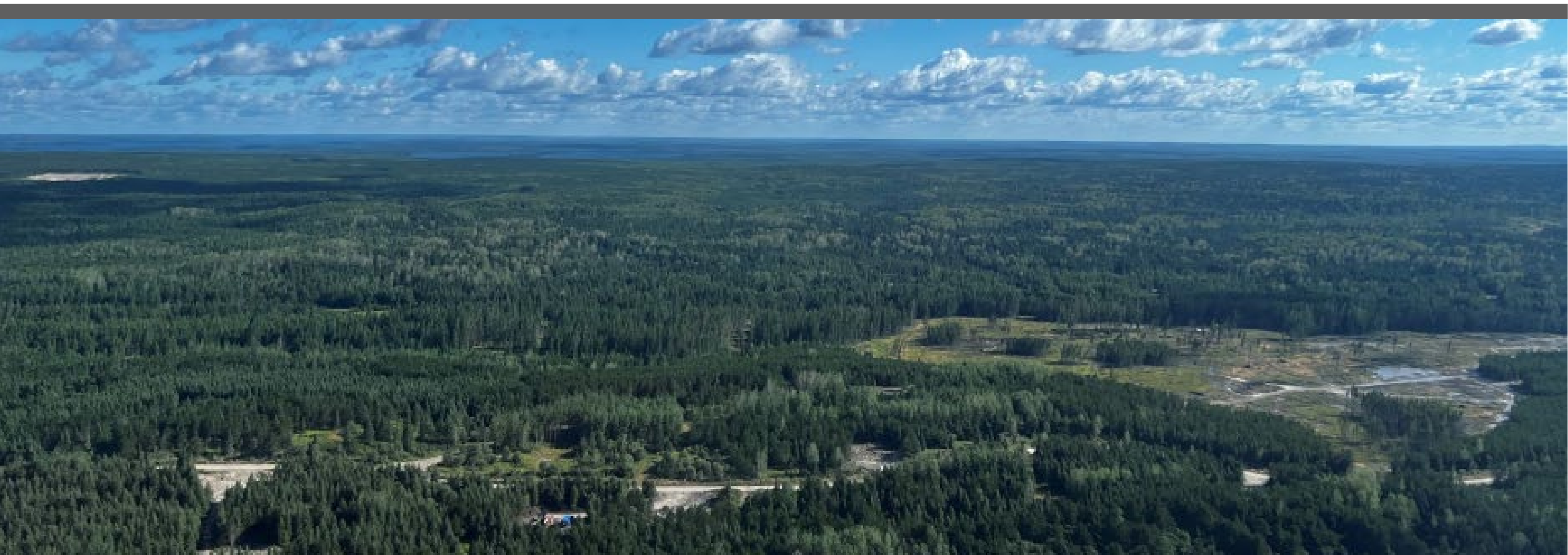
KINROSS Great Bear

Great Bear Gold Project Impact Statement

Appendix L-2:

Draft *Fisheries Act* Offset Plan and MDMER Schedule 2 Fish Habitat Compensation Plan



GREAT BEAR RESOURCES

GREAT BEAR PROJECT

FISHERIES ACT, PARAGRAPH 35(2)(B) AUTHORIZATION, OFFSET PLAN AND MDMER SCHEDULE 2 FISH HABITAT COMPENSATION PLAN – UPDATED DRAFT

MARCH 2026

GREAT BEAR PROJECT

FISHERIES ACT, PARAGRAPH 35(2)(B) AUTHORIZATION, OFFSET PLAN AND MDMER SCHEDULE 2 FISH HABITAT COMPENSATION PLAN – UPDATED DRAFT

GREAT BEAR RESOURCES

PROJECT NO.: OMEMA2303
MARCH 2026

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ABBREVIATIONS

BIC	Benthic invertebrate community
BsM	Broadscale monitoring
DFO	Fisheries and Oceans Canada
eDNA	Environmental DNA
ECCC	Environment and Climate Change Canada
FMZ	Fisheries Management Zone
ha	Hectares
HADD	Harmful Alteration, Disruption or Destruction
HEP	Habitat Evaluation Procedure
km	Kilometres
km^2	Square kilometres
kPa	Kilopascal
LGO	Low grade ore stockpile
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
Mm^3	Million cubic metres
mm/s	Millimetres per second
MNR	Ontario Ministry of Natural Resources
MRS	Mine rock stockpile
NAD	North American datum
NPAG	Non-potentially acid generating
OVB	Overburden stockpile
PoE	Pathways of Effects
P_{peak}	Peak pressure
PPV	Peak particle velocity
Project	Great Bear Project
ROM	Run of mine stockpile
TMF	Tailings management facility
UTM	Universal Transverse Mercator
WB	Waterbody
WC	Watercourse

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1 DESCRIPTION OF PROPOSED WORK, UNDERTAKING, OR ACTIVITY

1.1 PURPOSE OF THE PROJECT

Great Bear Resources Ltd. (Great Bear Resources) a wholly owned subsidiary of Kinross Gold Corporation, is proposing to develop the Great Bear Gold Project (the Project) at the Great Bear Property (the Property). The Property is located approximately 25 kilometres (km) southeast of the Municipality of Red Lake (Figure 1-1) in northwestern Ontario.

The purpose of the Project is to produce gold doré bars on site, by constructing and operating an underground and open pit mine, process plant and associated facilities. A site plan is provided in Figure 1-2. This site plan is subject to optimization based on further data collection, technical and economic evaluation, and engagement with Indigenous Nations and stakeholders.

Doré bars are semi-pure products of gold and silver that will be produced at the Project site and periodically trucked off site for further purification. The purified products will be sold to meet global demands for gold and silver, and provide a return on investment, while supporting local employment and prosperity for the region.

1.2 PROJECT OVERVIEW

Great Bear is planning to develop, operate and eventually reclaim a new underground and open pit, gold mine and processing facility on a portion of the Property (Figure 1-2). The mine and associated surface facilities are situated on lands held or anticipated to be held by Great Bear Resources (Figure 1-3).

The major components of the Project include:

- Mining areas: (underground mine and two open pits (LP Central pit and Viggo pit)
- Surface stockpiles: overburden stockpile (OVB), mine rock stockpile (MRS), low grade ore stockpile (LGO) and run of mine stockpile (ROM)
- Ore process plant
- Facilities to manage tailings from the processing of ore: tailings management facility (TMF) and Viggo management facility (VMF; operations phase)
- Water management and treatment works
- Dedicated aggregate operations to produce aggregate for onsite use
- Other onsite buildings, facilities, areas and infrastructure.

The site layout provided in Figure 1-2 places the required mine-related facilities on Great Bear Resources-held mining leases, near the open pits and openings to the underground to minimize the overall Project footprint. Extensive engineering and environmental studies have been completed to design the Project. The layout is supported by an assessment of feasible alternatives, which itself is guided in part by consultation activities to date. In addition to the components listed above, the Project will include all temporary activities associated with their construction including stockpiles, laydown areas, access roads, water management, temporary flow isolation and creek crossings. Further information regarding the Project will be provided in the Impact Statement (WSP 2026a).

As engineering studies progress and consultation with government agencies, Indigenous communities and the public continues, some of the details of the Project may be refined.

Efforts to avoid fish frequented waters with Project components have been made; however, due to 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. Approximately 20 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* (RSC 1985, c. F 14).

Offset and compensation options are assessed and proposed as candidate measures to counterbalance and mitigate the effects to fish and fish habitat. To demonstrate the ability for the Project to mitigate the predicted effects, the development of pond habitats adjacent to the mine has been proposed for implementation as the current selected measure. Additional candidate offset measures are discussed in Section 8 and may become the preferred measures depending on the result of ongoing community and regulatory engagement. DFO comments received to date, have been addressed, and responses have been incorporated throughout the Fish Habitat Offset and Compensation Plan (the Plan or FHOCP) and Appendix A.

1.3 DOCUMENT FRAMEWORK

This FHOCP includes the detailed assessment of potential effects to fish and fish habitat, as well as several candidate offset and compensation measures than can be implemented to counterbalance and mitigate the potential impacts of the Project on fish and fisheries. All of the proposed offset and compensation measures are feasible and have been vetted for consistency with the Fisheries and Oceans Canada (DFO 2025c) offsetting policy; however, not all of the presented measures may be required in the final Plan. The intent of presenting more offset and compensation measures than are needed, is to provide confidence that there are appropriate, and sufficient measures available to mitigate the predicted effects.

The Plan is provided as a draft for the impact assessment process in recognition that additional analysis, design and consultation will result in adjustments to the Project looking forward. Prior to the completion of permitting and approvals for the Project, the Plan will be finalized to reflect the adjustments.

REVISION HISTORY

Revision Date	Purpose of Revision
September 2025	Draft 1: Includes updates from receiver water balance modeling
December 2025	Draft 2: Includes updates based on community engagement findings, fish habitat offset and compensation workshops, and the DFO comments received on November 29, 2025, for inclusion in Impact Statement Submission 2 to the Impact Assessment Agency of Canada
March 2026	Updated Draft (Draft 3): Includes updates in response to DFO comments on the Impact Statement Submission #2 which included Draft 2, and preliminary questions from Lac Seul First Nation and Wabauskang First Nation for inclusion with the final Impact Statement.

