (B.Sc. in progress)
- Estefania Perez (B.Sc. in progress

Postdoctoral Research Associates supervised at Dillon Consulting Limited while a practicing environmental consultant

- Krista Patriquin
- Ryan Chlebak

Professional Committee Experience and Service

- The University of Winnipeg
    - University-level
        - Animal Ethics Committee (2024)
        - Research Leave Committee (2017, 2018, 2019)
        - Research Nomination Committee (2024)
        - Research and Volunteer Awards Committee (2019)
        - Honorary Degree and Fellowship Committee (2020, 2021)
        - Graduate Studies Scholarships and Awards Committee (2020, 2021, 2022)
        - Senate (2022, 2023)
        - Northern Research Funding Committee (2022, 2023)
    - Departmental-level
        - Time Table (2020/21)
        - Departmental Personnel Committee (2018/19, 2019/20, 2020/21, 2022/23, 2024)
        - Graduate Studies Committee (2019/20, 2022/23)
        - Research and Ethics Committee (2018/19, 2022/23)
        - *Ad hoc* Curriculum Review Committee (2019)
        - Curriculum Committee (2017/18, 2021/22)
        - Research and Travel Award Committee (2017/18)
        - Awards Committee (2021/22)
        - Nomination Committee (2024)
- Canadian Conference for Fisheries Research
    - President (2022, 2023)

- Board Member (2021, 2022, 2023)
  - Conference (Virtual) organizing committee (2021)
- Canadian Society of Aquatic Sciences
  - Chair of Awards Committee (2022, 2023)
  - Member of Nomination Committee (2022, 2023)
- American Fisheries Society Service
  - Physiology Section, Nominee for President-Elect (2024)
  - Executive Director Search Committee (2023-2024)
  - Mote Fellowship Committee (2021, 2022)
  - Emmeline Moore Prize Committee (2020)
  - Resource Policy Committee (2020-2021)
  - Membership Concerns Committee (2010-2014)
  - Education section, student subsection- Canadian representative (2005-2008)
  - Ontario Chapter, student subsection (Queen's Student Rep. (2006-07); President (2008-2011)
  - Canadian Aquatic Resource Sections, Communication officer (2008-2018); Governing Board – 2014, 2011 (mid-year)
  - Canadian Aquatic Resource Sections, Peter Larkin Graduate Student Award of Excellence review committee – 2015
  - Canadian Aquatic Resources Section, Policy Working Group (2016-present)
  - Canadian Aquatic Resources Section, Vice-president (2018-20)
  - Canadian Aquatic Resources Section, President (2020-22)
  - Canadian Aquatic Resources Section, Past President (2022-24)
- Assistant Professor of Stream Ecology Search Committee, Natural Resources and Environmental Sciences, University of Illinois (2014-15)
- Proposal Reviewer for the Great Lakes Fishery Commission (x5)
- Proposal Reviewer for Mitacs (x3)
- Proposal Reviewer for Maryland Sea Grant (x1)
- Proposal Reviewer for NSERC Discovery (x1)
- Proposal Reviewer for New Frontiers in Research Fund – Exploration 2021 competition
- Proposal Reviewer for New Frontiers in Research Fund – 2021 Innovative approaches to research in the pandemic context rapid response competition
- Reviewer for University of Manitoba Animal Care Protocols (x1)
- Reviewer for University of Waterloo Animal Care Protocols (x2)
- Co-editor of a special series on NSERC's Strategic Grants Networks in *Fisheries*
- 2010 Carleton University Dean of Science search committee (Graduate Student Representative; nominated and selected)
- Biology Graduate Students Association's departmental representative on promotions and hiring committees (non-elected)
- Co-planner (with Lauren Reed, Joel Gibson, and Marie-Ange Gravel) of the formation of a Carleton Biology Graduate Student Association
- Carleton University co-chair for the 2008 Ottawa-Carleton Integrative Biology Symposium

- Co-planner for NSERC Workshop to Enable the Establishment of a National Research Network to Assess the Impacts of Altered Flow Regimes on Riverine Ecosystems with Steven Cooke
- Reviewer, since 2006, for various peer-reviewed journals (81 manuscripts, 40 journals)
- Co-Editor, 2nd Edition of *Methods in Fish Biology*, American Fisheries Society (publisher)
- Co-editor, *Freshwater fisheries in Canada: historical and contemporary perspectives on the resources and their management* (1st Edition), American Fisheries Society (publisher)
- Associate Editor, Transactions of the American Fisheries Society (2018 to present)
- Lake Winnipeg Science Advisory Committee (2018 to present)

Volunteering and Outreach

- 2018, 2019: Science Rendez-vous (booth manager, What do fish eat?, 2020 event cancelled)
- 2011–2015: CHANCE Foundation Board of Directors (a grass roots children's charity that aimed to improved children's health, recreation, and education in Ottawa ON and the Caribbean)
- 2015–2016: Science fair judge, Next Generation School, Champaign IL (x2)
- 2014: International Fish Migration Day – volunteer and donor, Ottawa ON
- 2013–2014: Marc Garneau's Liberal Party of Canada Leadership team – Policy writer and researcher
- 1998–2001: Flinton Recreation Club, Board of Directors (a local club with the objective of improving recreation opportunities in a small rural community)
- Various guest lectures at for local high schools

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Attachment E
Preliminary Basin Reclamation Drawings

FIRST MINING GOLD

SPRINGPOLE GOLD
RECLAIMED OPEN PIT BASIN
RED LAKE, ONTARIO

FIGURE NUMBER	TITLE	REVISION
0	COVER PAGE	C
1	RECLAIMED OPEN PIT BASIN	C
2	NORTH END OF PIT RECLAMATION - PLAN AND PROFILE	C
3	PHASE I OPEN PIT RECLAMATION - PLAN AND PROFILE	C
4	FISH HABITAT DEVELOPMENT AREA - PLAN AND PROFILE	C
5	FISH HABITAT DEVELOPMENT AREA - SECTIONS	C
6	DEWATERED OPEN PIT BASIN ENHANCEMENTS	C
7	WEST DIKE PRELIMINARY PLAN AND CONSTRUCTED SPAWNING SHOAL	C
8	EAST DIKE PRELIMINARY PLAN AND CONSTRUCTED SPAWNING SHOAL	C
9	TYPICAL DETAILS	C

CLIENT
FIRST MINING GOLD
FIRST MINING GOLD

CONSULTANT
wsp

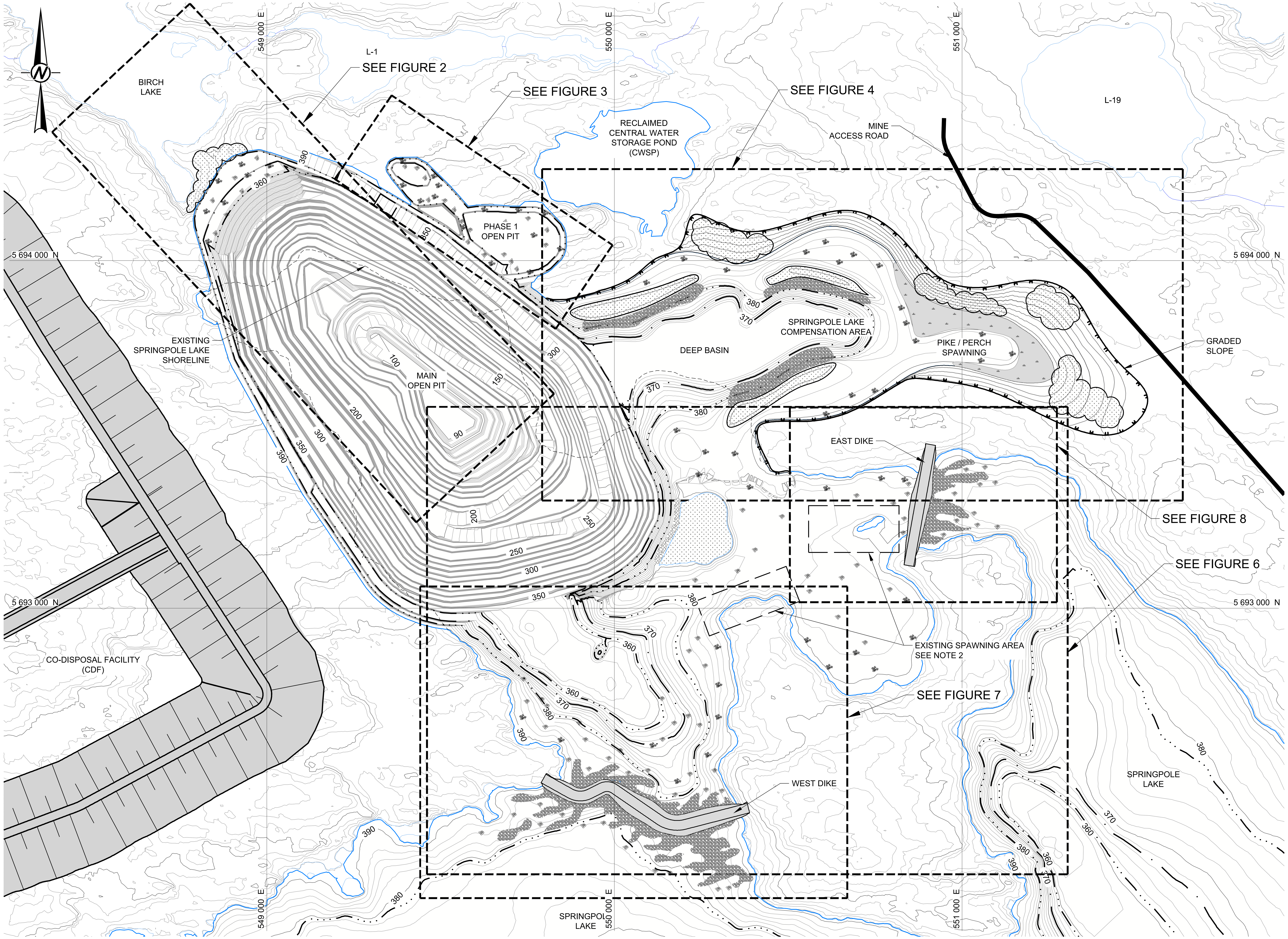
YYYY-MM-DD	2024-10-30
DESIGNED	KKJ
PREPARED	
REVIEWED	
APPROVED	

PROJECT
SPRINGPOLE GOLD
RECLAIMED OPEN PIT BASIN
RED LAKE, ONTARIO

TITLE
COVER PAGE

PROJECT NO.	CONTROL	REV.	FIGURE
ONS2104A.102	0001	C	0

25 mm
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D



LEGEND

	CONTOUR (2m INTERVAL)
	CONTOUR (10m INTERVAL)
	WATERBODY
	WATERCOURSE
	12 m DEEP
	24 m DEEP
	30 m DEEP
	FISH SPAWNING SHOAL
	TREES
	TREE PILE
	BOULDER PILE
	AQUATIC PLANTS

NOTES

1. ALL DIMENSIONS AND ELEVATIONS ARE IN METERS. GRID COORDINATES ARE IN NAD 1983 UTM ZONE 15N.
2. EXISTING SPAWNING AREAS TO BE PROTECTED FROM DISTURBANCES.

REFERENCES

1. THE DIGITAL FILES FOR THE BASE MAP WERE PRODUCED FROM DRAWING SP-0000-GX-LYD-0003-1.dwg, PROVIDED BY AUSENCO.

0 200 400
1:6,000 METRES

CLIENT
FIRST MINING GOLD

CONSULTANT

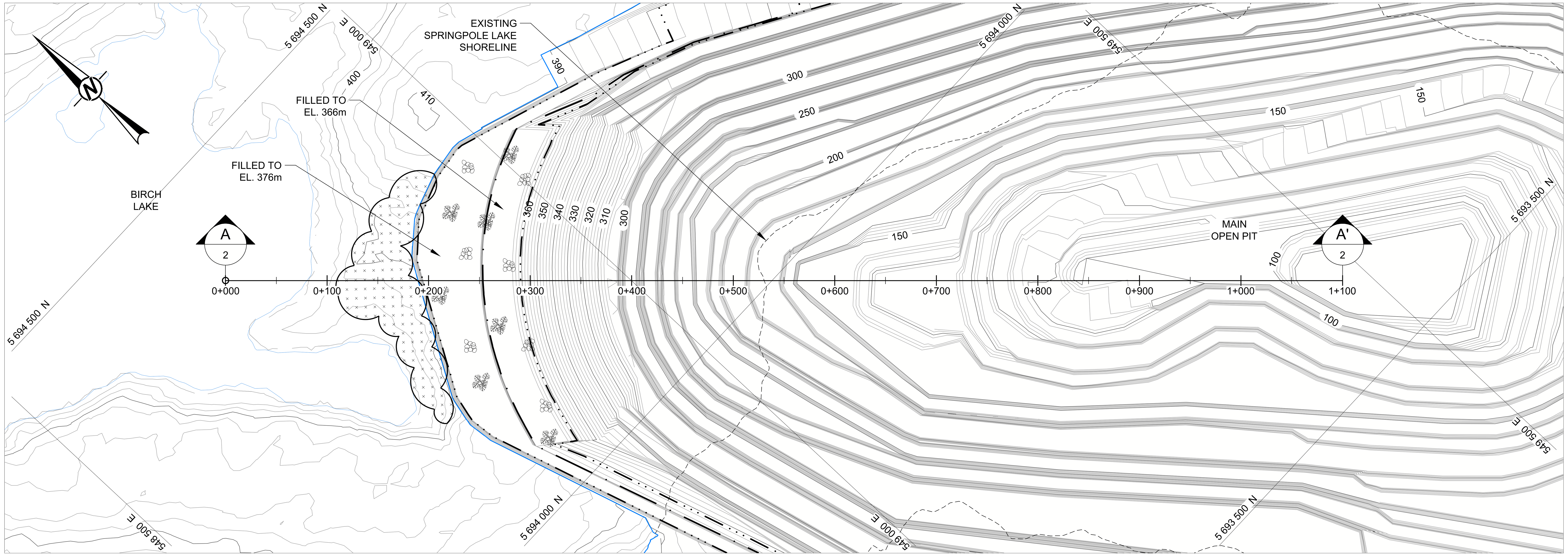
YYYY-MM-DD	2024-10-30
DESIGNED	KKJ
PREPARED	
REVIEWED	
APPROVED	