1.4 STAKEHOLDER CONSULTATION AND ENGAGEMENT

Great Bear Resources communicated Project information with stakeholders related to the Project during Phase 1 of the impact assessment process, including during preparation of the Initial Project Description and Detailed Project Description, as are continuing with their efforts. Great Bear Resources will continue to engage with stakeholders as the Project progresses, to gather information on the current capacity / services of local municipalities and townships, and to determine potential impacts (positive and negative) of the Project on the interests of stakeholders that may be affected.

Focused fish habitat offset and compensation workshops were held with Lac Seul First Nation and Wabauskang First Nation between February 18 and 20, 2025 to provide information to and receive ideas from the participants regarding the preferred type and locations of fish habitat offsets. This information has been incorporated in the Plan in Section 8.1. Information that was used during the Lac Seul First Nation / Wabauskang First Nation workshops was also shared with the Asubpeeschoseewagong Netum Anishinabek lands protection team for review and comment, however no response has been received to date. Great Bear Resources also offered a focused workshop to the Northwestern Ontario Métis Community; however they were unable to accommodate the request.

Additional workshops were undertaken on October 22 and 23, 2025 with Lac Seul First Nation and Wabauskang First Nation members, for the communities to provide feedback on ranking of the offsetting and contingency measures.

A second draft of the FHOCP was circulated to government and Indigenous communities with the Impact Statement Submission #2, such that their ongoing advice and recommendations could be incorporated into the document. Preliminary questions were received from Lac Seul First Nation and Wabauskang First Nation and have been address in this version of the Plan, with expanded discussion on the potential flow effects to Dixie Creek and the methods of monitoring potential Walleye spawning in Dixie Creek. Comments were also received from DFO with a focus on the classification of fish frequented waters, assessing flow reductions to Dixie Creek and changes to the Habitat Evaluation Procedure (HEP) model which is included as Appendix A. Where appropriate, received questions and comments have been address in this updated draft of the Plan.

1.5 GUIDANCE DOCUMENTS

The assessment of effects to fish and fish habitat; the development of offsetting / compensation measures; and the preparation of this Plan were determined using guidance provided in the documents listed in Table 1-1. Guidance documents include federal, provincial and community derived sources.

1.6 PHASES AND SCHEDULE

Great Bear proposes to develop, construct, operate and decommission the Project. The Project schedule has been established based on current knowledge. The Project phases are planned as follows:

- Construction phase: Year -3 to Year -1, 3 years in length, representing the primary period of Project construction
- Operations phase: Year 1 to Year 26, 26 years in length, during Year 1 the Project will transition from construction into operations and will not be at full capacity

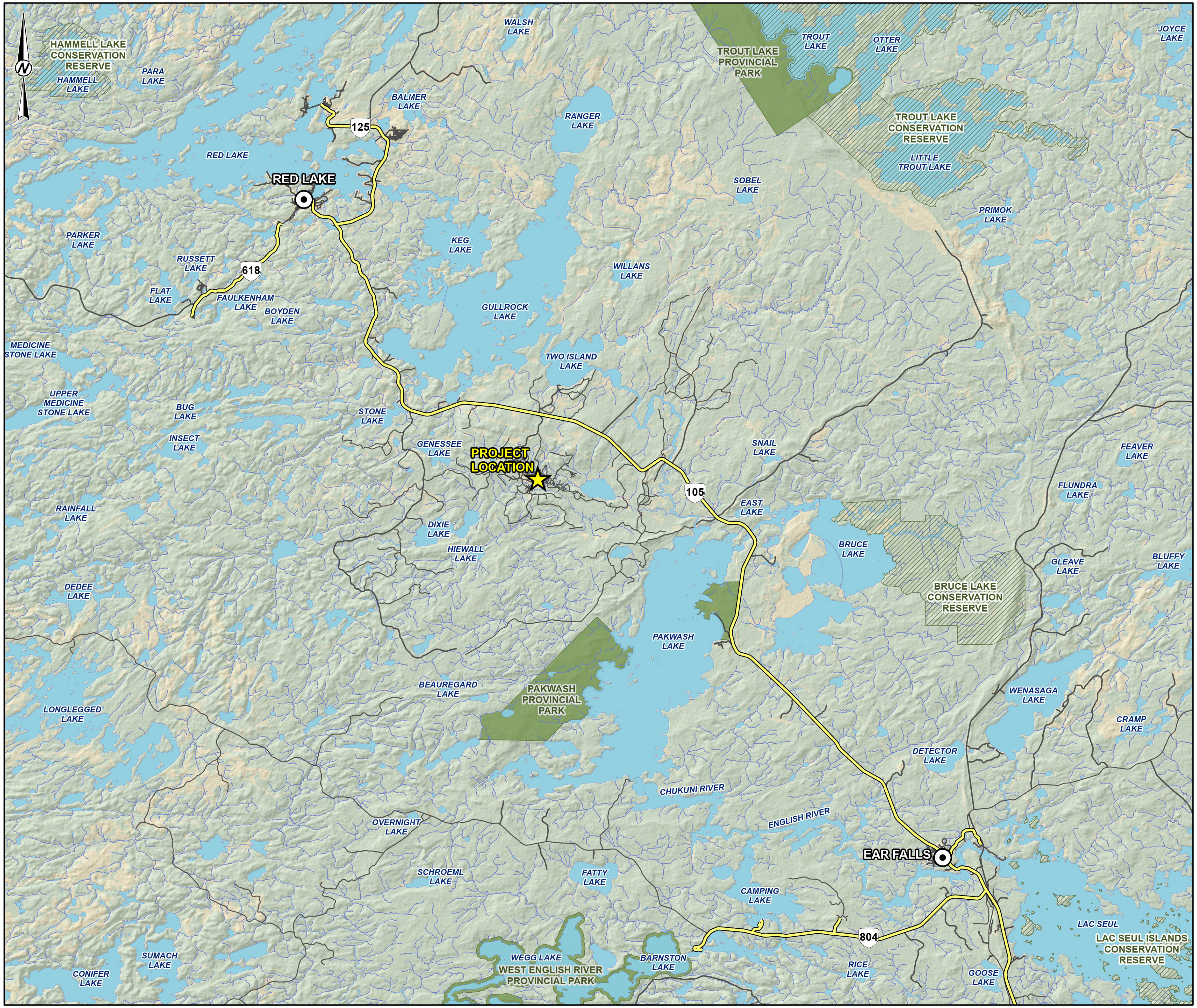
Decommissioning and closure (closure) phase:

- Active closure period: Year 27 to Year 29, 3 years in length. Represents the active closure period when the majority of the decommissioning and reclamation of the Project Area is completed
- Passive closure period: Year 30, minimum of approximately 1 additional year [1]. The passive closure period while the site is on care and maintenance as filling of the mine workings with water is completed, and excess water is treated
- Final closure period (removal of water management infrastructure): less than 1 year in length. Final close out period when water treatment infrastructure is removed and site waters are acceptable for passive release to the environment.

[1] Length of passive closure period depends on timing to receive regulatory approval for passive discharge to the environment from the site.

Table 1-1: Guidance Documents for Effects Determination, Offsetting and Compensation

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.
Fish and Fish Habitat Protection Policy Statement (DFO 2019)	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 2025a)	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 Harmful Impacts to Fish and Fish Habitat (DFO 2025c)	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 2025b)	Diagrams are provided for common land based and inwater 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.
Framework for Assessing the Ecological Flow Requirements to Support Fisheries in Canada (DFO 2013a)	Provides advice on the management of "*the flow regimes and water levels required to maintain the ecological functions that sustain fisheries associated with that water body and its habitat*".
Confidential report prepared on behalf of Wabauskang First Nation	The objective of this project was to identify community lands and resource use values to support the capacity of Wabauskang First Nation to participate and effectively respond to the consultation requests under the *Mining Act*.
Confidential Report prepared on behalf of Lac Seul First Nation	Indigenous knowledge provided by the Lac Seul First Nation to help understand important fish species, habitats and their use by the community.
Fisheries Management Plan (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.
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.
Guidelines for the Use of Explosives in or Near Canadian Fisheries Waters (Wright and Hopky 1998)	Guidelines used for preventing harm to fish from the overpressure and vibrations associated with blasting. Has detailed discussion on potential effects of blasting to fish. Overpressure guideline in this document is superseded by Cott and Hanna 2025 below.
Monitoring Explosive-Based Winter Seismic Exploration in Waterbodies, 2000 – 2002 (Cott and Hanna 2005)	Updated guideline for overpressure while blasting near fisheries waters as requested by DFO.
Habitat evaluation procedures (HEP) (U.S. FWS 1980) Standards for the Development of Habitat Suitability Index Models for use in the Habitat Evaluation Procedures (U.S. FWS 1981)	Guidelines used for the Habitat Evaluation Procedure modeling to determine quality and quantity of usable fish habitat for the Project's loss / gain calculations.