PROJECT
SPRINGPOLE GOLD
RECLAIMED OPEN PIT BASIN
RED LAKE, ONTARIO

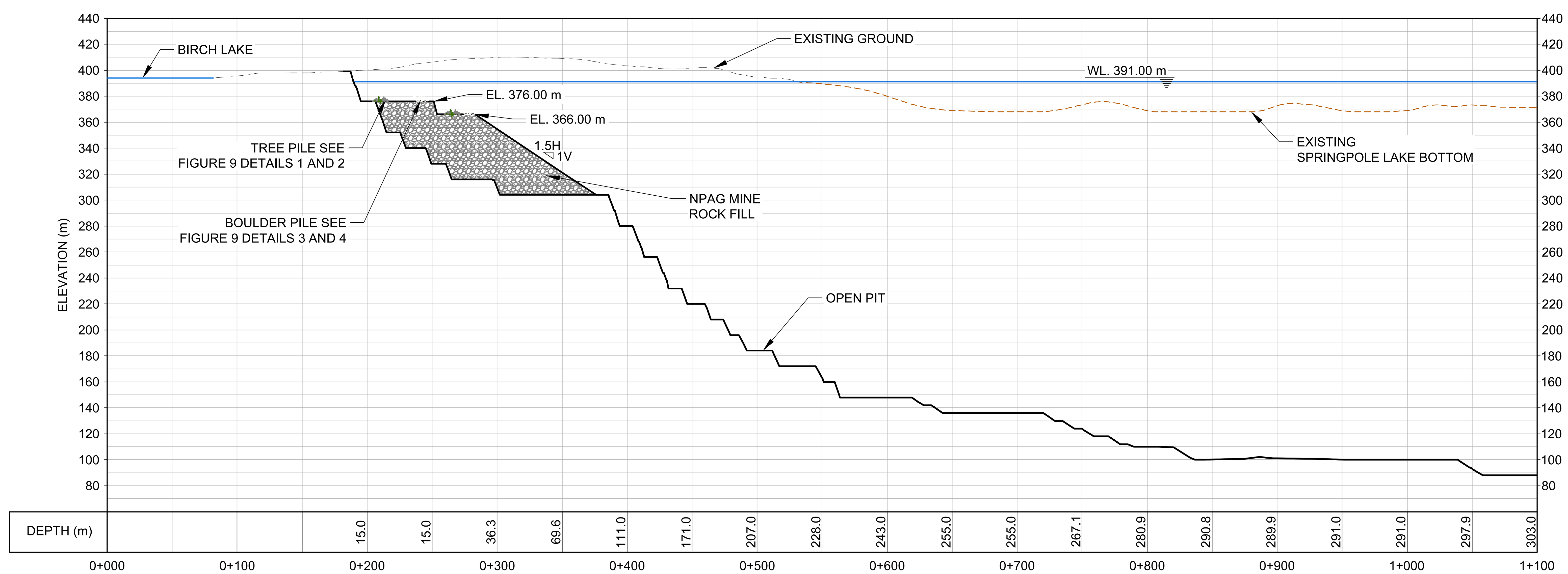
TITLE
RECLAIMED OPEN PIT BASIN

PROJECT NO.	CONTROL	REV.	FIGURE
ONS2104A.102	0001	C	1

25 mm
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D



PLAN VIEW
SCALE 1:2,500 m



SCALE 1:2,500 m (A / 2) MAIN OPEN PIT SECTION

LEGEND

- CONTOUR (2m INTERVAL)
- CONTOUR (10m INTERVAL)
- WATERBODY
- 12 m DEEP
- 24 m DEEP
- 30 m DEEP
- TREES
- TREE PILE
- BOULDER PILE

NOTES

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REFERENCES

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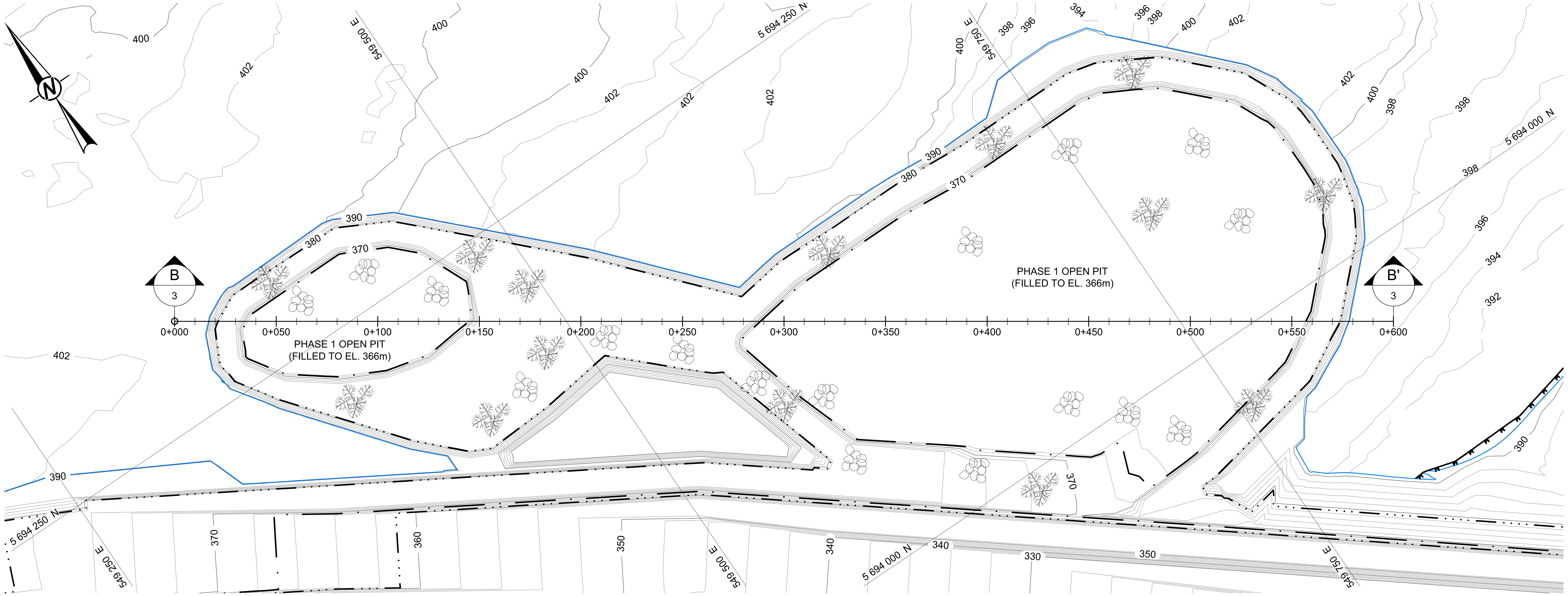
0 100 200
1:2,500 METRES

CLIENT	FIRST MINING GOLD
CONSULTANT	WSP
YYYY-MM-DD	2024-10-30
DESIGNED	KKJ
PREPARED	
REVIEWED	
APPROVED	

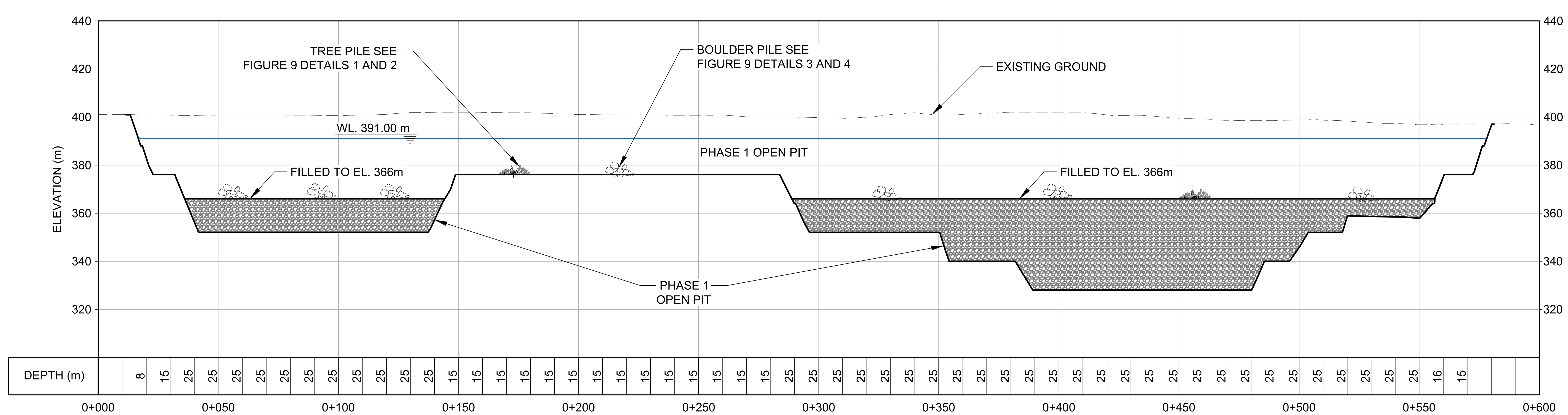
PROJECT
SPRINGPOLE GOLD
RECLAIMED OPEN PIT BASIN
RED LAKE, ONTARIO

TITLE
NORTH END OF PIT RECLAMATION PLAN AND PROFILE

PROJECT NO.	CONTROL	REV.	FIGURE
ONS2104A.102	0001	C	2



PLAN VIEW
SCALE 1:1,250 m



SCALE 1:1,250 m B 2 PHASE 1 OPEN PIT SECTION

LEGEND

- CONTOUR (2m INTERVAL)
- CONTOUR (10m INTERVAL)
- WATERBODY
- 12 m DEEP
- 24 m DEEP
- 30 m DEEP
- TREE PILE
- BOULDER PILE