KEY MAP

SCALE: 1:30,000,000

LEGEND

- PROJECT LOCATION
- TOWN
- CONSERVATION RESERVE
- PROVINCIAL PARK
- HIGHWAY
- LOCAL ROAD
- RESOURCE / RECREATION ROAD
- WATERCOURSE
- WATERBODY

0 2.5 5 10

1:250,000 KILOMETRES

NOTE(S)

1. ALL LOCATIONS ARE APPROXIMATE

REFERENCE(S)

1. CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENCE - ONTARIO
2. WATERCOURSES AND WATERBODY ACQUIRED FROM LAND INFORMATION ONTARIO (MNRF) AND MODIFIED TO MATCH AERIAL IMAGERY AND LIDAR.
3. ROADS INFORMATION PROVIDED BY GREAT BEAR RESOURCES, AUGUST 2022.
4. COORDINATE SYSTEM: NAD 1983 UTM ZONE 15N

CLIENT
GREAT BEAR RESOURCES

PROJECT
GREAT BEAR PROJECT

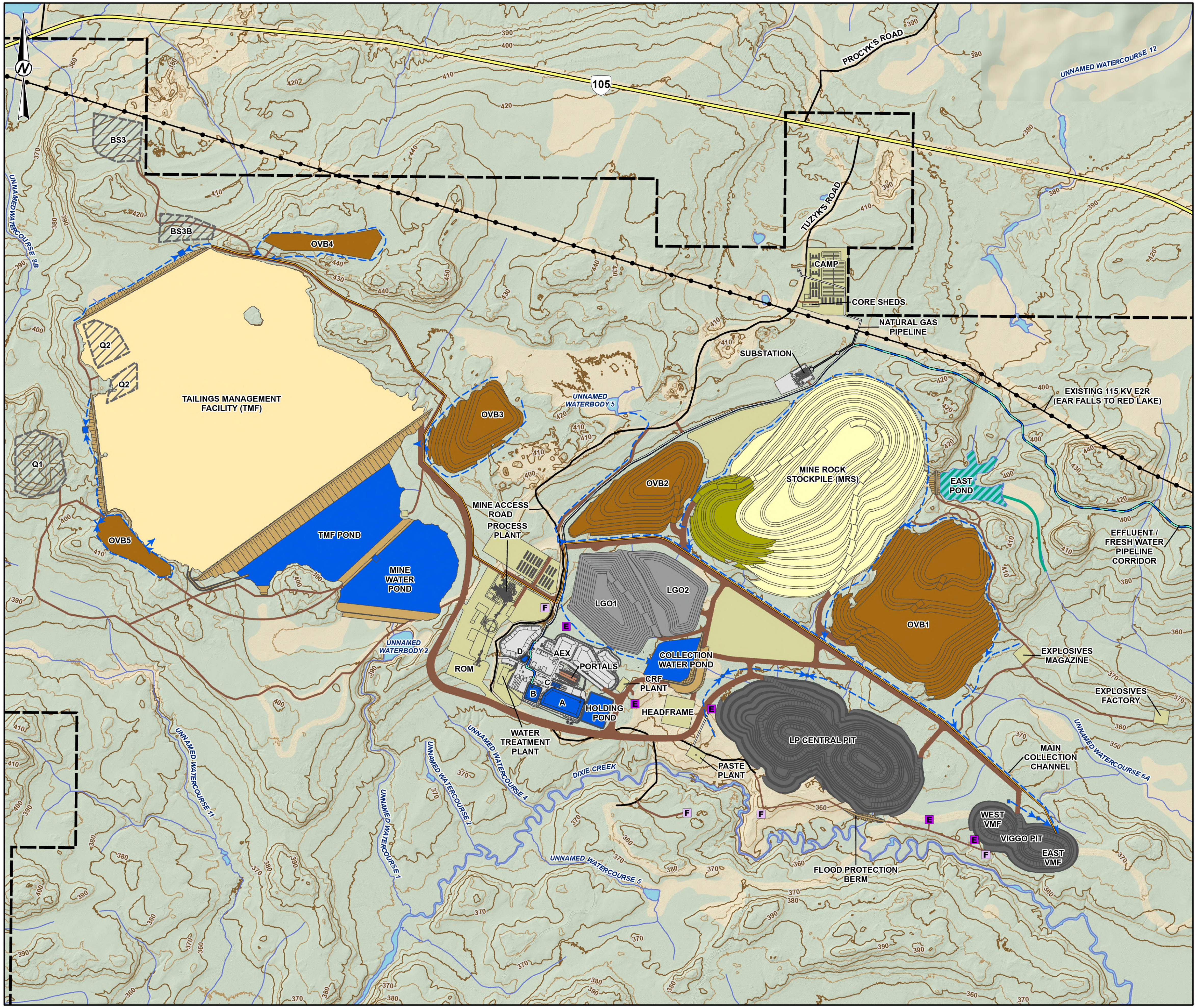
TITLE
PROJECT LOCATION

CONSULTANT

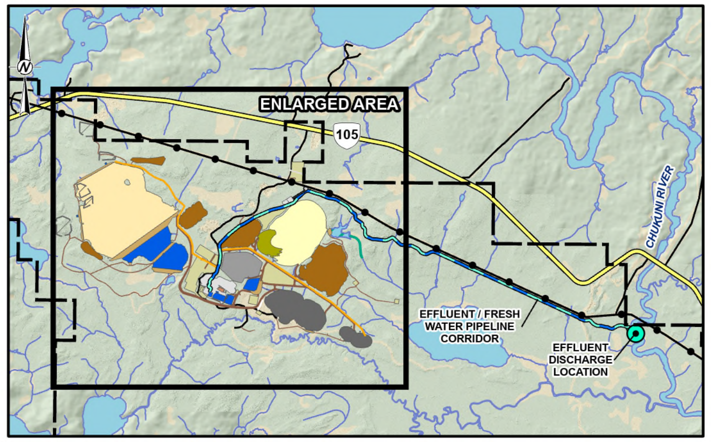
wsp

YYYY-MM-DD	2025-12-04
DESIGNED	----
PREPARED	MD
REVIEWED	----
APPROVED	----

PROJECT NO.	CONTROL	REV.	FIGURE
CA0031271	0001	A	1-1



KEY MAP



SCALE: 1:175,000

LEGEND

- PROPERTY BOUNDARY
- HIGHWAY (INCLUDING ENBRIDGE PIPELINE)
- LOCAL ROAD
- EXISTING TRANSMISSION LINE
- WATERCOURSE
- WATERBODY
- MAJOR CONTOURS (10 M INTERVAL)
- MINOR CONTOURS (5 M INTERVAL)

PROPOSED MINE FEATURE

- OPEN PIT
- MINE ROCK STOCKPILE (NPAG)
- MINE ROCK STOCKPILE (PAG)
- LOW GRADE ORE STOCKPILE (LGO)
- OVERBURDEN STOCKPILE (OVB)
- TAILINGS MANAGEMENT FACILITY (TMF)
- DAM
- POND
- COLLECTION DITCH
- MINE FACILITIES / INFRASTRUCTURE
- ROAD
- PORTAL
- ADVANCED EXPLORATION SITE (AEX)
- ROCK QUARRY (Q) / SAND AND GRAVEL PIT (B)
- FISH HABITAT OFFSETTING WATERBODY
- DIVERSION CHANNEL
- EXHAUST VENT RAISE
- FRESH AIR VENT RAISE
- TRANSMISSION LINE
- TAILINGS PIPELINE
- PASTE PLANT PIPELINE
- EFFLUENT / FRESH WATER PIPELINE CORRIDOR
- EFFLUENT DISCHARGE LOCATION

0 0.25 0.5 1

1:26,500 KILOMETRES

NOTE(S)

1. ALL LOCATIONS ARE APPROXIMATE
2. VMF: VIGGO MANAGEMENT FACILITY
3. ROM: RUN OF MINE ORE
4. AEX PONDS: A-AEX MINE WATER POND, B-AEX TREATED WATER POND, C-AEX SETTLING POND, D-AEX SEDIMENT POND

REFERENCE(S)

1. CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENCE - ONTARIO
2. CONTOURS ACQUIRED FROM 2022 LIDAR SURVEY.
3. PROPERTY BOUNDARY PROVIDED BY GREAT BEAR RESOURCES, AUGUST 2024.
4. ROADS INFORMATION PROVIDED BY GREAT BEAR RESOURCES, AUGUST 2022.
5. SITE PLAN BASED ON INFORMATION PROVIDED BY GREAT BEAR RESOURCES, DECEMBER 2024 / JUNE 2025.
6. COORDINATE SYSTEM: NAD 1983 UTM ZONE 15N

CLIENT
GREAT BEAR RESOURCES

PROJECT
GREAT BEAR PROJECT

TITLE
SITE PLAN (TOPOGRAPHY)

CONSULTANT

wsp

YYYY-MM-DD	2025-12-04
DESIGNED	----
PREPARED	MD
REVIEWED	----
APPROVED	----

PROJECT NO.	CONTROL	REV.	FIGURE
CA0031271	0001	A	1-2

2 PROJECT CONTACT INFORMATION

Great Bear Resources Ltd. (Great Bear Resources) is a wholly (100%) owned subsidiary of Kinross Gold Corp., a Canadian-based gold and silver mining company founded in 1993 and headquartered in Toronto, Ontario, Canada.

Proponent:

Name and Address of Owner	Authorized Contact Person
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3 LOCATION OF WATERBODIES POTENTIALLY AFFECTED BY THE PROJECT

The Property is located approximately 25 km southeast of the Municipality of Red Lake (Figure 1-1) in northwestern Ontario. The Universal Transverse Mercator (UTM) coordinates for the general Project are UTM 455,352 N and 5,634,521 E (NAD 83 Zone 15).

There are several waterbodies (lakes, small ponds and creeks) affected by the Project where Harmful Alteration, Disruption or Destruction (HADD) to fish and fish habitat would occur or where the deposition of mine waste may require that natural waterbodies be listed on Schedule 2 of the MDMER. These waterbody locations are summarized in Table 3-1 (Schedule 2) and Table 3-2 (Paragraph 35 waterbodies), and are shown in Figure 3-1. Waterbody locations have been delineated into impact segments in Figure 3-1 to better identify and summarize potential effects as in some cases, only portions of a waterbody will be impacted; or the waterbody may be affected by more than one type of pathway.

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

Impact Segment ID	Watercourse / Waterbody	Mine Feature	Centroid Coordinates		Upstream Coordinates		Downstream Coordinates	
			Easting	Northing	Easting	Northing	Easting	Northing
IS-1	Unnamed Watercourse 1A	TMF	-	-	452237	5635758	453319	5635547
IS-3	Unnamed Watercourse 1A	TMF Pond	-	-	453560	5635555	453973	5635466
IS-5	Unnamed Watercourse 1B	TMF	-	-	452261	5637085	452909	5636484
IS-6	Unnamed Waterbody 4	TMF	452899	5636405	-	-	-	-
IS-7	Unnamed Watercourse 1B	TMF	452929	5636299	-	-	-	-
IS-8	Unnamed Watercourse 1B	TMF	453003	5636262	-	-	-	-
IS-9	Unnamed Watercourse 1B	TMF	-	-	453006	5636254	453885	5635954
IS-11	Unnamed Watercourse 1B	TMF	-	-	453938	5635826	453984	5635423
IS-12	Unnamed Watercourse 1B-02	TMF	-	-	453230	5636462	453555	5636222
IS-13	Unnamed Watercourse 1B-01	TMF	-	-	453495	5636963	453552	5636159
IS-15	Unnamed Watercourse 1B-03	TMF	454364	5636421	-	-	-	-
IS-16	Unnamed Watercourse 1B-03	TMF	-	-	454345	5636410	454196	5636260
IS-17	Unnamed Watercourse 1B-03	TMF	454191	5636255	-	-	-	-
IS-18	Unnamed Watercourse 1B-03	TMF	-	-	454187	5636252	454069	5636082
IS-19	Unnamed Watercourse 1B-03	TMF	454059	5636076	-	-	-	-
IS-21	Unnamed Watercourse 1B-04	OVB3	-	-	454731	5636262	454490	5636245
IS-23	Unnamed Watercourse 1B-04	TMF	-	-	454370	5636296	454219	5636286
IS-24	Unnamed Watercourse 1B-05	TMF	-	-	454417	5635816	454047	5635710
IS-25	Unnamed Waterbody 1	TMF / MWP	454124	5635292	-	-	-	-
IS-29	Unnamed Watercourse 3	OVB2	-	-	456160	5635887	455875	5635526
IS-31	Unnamed Watercourse 3	LGO	-	-	455874	5635403	456120	5634732
IS-32	Unnamed Watercourse 3	CWP	456168	5634710	-	-	-	-
IS-33	Unnamed Watercourse 3	CWP	-	-	456202	5634692	456286	5634636
IS-36	Unnamed Watercourse 3A	MRS	-	-	457060	5636371	456643	5635223
IS-42	Unnamed Watercourse 3B	MRS	-	-	457912	5635876	457783	5635874
IS-43	Unnamed Watercourse 3B	MRS	457771	5635867	-	-	-	-
IS-44	Unnamed Watercourse 3B	MRS	-	-	457752	5635862	457226	5635128
IS-48	Unnamed Watercourse 3B-03	MRS	-	-	457311	5636553	457454	5635361
IS-49	Unnamed Watercourse 3B-04	MRS	-	-	457237	5635975	457470	5635813
IS-50	Unnamed Watercourse 3B-05	MRS	-	-	456967	5635481	457242	5635149
IS-51	Unnamed Watercourse 3C	LGO1	-	-	455636	5634976	456070	5634809
IS-52	Unnamed Watercourse 3D	OVB1	-	-	457531	5634932	457470	5634655
IS-55	Unnamed Watercourse 3F	MRS	-	-	456566	5635997	456289	5635488
IS-57	Unnamed Watercourse 3F	LGO2	-	-	456170	5635344	456008	5635103
IS-58	Unnamed Watercourse 6A	OVB1	-	-	457756	5635213	458164	5634498

Notes:
Coordinates are in UTM NAD 83, Zone 15; E : Easting; N : Northing
Waterbody centroid is the approximate centremost point of the waterbody (lake / pond) portion affected by the Project.

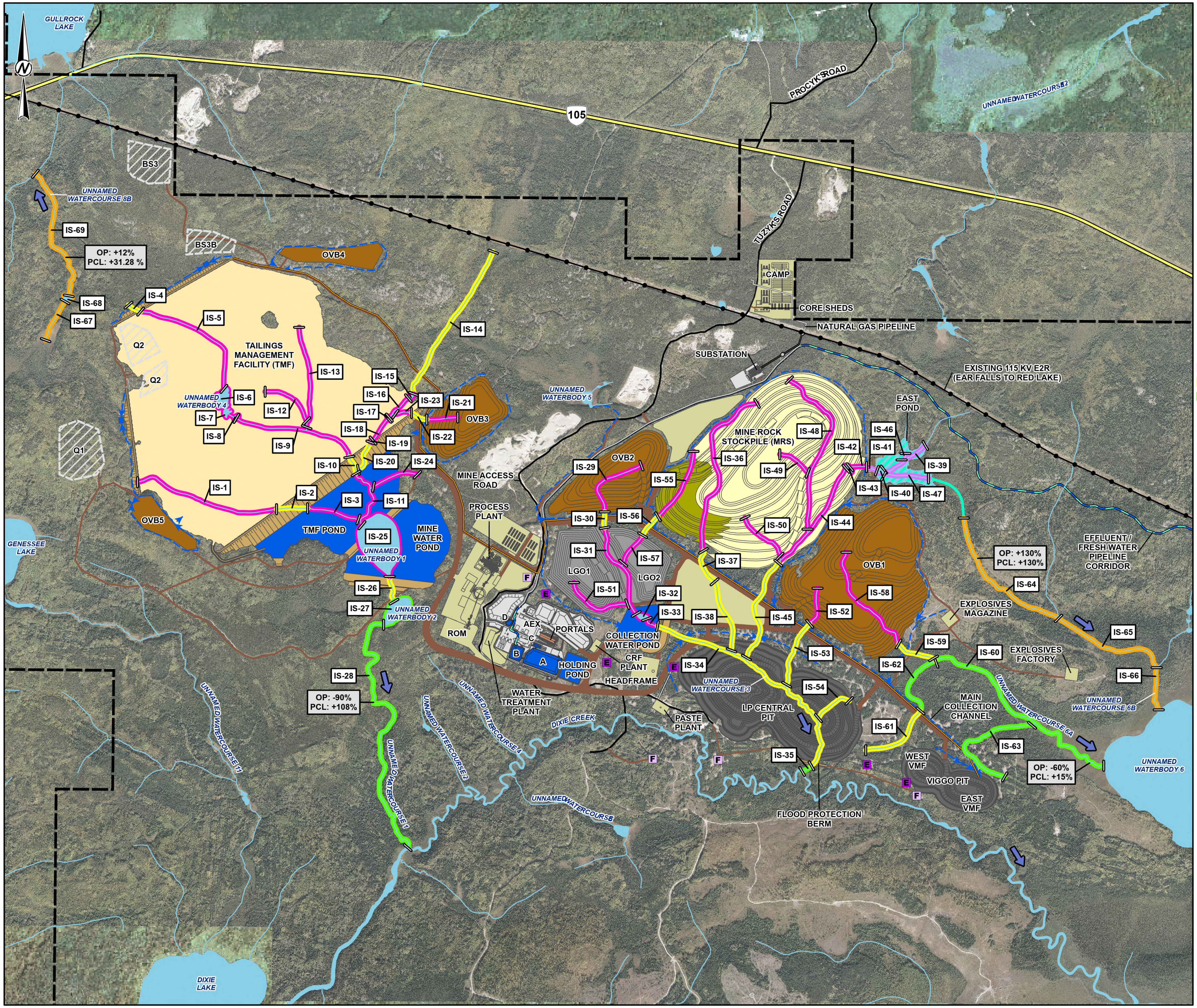
Watercourse limits are the approximate upstream and downstream location of the watercourse (creek / stream / river) portion affected by the Project.
TMF: tailings management facility; LGO: low grade ore stockpile; OVB: overburden stockpile; MRS: mine rock stockpile; MWP: mine water pond, CWP: collection water pond
- : is not applicable
Schedule 2 waterbodies are those expected to require listing on Schedule 2 of the MDMER.