NOTES

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REFERENCES

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0 50 100
1:1,250 METRES

CLIENT
FIRST MINING GOLD

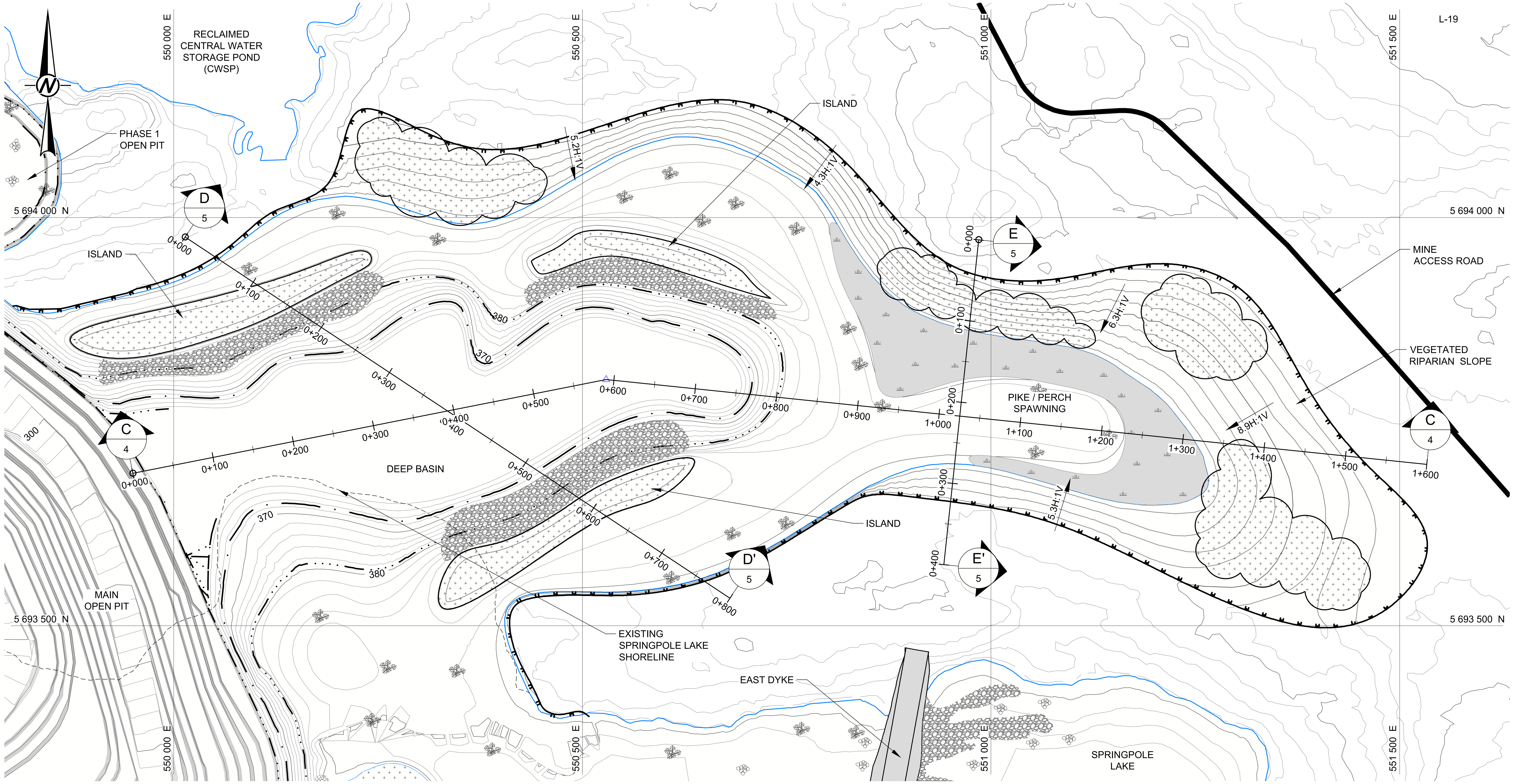
CONSULTANT
WSP

YYYY-MM-DD	2024-10-30
DESIGNED	KKJ
PREPARED	
REVIEWED	
APPROVED	

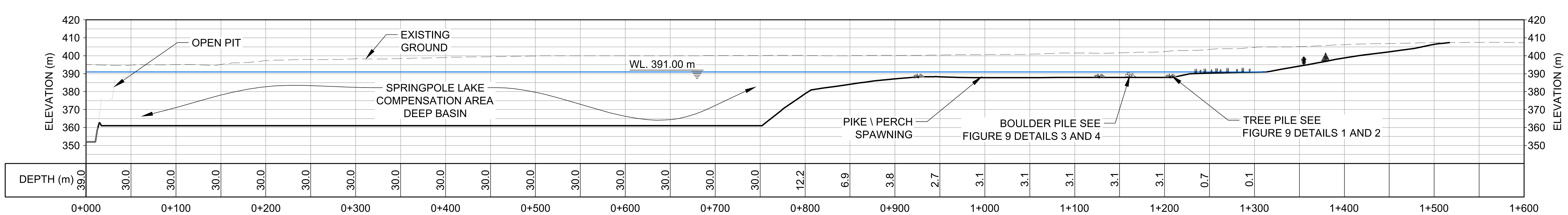
PROJECT
SPRINGPOLE GOLD
RECLAIMED OPEN PIT BASIN
RED LAKE, ONTARIO

TITLE
PHASE I OPEN PIT RECLAMATION PLAN AND PROFILE

PROJECT NO.	CONTROL	REV.	FIGURE
ONS2104A.102	0001	C	3



PLAN VIEW
SCALE 1:3,000 m



SCALE 1:3,000 m
VERT. SCALE 1:1,500 m
C 4 COMPENSATION SECTION - PROFILE

LEGEND

- CONTOUR (2m INTERVAL)
- CONTOUR (10m INTERVAL)
- WATERBODY
- WATERCOURSE
- 12 m DEEP
- 24 m DEEP
- 30 m DEEP
- TREES
- TREE PILE
- BOULDER PILE
- AQUATIC PLANTS

NOTES

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2. EXISTING SPAWNING AREAS TO BE PROTECTED FROM DISTURBANCES.

REFERENCES

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0 50 100
1:1,500 METRES

0 100 200
1:3,000 METRES

CLIENT
FIRST MINING GOLD

CONSULTANT
WSP

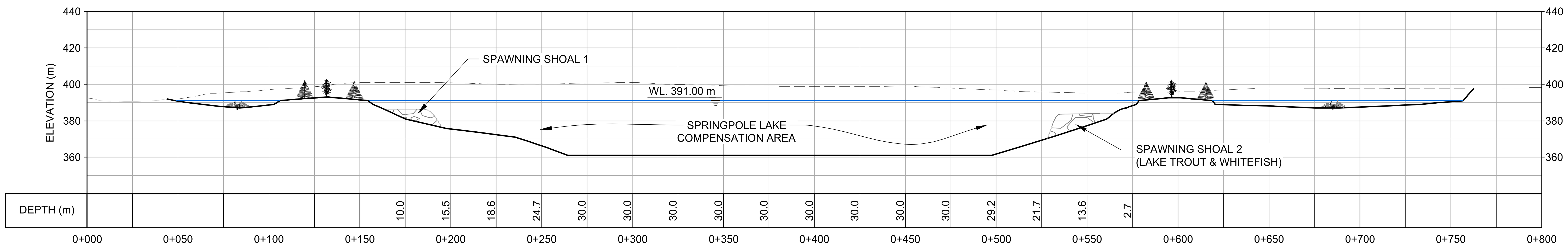
YYYY-MM-DD	2024-10-30
DESIGNED	KKJ
PREPARED	
REVIEWED	
APPROVED	

PROJECT
SPRINGPOLE GOLD
RECLAIMED OPEN PIT BASIN
RED LAKE, ONTARIO

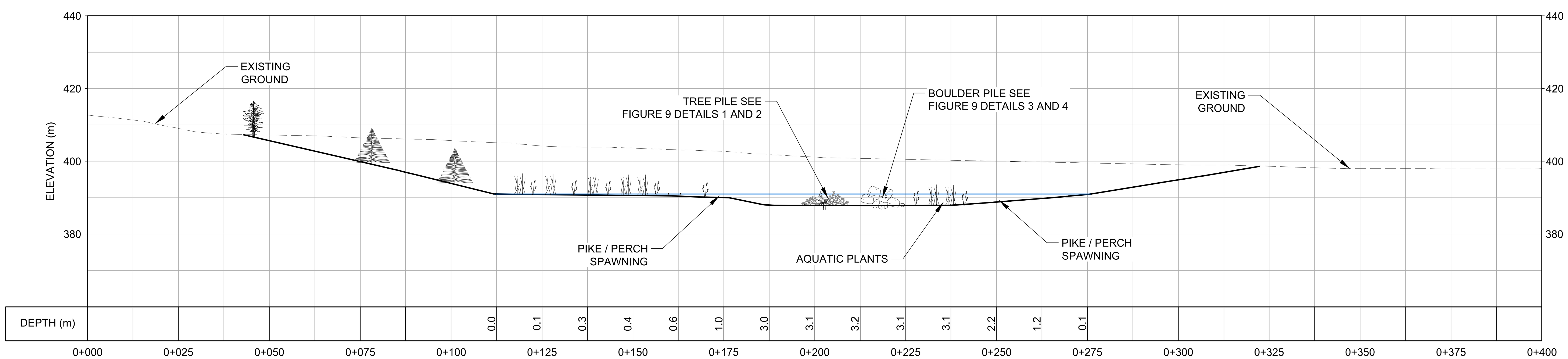
TITLE
FISH HABITAT DEVELOPMENT AREA
PLAN AND PROFILE

PROJECT NO.	CONTROL	REV.	FIGURE
ONS2104A.102	0001	C	4

25 mm IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D



SCALE 1:1,500 m D 4 COMPENSATION SECTION - DEEP



SCALE 1:750 m E 4 COMPENSATION SECTION - SHALLOW

NOTES

1. ALL DIMENSIONS AND ELEVATIONS ARE IN METERS.

0 25 50
1:750 METRES

0 50 100
1:1,500 METRES

CLIENT

FIRST MINING GOLD

FIRST MINING GOLD

CONSULTANT

wsp

YYYY-MM-DD	2024-10-30
DESIGNED	KKJ
PREPARED	
REVIEWED	
APPROVED	

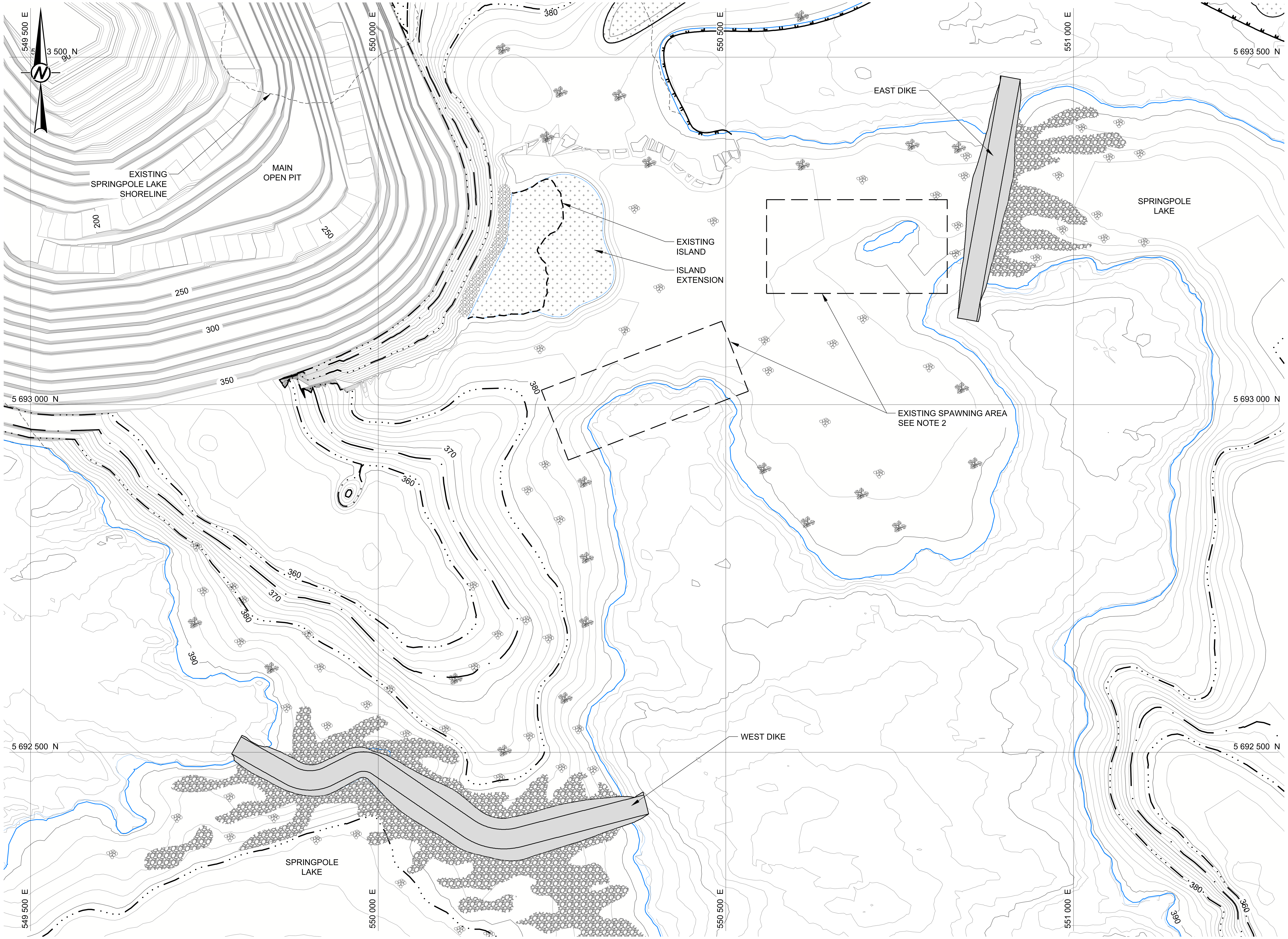
PROJECT

SPRINGPOLE GOLD
RECLAIMED OPEN PIT BASIN
RED LAKE, ONTARIO

TITLE

FISH HABITAT DEVELOPMENT AREA SECTIONS

PROJECT NO.	CONTROL	REV.	FIGURE
ONS2104A.102	0001	C	5



LEGEND

- CONTOUR (2m INTERVAL)
- CONTOUR (10m INTERVAL)
- WATERBODY
- WATERCOURSE
- 12 m DEEP
- 24 m DEEP
- 30 m DEEP
- FISH SPAWNING SHOAL
- TREE
- TREE PILE
- BOULDER PILE

NOTES

1. ALL DIMENSIONS AND ELEVATIONS ARE IN METERS. GRID COORDINATES ARE IN NAD 1983 UTM ZONE 15N.
2. EXISTING SPAWNING AREAS TO BE PROTECTED FROM DISTURBANCES.

REFERENCES

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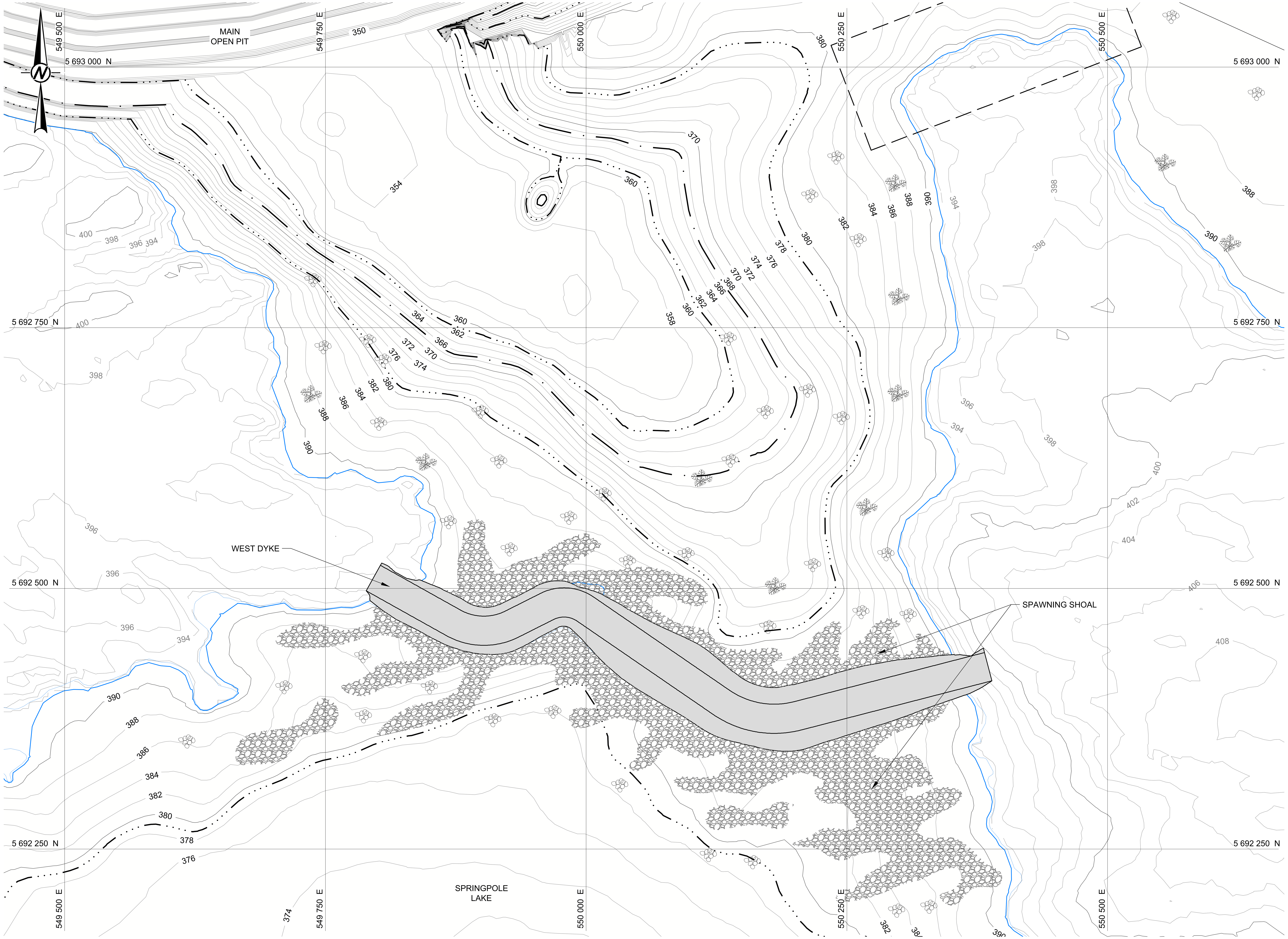
0 100 200
1:3,000 METRES