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

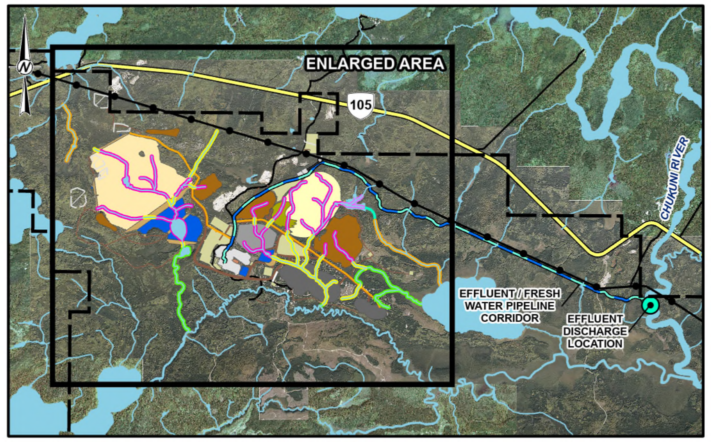
Impact Segment ID	Watercourse / Waterbody	Mine Feature	Centroid Coordinates		Upstream Coordinates		Downstream Coordinates	
			Easting	Northing	Easting	Northing	Easting	Northing
IS-39	Unnamed Watercourse 3B	EP	-	-	458371	5636043	458056	5635836
IS-40	Unnamed Watercourse 3B	EP	458023	5635843	-	-	-	-
IS-41	Unnamed Watercourse 3B	EP Dam	-	-	457993	5635846	457912	5635876
IS-46	Unnamed Watercourse 3B-01	EP	-	-	458217	5635981	458213	5635933
IS-47	Unnamed Watercourse 3B-02	EP	-	-	458396	5635787	458058	5635826
IS-2	Unnamed Watercourse 1A	TMF Dam	-	-	453319	5635547	453560	5635555
IS-4	Unnamed Watercourse 1B	TMF Dam	-	-	452167	5637136	452261	5637085
IS-10	Unnamed Watercourse 1B	TMF Dam	-	-	453885	5635954	453938	5635826
IS-14	Unnamed Watercourse 1B-03	Support Infrastructure	-	-	455006	5637551	454386	5636445
IS-20	Unnamed Watercourse 1B-03	TMF Dam	-	-	454055	5636066	453936	5635844
IS-22	Unnamed Watercourse 1B-04	Support Infrastructure and TMF Dam	-	-	454490	5636245	454370	5636296
IS-26	Unnamed Watercourse 1	MWP Dam	-	-	454199	5635024	454233	5634827
IS-30	Unnamed Watercourse 3	Support Infrastructure	-	-	455875	5635526	455874	5635403
IS-34	Unnamed Watercourse 3	Open Pit / CWP Dam	-	-	456286	5634636	457483	5633550
IS-37	Unnamed Watercourse 3A	Support Infrastructure	-	-	456643	5635223	456730	5634982
IS-38	Unnamed Watercourse 3A	Support Infrastructure / Open Pit	-	-	456730	5634982	456869	5634426
IS-45	Unnamed Watercourse 3B	Support Infrastructure / Open Pit	-	-	457226	5635128	456974	5634373
IS-53	Unnamed Watercourse 3D	Support Infrastructure / Open Pit	-	-	457470	5634655	457281	5634159
IS-54	Unnamed Watercourse 3E	Open Pit	-	-	457778	5634056	457526	5633907
IS-56	Unnamed Watercourse 3F	Support Infrastructure	-	-	456289	5635488	456170	5635344
IS-59	Unnamed Watercourse 6A	Support Infrastructure	-	-	458164	5634498	458448	5634369
IS-27	Unnamed Waterbody 2	Flow Reduction	454268	5634757	-	-	-	-
IS-28	Unnamed Watercourse 1	Flow Reduction	-	-	454152	5634648	454340	5632913
IS-35	Unnamed Watercourse 3	Flow Reduction	-	-	457483	5633550	457411	5633507
IS-60	Unnamed Watercourse 6A	Flow Reduction	-	-	458448	5634369	459760	5633551
IS-61	Unnamed Watercourse 6A-01	Flow Reduction and Support Infrastructure	-	-	457906	5633672	458334	5633978
IS-62	Unnamed Watercourse 6A-01	Flow Reduction	-	-	458334	5633978	458448	5634369
IS-63	Unnamed Watercourse 6A-02	Flow Reduction and Support Infrastructure	-	-	458990	5633465	459226	5633883

Impact Segment ID	Watercourse / Waterbody	Mine Feature	Centroid Coordinates		Upstream Coordinates		Downstream Coordinates	
			Easting	Northing	Easting	Northing	Easting	Northing
IS-64	Unnamed Watercourse 6B-02	Flow Increase	-	-	458672	5635478	459409	5634698
IS-65	Unnamed Watercourse 6B-01	Flow Increase	-	-	459409	5634698	460173	5634314
IS-66	Unnamed Watercourse 6B	Flow Increase	-	-	460173	5634314	460189	5633986
IS-67	Unnamed Watercourse 8B	Flow Increase	-	-	451522	5636863	451673	5637164
IS-68	Unnamed Watercourse 8B	Flow Increase	451687	5637185	-	-	-	-
IS-69	Unnamed Watercourse 8B	Flow Increase	-	-	451702	5637208	451442	5638158

Notes:
Coordinates are in UTM NAD 83, Zone 15; E – Easting; N – Northing
Waterbody centroid is the approximate centremost point of the waterbody (lake / pond) portion affected by the Project.
Watercourse limits are the approximate upstream and downstream point of the watercourse (creek / stream / river) portion affected by the Project.
TMF: tailings management facility, EP: East Pond, MWP: mine water pond, CWP: collection water pond
- : is not applicable
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*.



KEY MAP



SCALE: 1:175,000

LEGEND

- PROPERTY BOUNDARY
- HIGHWAY
- LOCAL ROAD
- EXISTING TRANSMISSION LINE
- WATERCOURSE
- WATERBODY
- FLOW DIRECTION

ANTICIPATED FISHERIES IMPACTS (LABELLED WITH IMPACT SEGMENT ID AND PERCENT FLOW INCREASE/DECREASE)

- SCHEDULE 2
- PARAGRAPH 35 (DIRECT IMPACT)
- PARAGRAPH 35 (FLOW REDUCTION)
- PARAGRAPH 35 (FLOW INCREASE)
- PARAGRAPH 35 (ALTERED HABITAT)

PROPOSED MINE FEATURE

- OPEN PIT
- MINE ROCK STOCKPILE (NPAG)
- MINE ROCK STOCKPILE (PAG)
- LOW GRADE ORE STOCKPILE (LGO)
- OVERBURDEN STOCKPILE (OVB)
- TAILINGS MANAGEMENT FACILITY (TMF)
- DAM
- POND
- COLLECTION DITCH
- MINE FACILITIES / INFRASTRUCTURE
- ROAD
- PORTAL
- ADVANCED EXPLORATION SITE (AEX)
- ROCK QUARRY (Q) / SAND AND GRAVEL PIT (B)
- FISH HABITAT OFFSETTING WATERBODY
- DIVERSION CHANNEL
- F FRESH AIR VENT RAISE
- E EXHAUST VENT RAISE
- TRANSMISSION LINE
- TAILINGS PIPELINE
- PASTE PLANT PIPELINE
- EFFLUENT / FRESH WATER PIPELINE CORRIDOR
- EFFLUENT DISCHARGE LOCATION

0 0.25 0.5 1
1:30,000 KILOMETRES

NOTE(S)

1. ALL LOCATIONS ARE APPROXIMATE
2. VMF: VIGGO MANAGEMENT FACILITY
3. ROM: RUN OF MINE ORE
4. AEX PONDS: A-AEX MINE WATER POND, B-AEX TREATED WATER POND, C-AEX SETTLING POND, D-AEX SEDIMENT POND
5. OP: OPERATIONS, PCL: POST-CLOSURE
6. +: FLOW INCREASE, -: FLOW DECREASE

REFERENCE(S)

1. CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENCE - ONTARIO
2. AERIAL IMAGERY PROVIDED BY GREAT BEAR RESOURCES (SCENE DATE: SEPTEMBER 2022).
3. PROPERTY BOUNDARY PROVIDED BY GREAT BEAR RESOURCES, AUGUST 2024.
4. ROADS INFORMATION PROVIDED BY GREAT BEAR RESOURCES, AUGUST 2022.
5. SITE PLAN BASED ON INFORMATION PROVIDED BY GREAT BEAR RESOURCES, DECEMBER 2024 / JUNE 2025.
6. COORDINATE SYSTEM: NAD 1983 UTM ZONE 15N.