CLIENT	FIRST MINING GOLD	PROJECT	SPRINGPOLE GOLD RECLAIMED OPEN PIT BASIN RED LAKE, ONTARIO
CONSULTANT	YYYY-MM-DD: 2024-10-30 DESIGNED: KKJ PREPARED: REVIEWED: APPROVED:	TITLE	DEWATERED OPEN PIT BASIN ENHANCEMENTS

PROJECT NO.	CONTROL	REV.	FIGURE
ONS2104A.102	0001	C	6



LEGEND

CONTOUR (2m INTERVAL)
CONTOUR (10m INTERVAL)
WATERBODY
WATERCOURSE
12 m DEEP
24 m DEEP
30 m DEEP
TREE PILE
BOULDER PILE

NOTES

1. ALL DIMENSIONS AND ELEVATIONS ARE IN METERS. GRID COORDINATES ARE IN NAD 1983 UTM ZONE 15N.
2. EXISTING SPAWNING AREAS TO BE PROTECTED FROM DISTURBANCES.

REFERENCES

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0 100 200
1:2,000 METRES

CLIENT
FIRST MINING GOLD

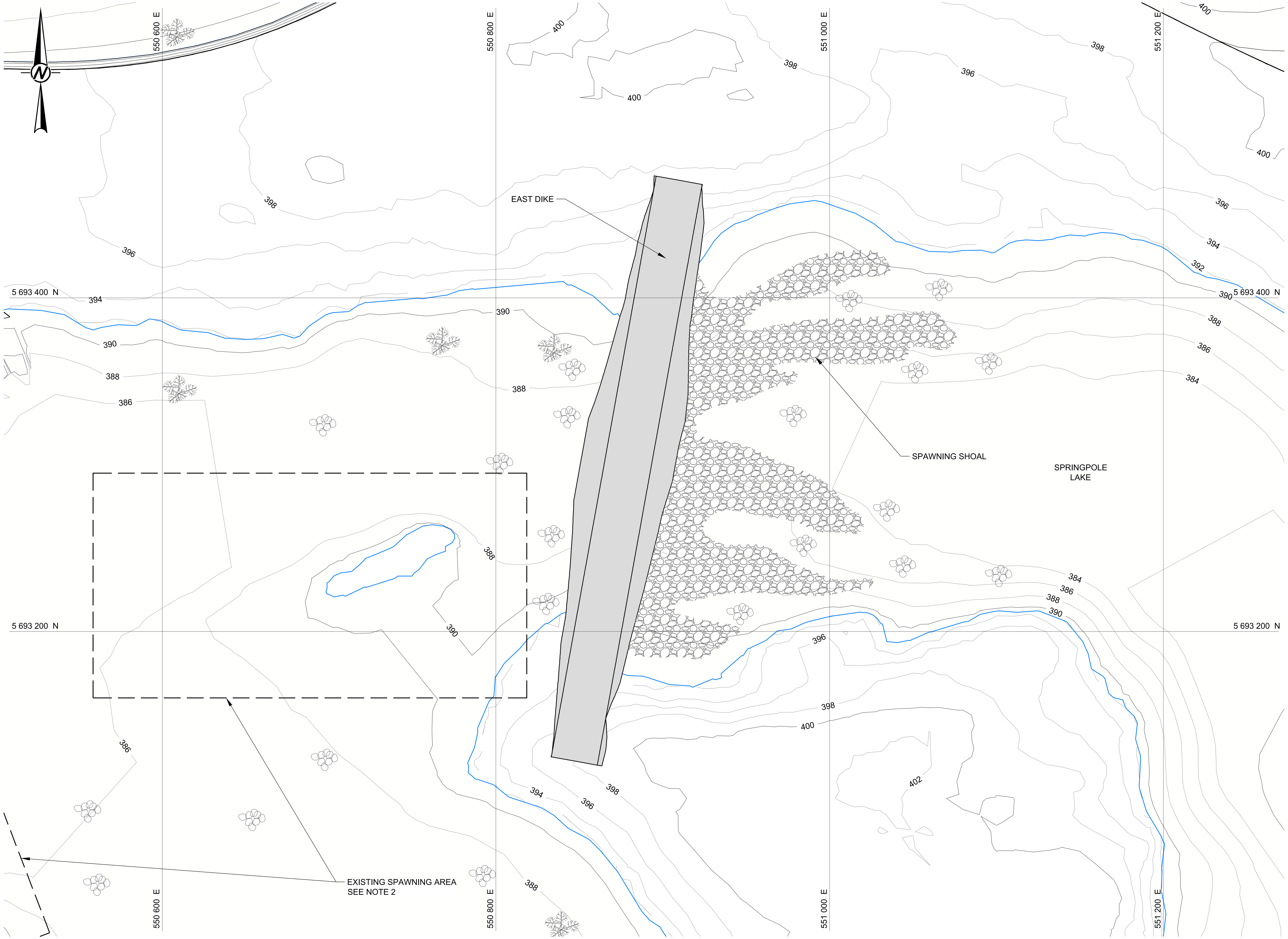
CONSULTANT
WSP

YYYY-MM-DD	2024-10-30
DESIGNED	KKJ
PREPARED	
REVIEWED	
APPROVED	

PROJECT
SPRINGPOLE GOLD
RECLAIMED OPEN PIT BASIN
RED LAKE, ONTARIO

TITLE
WEST DIKE CONSTRUCTED SPAWNING SHOAL

PROJECT NO.	CONTROL	REV.	FIGURE
ONS2104A.102	0001	C	7



LEGEND

- CONTOUR (2m INTERVAL)
- CONTOUR (10m INTERVAL)
- WATERBODY
- WATERCOURSE
- 12 m DEEP
- 24 m DEEP
- 30 m DEEP
- FISH SPAWNING SHOAL
- TREE PILE
- BOULDER PILE

NOTES

1. ALL DIMENSIONS AND ELEVATIONS ARE IN METERS. GRID COORDINATES ARE IN NAD 1983 UTM ZONE 15N.
2. EXISTING SPAWNING AREAS TO BE PROTECTED FROM DISTURBANCES.

REFERENCES

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0 50 100
1:1,250 METRES

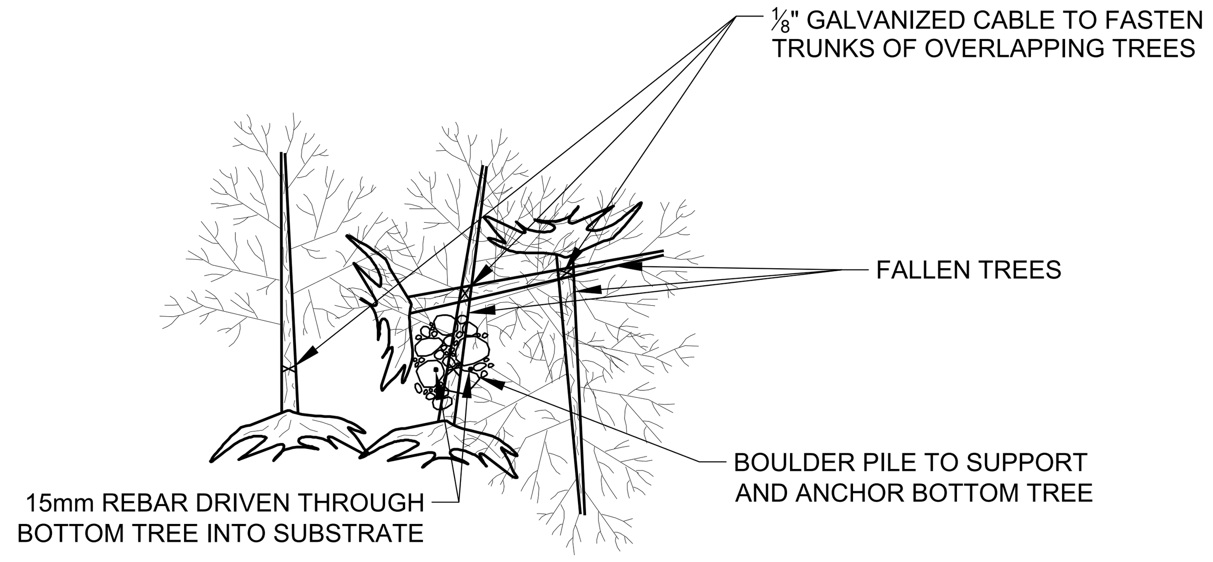
CLIENT	FIRST MINING GOLD
CONSULTANT	WSP
YYYY-MM-DD	2024-10-30
DESIGNED	KKJ
PREPARED	
REVIEWED	
APPROVED	

PROJECT
SPRINGPOLE GOLD
RECLAIMED OPEN PIT BASIN
RED LAKE, ONTARIO

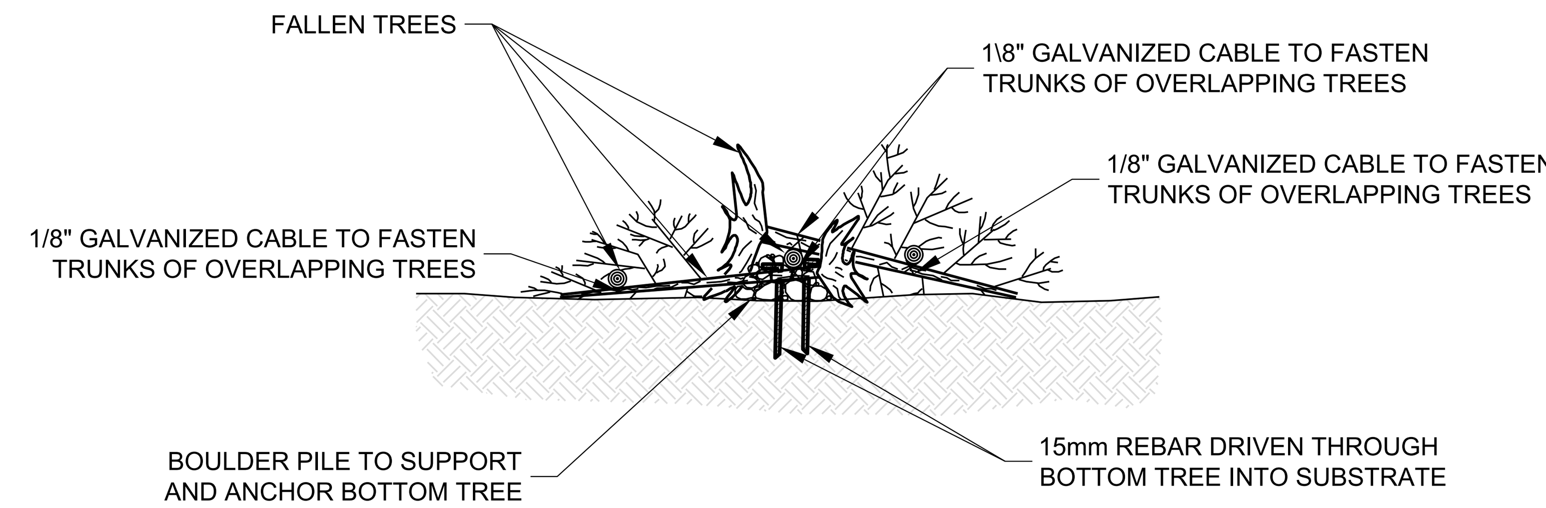
TITLE
EAST DIKE CONSTRUCTED SPAWNING SHOAL

PROJECT NO.	CONTROL	REV.	FIGURE
ONS2104A.102	0001	C	8

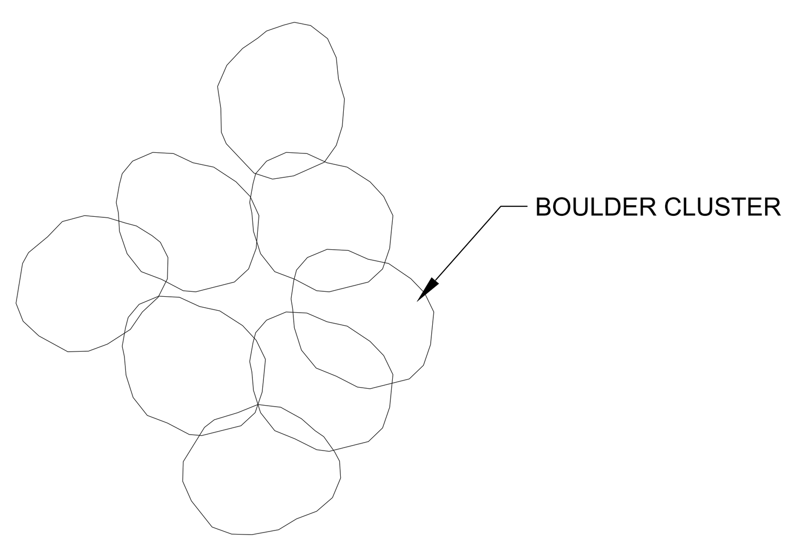
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D