CLIENT
GREAT BEAR RESOURCES

PROJECT
GREAT BEAR PROJECT

TITLE
ANTICIPATED FISHERIES IMPACTS

CONSULTANT

wsp

YYYY-MM-DD	2026-03-10
DESIGNED	MR
PREPARED	MD
REVIEWED	----
APPROVED	----

PROJECT NO.	CONTROL	REV.	FIGURE
CA0031271	0001	A	3-1

4 BACKGROUND AND ENVIRONMENTAL SETTING

4.1 CONTEXT AND DATA SOURCES

4.1.1 PROJECT SPECIFIC DATA COLLECTION

Detailed fisheries and fish habitat studies have been undertaken at the Project site and environs since 2022 and include multiple years and multiple seasons of investigation which have been documented in a Fisheries Resources Baseline Report (WSP 2025a).

Project specific baseline monitoring field programs included in the baseline report (WSP 2025a) were conducted during the following periods in chronological order:

- 2022 Spring (May 25 to June 6)
- 2022 Summer (July 11 to 23)
- 2022 Fall (October 20 to 29)
- 2023 Spring (June 5 to 19)
- 2023 Summer (July 24 to August 4, and August 12 to 13)
- 2023 Fall (September 5 to 18 and September 25 to October 3)
- 2024 Spring (June 10 to June 17)
- 2024 Summer (July 22 to July 29)
- 2024 Fall (September 9 to September 22).

Additional habitat and fish community sampling was completed in 2025 and as applicable, is presented in a Fish and Fish Habitat Supplemental Report - Dixie Creek (WSP 2026b).

Project specific aquatic baseline sampling since 2022 included the following:

- Multi-season multi-year habitat assessments within Genessee Lake, Chukuni River, Dixie Creek, and nearby unnamed watercourses and waterbodies
- Lake profile measurements of temperature and dissolved oxygen from the deepest point within Genessee Lake, and Unnamed Waterbodies
- Bathymetry measurements within Unnamed Waterbody 6 and Chukuni River
- Primary productivity (zooplankton, periphyton, and benthic invertebrate community) assessments within Genessee Lake, Unnamed Waterbody 6, Unnamed Waterbody 2, Pakwash Lake, and the Chukuni River
- Multi-season assessment of fish community within Genessee Lake, Chukuni River, Dixie Creek, and nearby unnamed watercourses and waterbodies
- Fall large-bodied fish species lethal sampling to assess condition of fish tissue, fish community age structure, and to provide baseline data in support of future biological monitoring programs
- Fish tissue and aging studies for large body and small body fish
- Fall sediment quality assessment in Dixie Creek, Genessee Lake, Chukuni River, Pakwash Lake, and nearby unnamed watercourses and waterbodies

- Fall mercury sampling program including sediment, sediment / soil porewater, invertebrates and zooplankton
- Winter ice measurements and lake profiles.

Detailed methodologies and findings of the Project baseline monitoring programs is provided in the Great Bear Project Fisheries Resources Baseline Report (WSP 2025a) and the Fish and Fish Habitat Supplemental Report - Dixie Creek (WSP 2026b).

4.1.2 SECONDARY SOURCE DATA SOURCES

In addition to these Project specific investigations, historic broadscale fisheries monitoring (BsM) fish sampling and fish tissue collections by the Ontario Ministry of Natural Resources (MNR) have been completed for Pakwash Lake. This includes the following BsM bulletins:

- Cycle 1, Broad-scale Fisheries Monitoring Bulletin PAKWASH LAKE - FMZ 4 - 2008-2012 (MNR 2024a)
- Cycle 2, Broad-scale Fisheries Monitoring Bulletin PAKWASH LAKE - FMZ 4 - 2013-2017 (MNR 2024b)
- Cycle 3, Broad-scale Fisheries Monitoring Bulletin PAKWASH LAKE - FMZ 4 – 2018-2024 (MNR 2024c).

Stream orders (numerical classification of stream by their relative size) were derived from the ARC GIS Software using Ontario Integrated Hydrology Data from the MNR.

4.2 PROJECT AREA WATERBODIES

The Project is primarily situated within the Dixie Creek watershed which feeds into the Chukuni River and eventually drains into Pakwash Lake. The proposed Project footprint (approximately 18 km^2) comprises of roughly 0.4% of the Chukuni River watershed (4,801 km^2), upstream of Pakwash Lake. The Chukuni River drains to the larger English River downstream of the Project and ultimately into Hudson Bay as part of the Nelson River primary watershed (MNR 2014). Both the Chukuni river and the English River are regulated by dams in the vicinity of the Project. The Snowshoe Rapids Dam, managed by the MNR, is located on the Chukuni River, upstream of the Project. This dam regulates water levels upstream to Red Lake. The Ear Falls generating station is located on the English River, approximately 20 km upstream the Chukuni River confluence, while the Manitou Falls generating station is located approximately 14 km downstream of the confluence. Both generating stations and the Snowshoe Rapids dam are considered complete barriers to upstream fish movement.

The Project is within the MNR Fisheries Management Zone 4 (FMZ 4; MNR 2014). There are over 22,500 lakes and 44,315 km of rivers and streams which cover more than 17% of the total area in permanent water within FMZ 4.

The Project Area waterbodies described below represent habitats ranging from diffuse flow paths to well defined permanent creeks to large regional rivers. These drainages connect pond and lake type features that similarly range in size and depth. Figure 4-1 delineates the Project Area watercourses by stream order using the Strahler method of classification.

The stream order is an escalating number that provides an indication of how large the watercourse is by counting the number of similar sized tributaries joining the main channel. Small numbers such as one and two mean that the feature may be ephemeral to intermediate and sometimes there is no water or fish present. Larger numbers such as four and five mean that numerous small creeks have joined together to make a large creek or river. Most of the unnamed creeks in the Project Area are small with stream orders of three or less. Dixie Creek is a bit larger with stream orders of four and five. The Chukuni River is a large waterway and accordingly has a large stream order of seven.

There is a close relationship between the stream orders presented in Figure 4-1 and the presence of fish species as larger watercourses tend to support more species than smaller ones. This is demonstrated in Table 4-1 that lists the species of fish identified in each Project Area watercourse and waterbody. The sampling locations associated with Table 4-1 are provided in Figure 4-2. In many cases, drainages with stream orders of two or less have only a few resilient species present such as Central Mudminnow or Brook Stickleback. Several watercourses were originally considered not fish occupied, as no fish were captured or observed based on multi-season, multi-year field observations, and they lacked sufficient water or defined channel characteristics to contain fish at the time of survey. After subsequent comments and discussions with DFO in 2026, these waterbodies were re-classified as potentially fish frequented based on potential fish access, proximity to confirmed fish frequented water and insufficient evidence to confirm that fish could not be present. Potentially fish frequented watercourses and waterbodies have been treated within the effects assessment (Section 6) as confirmed fish frequented waterbodies as a precautionary approach.

The probability of fish being present and the number of species present increases with stream size to more complex multi trophic fish communities in habitats such as Dixie Creek and the Chukuni River where the number of species present range from 16 to 35 and include species such as Northern Pike, Walleye and Lake Whitefish. Figure 4-3 illustrates the typical trophic level of the Project Area fish community and the typical presence by waterbody size. Muskellunge, Lake Trout and Lake Sturgeon are shown for regional context within the food web but are not considered present in the Project Area.

Based on comments from participants during the Planning Phase of the impact assessment for the Project, Lake Whitefish, Walleye, Lake Trout, and Lake Sturgeon were identified as important considerations for the Project. Lake Whitefish and Walleye are common in the larger watercourses including Dixie Creek and the Chukuni River; and in larger waterbodies such as Dixie Lake, Genessee Lake, Gullrock Lake and Pakwash Lake. Lake Trout and Lake Sturgeon are not resident species within the Project Area, although occasionally incidental Lake Trout do migrate downstream into or through the Project Area from upstream. Lake Sturgeon have not been observed as present in the Project area waterbodies, and the nearest population is believed to exist in the English River downstream of the confluence of the Chukuni River.

4.2.1 CHUKUNI RIVER

The Chukuni River originates north and west of the Project site, draining lands as far north as Ooshkahtakahwee Sahkaheekahn / Nungesser Lake and includes several prominent lakes such as Little Vermilion Lake, Colie Lake, Red Lake, Gullrock Lake, Keg Lake, Ranger Lake and Two Island Lake. The Chukuni River is the largest watercourse draining the Project Area with a drainage area of 4,801 km^2. It has typical wetted widths in the order of 100 metres (m), but ranges from 50 m to 250 m. Depth within the river nearer the Project vary considerable from shallow rapids to deeper pools with typical conditions being greater than 5 m. The river is regulated by the MNR at the Snowshoe Rapids Dam approximately 15.5 km upstream of the inflow from Dixie Creek. Regulation of the dam combined with seasonal conditions, influence flow and water levels through the area.

The river has deep u-shaped cross channel sections, surrounded by mixed coniferous and deciduous forest with emergent vegetation (grasses) lining the margins. Substrate consists primarily of silt and fine sand with moderate amounts of course sand, however riffle / rapid habitats used for Lake Whitefish and Walleye spawning occur upstream of the Project Area that are high in gravel and cobble material. As the river nears Pakwash Lake it exhibits large, wide meander bends in its plan form with a deep thalweg as a result of a decreasing channel gradient.