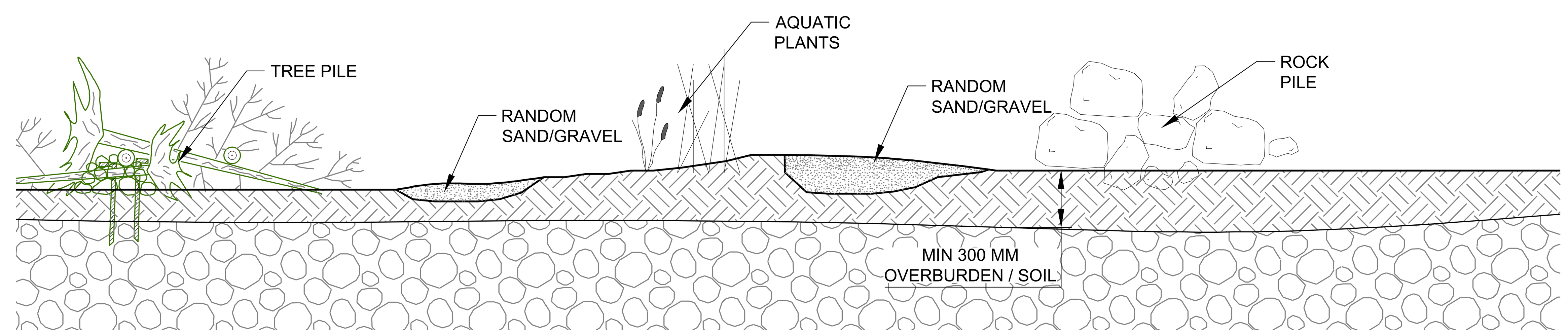
n.t.s. 1 TYPICAL TREE PILE - PLAN VIEW



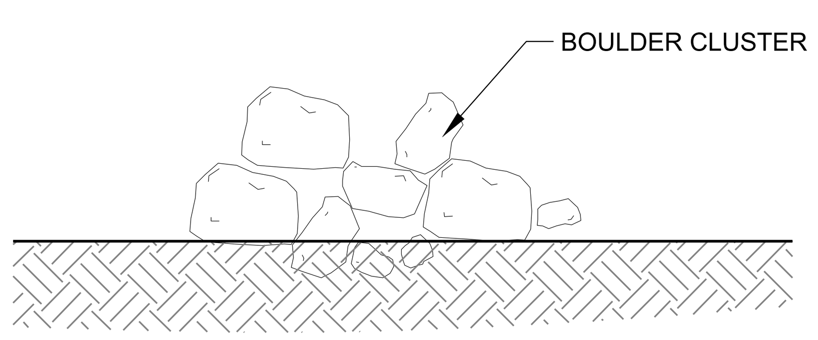
n.t.s. 2 TYPICAL TREE PILE - SECTION



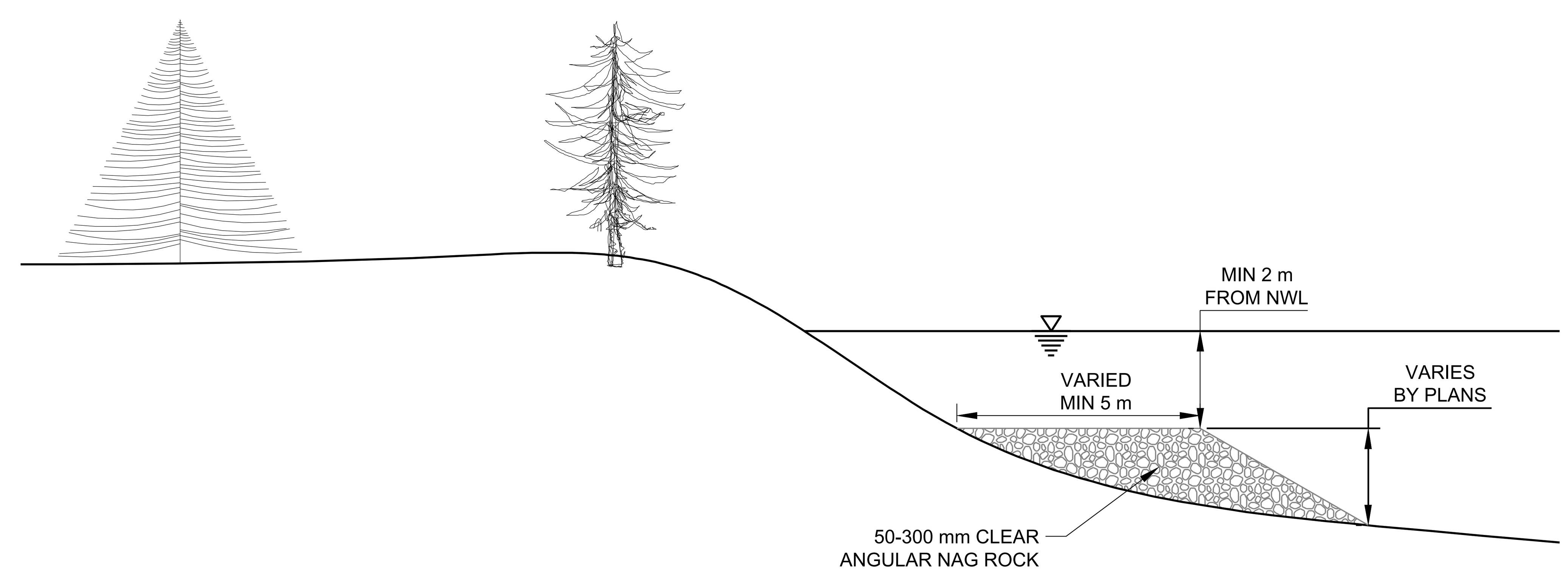
n.t.s. 3 TYPICAL BOULDER CLUSTER - PLAN VIEW



n.t.s. 5 BACKFILLED AREA AND FISH HABITAT DEVELOPMENT AREA



n.t.s. 4 TYPICAL BOULDER CLUSTER - SECTION



n.t.s. 6 SHOAL DETAIL

NOTES

TREE PILE MATERIALS:
1. TREE PILES SHALL CONSIST OF A MINIMUM OF 5 TREES OR LOGS.
2. TREES SHALL HAVE A MINIMUM DIAMETER OF 150mm AND A MINIMUM LENGTH OF 3m.
3. IT IS PREFERRED THAT TREES WITH ROOTS AND BRANCHES INTACT BE UTILIZED FOR CONSTRUCTION OF TREE PILES.
4. TREES SHALL BE SOUND AND FREE OF CENTER ROT.
5. TREES UTILIZED SHALL BE A MIXTURE OF CONIFEROUS AND DECIDUOUS TREES
6. BOULDERS UTILIZED FOR CRADLE/SADDLE AND WEIGHTING OF BOTTOM TREE SHALL BE A UNIFORM MIXTURE OF 150mm TO 400mm ROCK WHICH IS NOT POTENTIALLY ACID GENERATING.
7. TREES SHALL BE FASTENED TOGETHER UTILIZING 1/8 " GALVANIZED CABLE (OR EQUIVALENT).

TREE PILE INSTALLATION:
1. TREE PILES SHALL BE PLACED IN LOCATIONS OUTLINED IN THE APPROVED PLANS.
2. ALL TREE PILES SHALL BE INSTALLED IN THE DRY.
3. TREE PILES SHALL BE CONSTRUCTED BY STACKING TREES ATOP ONE ANOTHER TO PROVIDE HEIGHT TO THE STRUCTURE.
4. THE BOTTOM TREE IN THE PILE SHALL BE PLACED IN A BOULDER CRADLE/SADDLE AND FURTHER WEIGHTED WITH BOULDERS IN ADDITION TO BEING ANCHORED TO THE GROUND WITH REBAR.
5. REBAR ANCHORING SHALL CONSIST OF A MINIMUM OF TWO 15mm REBAR STAKES.
6. TWO PILOT HOLES SHALL BE DRILLED VERTICAL IN THE TREE TRUNK OF THE BOTTOM TREE ONCE IT HAS BEEN PLACED SECURELY IN THE BOULDER CRADLE. THE HOLES SHALL BE A MINIMUM OF 300mm APART FROM EACH OTHER.
7. EACH REBAR STAKE SHALL BE DRIVEN INTO THE NATIVE GROUND THROUGH THE PILOT HOLE LEAVING 150mm OF REBAR EXPOSED OUT OF THE TRUNK.
8. EACH EXPOSED REBAR SECTION SHALL BE BENT OVER THE SIDES OF THE TREE IN OPPOSITE DIRECTIONS, THUS LOCKING THE TREE IN PLACE.
9. BOULDERS SHALL BE ADDED TO THE CRADLE TO CREATE A BOULDER PILE WHICH COVERS THE REBAR STAKES.
10. TREES SHALL THEN BE ADDED TO THE PILE BY OVERLAPPING TREE TRUNKS AND BINDING THE TREES TOGETHER AT THE POINT OF OVERLAP UTILIZING 1/8 " GALVANIZED CABLE (OR EQUIVALENT).
11. TREE TRUNKS MAY BE CLEARED OF BRANCHES AT THEIR POINT OF OVERLAP TO FACILITATE FASTENING WITH OVERLAPPING TREES.

BOULDER CLUSTER:
1. BOULDER CLUSTERS SHALL BE PLACED IN LOCATIONS OUTLINED IN THE APPROVED PLANS.
2. BOULDERS SHALL BE APPROXIMATELY 300mm TO 500+mm IN DIAMETER.
3. USE OF IRREGULARLY SHAPED BOULDERS WITH A VARIETY OF DIAMETERS IS PREFERRED.
4. BOULDER CLUSTERS SHALL CONSIST OF 3 TO 10 BOULDERS.
5. BOULDERS MAY BE PLACED SUCH THAT THE TOPS OF SOME BOULDERS ARE ABOVE THE NORMAL WATER LEVEL.

CLIENT		PROJECT	
FIRST MINING GOLD	FIRST MINING GOLD	SPRINGPOLE GOLD RECLAIMED OPEN PIT BASIN RED LAKE, ONTARIO	
CONSULTANT	YYYY-MM-DD 2024-10-30	TITLE	
wsp	DESIGNED KKJ	**TYPICAL DETAILS**	
	PREPARED		
	REVIEWED	PROJECT NO. ONS2104A.102	CONTROL 0001
	APPROVED	REV. C	FIGURE 9