Nearshore areas along river margins range from steep to gentle sloping banks with submergent and emergent vegetation, and coarse woody structure, providing cover for both small-body and large-bodied fish.

Three detailed sampling locations shown in Figure 4-1, were established along the Chukuni River to reflect conditions upstream (Station CR-REF), at the freshwater discharge location (Station CR-FDP) and downstream (Station CR-DS). Sampling at all three Chukuni River locations included:

- Fish habitat assessments including bathymetry
- Fish community assessments using standard capture techniques like minnow traps, gill nets, seine nets, and angling
- Fish community assessment using environmental DNA (eDNA) and metabarcoding analysis
- Fish tissue and age sampling during the fall season
- Lower trophic periphyton sampling
- Sediment quality sampling
- Benthic invertebrate community (BIC) sampling.

Fish community sampling efforts targeted both large bodied and small bodied fish species using multiple gear types. The Chukuni River is one of the more diverse fisheries investigated, supporting up to 34 species of fish based on conventional netting and eDNA sampling (Table 4-1). Species include sportfish such as Walleye, Sauger, Northern Pike, Lake Whitefish and Smallmouth Bass. Muskellunge was listed as present in the Ontario Fish ON-line data base but was not captured in the Chukuni River with any of the conventional sampling; nor was it detected in any eDNA samples. The Fish ON-line database cautions that inaccuracies may exist in the database and it is noted that public users can enter species data.

For more information on the Chukuni River surveys see Section 3.3 of the Fisheries Resources Baseline Report (WSP 2025a).

4.2.2 DIXIE CREEK

Dixie Creek is an intermediate watercourse ranging from 4 m to greater than 20 m in wetted width, that runs approximately east to west, directly south of the main project footprint. From its upstream outlet of Dixie Lake, Dixie Creek has steep banks with a narrow floodplain, and a riparian consisting of alder and willow species with upland Black Spruce and poplar. The substrate consists mostly of soft fine-grained sediments with occasional cobble and large woody debris, and emergent macrophytes, such as Broadleaf Arrowhead within the margins. Habitat remain consistent for most of its length through the Project Area; however, flow varies from elevation changes and beaver impoundments. Near its outlet into the Chukuni River, Dixie Creek becomes a moderate flowing, wide watercourse (less than 10 m wetted width) with a broad floodplain dominated by alder with grasses and sedges along the riparian area.

Four main sample locations in Dixie Creek (DC-01, DC-02, DC-03 and DC-04) were studied over multiple years and seasons. Sampling consisted of the following:

- Fish habitat assessments
- Fish community assessments using standard capture techniques like minnow traps, gill nets, seine nets, and angling
- Fish community assessment using eDNA and metabarcoding analysis
- Fish tissue and age sampling during the fall season
- Lower trophic periphyton sampling
- Sediment quality sampling
- BIC sampling.

Additional sampling in 2025 focused on assessing potential spawning riffle habitats for Walleye and Lake Whitefish, as well as additional fish sampling over the length of Dixie Creek (WSP 2026b).

Dixie Creek supports up to 31 species of fish based on conventional netting and eDNA sampling (Table 4-1), although only 16 species were captured by direct netting or trapping effort. Dixie Creek stations are downstream of Dixie Lake and as such eDNA samples may also detect species that are resident species within the lake. Species detected include sportfish such as Walleye, Sauger, Northern Pike, Lake Whitefish, Yellow Perch and Smallmouth Bass.

For more information on the Dixie Creek surveys see Section 3.2 of the Fisheries Resources Baseline Report (WSP 2025a) and the Fish and Fish Habitat Supplemental Report - Dixie Creek (WSP 2026b).

4.2.3 UNNAMED WATERBODY 1

Unnamed Waterbody 1 (WB-1) is a shallow, heavily vegetated waterbody, with a wide riparian habitat dominated by shrubs, grasses, and sedges along the margins and outlet drainage to Unnamed Waterbody 2. The upland vegetation is mostly coniferous species such as Black Spruce. The substrate consists of soft fine-grained sediments with a uniform depth ranging from 0.5 to 1.0 m. The lake is dominated by an emergent aquatic macrophyte, Northern Wild Rice, which forms a dense cover across the entire wetted surface area. Travel by boat within the lake during the growing season is severely restricted due to this dense Wild Rice cover.

WB-1 was assessed over multiple years and seasons. A summary of the sampling includes:

- Fish habitat assessments
- Fish community assessments using standard capture techniques like minnow traps, gill nets, seine nets, and angling
- Sediment quality sampling
- BIC sampling.

Fish sampling identified only two species that are considered tolerant of the shallow depths and dense vegetation. Central Mudminnow and Golden Shiner were captured in low numbers. WB-1 may contain Northern Pike due to the direct channel connectivity from WB-2 downstream although none have been sighted or captured in WB 1. For more information on the WB-1 surveys see Section 3.5.1 of the Fisheries Resources Baseline Report (WSP 2025a).

4.2.4 UNNAMED WATERBODY 6

Unnamed Waterbody 6 (WB-6) is a shallow waterbody with a wide riparian habitat comprised of grasses, sedges and shrubs along the northwest margin and outlet to Dixie Creek. The upland vegetation is mostly coniferous species such as Black Spruce. The south shore consists of a steep gradient tree line comprised of large boulders and dead fall log cover within the lake margins. Submergent aquatic macrophytes such as pondweed were observed within the nearshore areas and in patches within the lake and Wild Rice is present. The lake bottom consisted almost completely of silt with some clay and fine sand.

A bathymetric survey showed the lake consisted of a shallow water littoral zone in the east and west and a large uniform middle basin. The maximum recorded water depth was 1.78 m, with an average water depth of 1.26 m.

Fish captured from WB-6 during the 2022 and 2023 field programs, included mainly small-bodied minnow species such as Blackchin Shiner, Blacknose Shiner, Fathead Minnow, with eDNA detected for Central Mudminnow and Iowa Darter. Sport fish included Northern Pike and Yellow Perch.

For more information on the WB-6 surveys see Section 3.6.6 of the Fisheries Resources Baseline Report (WSP 2025a).

4.2.5 OTHER SMALL UNNAMED WATERBODIES

Other small unnamed waterbodies in the vicinity of the project were also surveyed between 2022 and 2024. These waterbodies are characterized by a low number of fish species (low diversity) and low fish abundance. The waterbodies are typically small in size (<15 ha); have 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 8 m but typical maximum depth is 1 to 2 m. Most small waterbodies were found to contain only a few small bodied fish such as Brook Stickleback, Central Mudminnow, and Finescale Dace (Table 4-1) although some included larger piscivorous species such as Northern Pike and Yellow Perch.

Additional detailed descriptions of fish presence and fish habitat can be found in Section 3 of the Fisheries Resources Baseline Report (WSP 2025a).

4.2.6 OTHER SMALL UNNAMED WATERCOURSES

Watercourses as presented are from provincial integrated hydrology mapping and Land Information Ontario datasets. Many of the upper sections of watercourses delineated in Figure 4-1 with stream orders of one, 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. Watercourses when present are often ephemeral or intermittent in flow regime (due to small drainage areas typically less than 1 km^2) are influenced by beaver activity, and are typically characterized by low velocity, shallow depth, soft organic sediment, and poorly to undefined channels. For consistency and to be conservative, the provincial base mapping has been retained with one exception. A minor watercourse identified in the provincial mapping south of the proposed LP Central pit which was reviewed by MNR in the field and deemed to not be present. This watercourse has been removed from Project mapping. Many of these drainages, particularly their upper reaches, are not occupied by fish (Figure 3-1). Fish presence by watercourse is provided in Table 4-1.

Watercourses draining the Project footprint typically flow into Dixie Creek including Unnamed Watercourse 1 (WC-1), Unnamed Watercourse 2 (WC-2),Unnamed Watercourse 3 (WC-3), Unnamed Watercourse 4 (WC-4), Unnamed Watercourse 5 (WC-5), Unnamed Watercourse 6 (WC-6); and Unnamed Watercourse 7 (WC-7; also locally termed Hiewall Creek). Additional detailed descriptions of fish presence and fish habitat can be found in Section 3 of the Fisheries Resources Baseline Report (WSP 2025a).

4.3 FISH HABITAT TYPES

Project waterbodies and watercourses described above are further summarized and delineated by habitat type as shown in Figure 4-4 and summarized in Table 4-2. Additional details for each individual waterbody and watercourse, including channel dimensions, are provided in Fisheries Resources Baseline Report (WSP 2025a).

4.3.1 WATERBODIES

Pond and lake habitats were delineated and classified as one of three habitat types (A, B and C).

Habitat type A: shallow waterbodies (less than 4 m total depth) within the PA area that are likely to support spawning, rearing, and foraging habitat for a variety of small-body species with the potential for large-body fish species such as Northern Pike and Yellow Perch. Substrate composition in habitat type A includes predominantly soft, fine-grained sediments with some localized boulder / bedrock and cobble / sand occurrences, as well as coarse woody debris with detritus. Vegetation in the upland zones is composed mainly of mixed coniferous and deciduous dominated by Black Spruce and Tamarack. Vegetation near the riparian zone includes wood shrub species such as alder, and a variety herbaceous species, including sedges and grasses. In general, two types of riparian zone vegetation were observed in habitat type A: a graminoid (grasses and sedges) floating mat with mosses (bryophytes), Sweetgale and herbaceous species; or a narrow riparian zone with overhanging shrubs and rushes, such as Hardstem Bulrush, that extended into the open water littoral zone covering a portion of the open water surface. Nearshore, shallow areas were also commonly populated by other emergent and submergent or floating aquatic macrophytes such as Yellow Pond Lily and pondweed. Waterbodies delineated as habitat type A are the most frequent waterbody type and include Unnamed Waterbody 1, Unnamed Waterbody 4, Unnamed Waterbody 5, Unnamed Waterbody 6 and smaller inline ponds within the unnamed tributary flow paths commonly resulting from beaver activity.

Habitat type B: small, deep (greater than 4 m total depth) inland waterbodies and include Unnamed Waterbody 2 and Unnamed Waterbody 3. The total depth is the primary difference between habitat types A and B, where habitat type B is characteristically deeper. The difference in depth can influence fish species community composition, vegetation, and thermal regime. Habitat type B is likely to support a variety of small-body and large-body species of varying life stages. Substrate composition in habitat type B is similar to habitat type A, being composed predominantly of soft, fine-grained sediments and a greater abundance of localized boulder, bedrock and cobble or sand occurrences, as well as coarse woody debris with detritus. Vegetation in the upland zones is mainly mixed coniferous and deciduous dominated by Black Spruce and White Spruce; while vegetation near to the riparian zone included woody shrub species such as alder, and a variety of herbaceous species, including sedges and grasses. In general, two types of riparian zone vegetation were observed in habitat type B; a graminoid floating mat with mosses and herbaceous species or a narrow riparian zone with overhanging shrubs and rushes, such as Hardstem Bulrush, that extended into the open water littoral zone covering a portion of the open water surface. Nearshore, shallow areas were also commonly populated by other emergent and submergent or floating aquatic macrophytes such as Yellow Pond Lily and pondweed species.

Habitat type C: deep water lentic habitat characterizing the large lake environs in the area such as Genessee Lake, differing from habitat type B by surface area and habitat type A by depth. These lake habitats support a variety of forage fish and large-body / sport fish, such as Northern Pike and Walleye, indicative of deep water and rocky shoal habitat. Substrate composition nearshore is mainly comprised of exposed bedrock and boulder, with localized areas of soft, fine-grained sediments commonly associated with tributary inflows and sheltered embayments. Coarse wood structure, such as driftwood, and some localized areas of aquatic macrophytes within the soft sediment substrate areas are present. Vegetation in the upland zones consists mainly of mixed coniferous and deciduous dominated by Black Spruce and White Spruce, while vegetation near to the riparian zone included woody shrub species such as alder and various herbaceous species.

4.3.2 WATERCOURSES

Watercourse fish habitat types are provided below in order of increasing size and flow permanency, and include habitat type D to I. The habitat types define homogenous reaches of stream that share common attributes such as channel size and habitat characteristics. The existing watercourses as shown in Figures 4-1, 4-2 and 4-4 were extracted from the current Ontario hydro network databases layers available through Geospatial Ontario. Many watercourses delineated in the figures as habitat type D (stream order one) are computer interpretations of drainage segments during development of the provincial mapping. These virtual segments reflect land topography and likely drainage directions; however, 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.

- Habitat type D: ephemeral stream environments characterized as low-lying areas that may contain diffused pockets of standing water which only convey overland flow during periods of heavy rainfall or during spring freshet (snowmelt). Habitat type D environments are commonly associated with a complete loss of defined channel, transitioning into areas of muskeg drainage and underground seepage that are often not considered fish habitat. Some habitat type D sections support fish presence, likely as a result of the proximity to adjacent higher order streams or waterbodies (habitat types A, B and C) as this has been shown to be important in fish abundance and distribution where lower order streams are utilized by nearby and connected higher stream order fish communities (Hitt and Angermeier 2006). Habitat type D is characterized by subsurface flow paths typically observed in the headwater areas and was dominated by alder, grasses, and sedges, with some Black Spruce and various mosses.

- Habitat type E: riverine habitat that experiences intermittent flow or low year-round flow. The habitat includes little to no floodplain, steep banks and shrub riparian vegetation providing nearly complete canopy cover. The substrate is mostly exposed bedrock and boulder with some isolated pockets of fine-grained sediments. This habitat type supports fish communities, with increased usage during the higher flow periods (e.g., spring freshet and spawning season). Riparian vegetation is dense alder and willow, with some Balsam Fir, Black Spruce and various poplar. This habitat type commonly occurs within gradient changes of inland streams and habitat type C waterbodies.
- Habitat type F: riverine habitats with beaver dams and activity creating alternating series of pools and impoundments. These areas are characterized by side overflow channels formed during high flow events. The pool habitat has abundant coarse and fine woody debris, with soft, fine-grained sediments that support dense aquatic macrophytes. Riparian vegetation is mostly comprised of grasses and sedges (graminoids) with alder and willow species further upland adjacent to mixed conifer and deciduous forest. Habitat type F environments typically occur between inland waterbodies and at the downstream extent of the habitat types G and H reaches, where beavers have utilized the natural narrow topography to construct dams. These pooled areas can support a variety of small-body fish species.
- Habitat type G: riverine habitat with a broad floodplain and extensive floating mats of herbaceous species typical of wetlands and beaver ponds. This habitat is primarily represented by flat channel morphology with occasional pools in the thalweg of meander bends and back bays of the channel and provides fish habitat for various small-body fish. The substrate is characterized by soft, fine-grained sediment with occasional boulders and localized areas of exposed bedrock. Dense aquatic macrophyte growth and coarse wood debris contribute most of the instream cover. Vegetation in the upland zones is mainly mixed coniferous and deciduous dominated by Black Spruce, poplar species, and Tamarack; while vegetation near to the riparian zone includes alder, willow, and herbaceous species.
- Habitat type H: riverine habitat with a moderate to broad floodplain like habitat type G, however wetted width of habitat type H is much wider (greater than 10 m). As with habitat type G, the type H habitat is characterized by U shaped channel morphology with occasional pools and provides fish habitat for various small-body and large-body fish. The substrate is characterized by soft, fine-grained sediment with small amount of boulder with the presence of sparse aquatic macrophytes and coarse woody debris. The riparian zone consists mostly of grasses and sedges. Upland areas are mainly mixed coniferous and deciduous dominated by Black Spruce, poplar species and Tamarack, while vegetation near to the riparian zone includes alder and herbaceous species.
- Habitat type I: the Chukuni River, or large river, habitat and is mostly characterized by reaches with moderate flow and occasional fast flowing sections consisting of cobble, boulder and bedrock riffle. This habitat type is characteristic of moderate gradients and generally deep channel cross sections. The substrate consists of soft, fine-grained sediments with some localized boulder / bedrock and cobble / sand occurrences, as well as coarse woody debris with detritus. The upland vegetation communities are mainly mixed coniferous and deciduous dominated by Black Spruce and poplar species while vegetation near to the riparian zone included alder, willow and herbaceous species. Nearshore, shallow areas are also commonly populated by emergent and submergent macrophytes such as Hardstem Bulrush, cattail and pondweed species.

4.4 FISH COMMUNITIES

The most common sport fish species within FMZ4 include Walleye, Northern Pike, Lake Trout, Yellow Perch, Smallmouth Bass, Muskellunge, and Lake Whitefish (MNR 2014). Lake Whitefish and Walleye are common in the larger watercourses including the Chukuni River; and in larger waterbodies such as Genessee Lake, Gullrock Lake and Pakwash Lake. Lake Trout and Lake Sturgeon are not resident species within the PA, although occasionally incidental Lake Trout do migrate downstream into or through the PA from Red Lake upstream (Red Lake Community engagement pers. comm. 2025). Information shared by Lac Seul First Nation with Great Bear Resources through confidential Indigenous knowledge studies, stated that the aquatic ecosystem in the local and surrounding waterbodies include Walleye, Northern Pike, (Yellow) Perch, (Lake) Whitefish, Smallmouth Bass, Sucker, Rock Bass, Mooneye, Tullibee (Cisco) and Shiner-Minnow species. Information shared by Wabauskang First Nation with Great Bear Resources through confidential Indigenous knowledge studies stated communities have long harvested species such as Walleye, (Lake) Whitefish, Lake Trout, Muskie (Muskellunge), Bass, (Northern) Pike, Sucker, Jackfish (Northern Pike) and (Yellow) Perch across the region. Information shared by the NWOMC with Great Bear Resources through confidential Indigenous knowledge studies stated that fishing within local and surrounding waterbodies included Walleye, Perch, Bass, Northern Pike and Whitefish; and other species within a 100 km radius of the Project also included Trout, Minnows, Crappie, Sucker, Sauger, Muskie and other non-commercial fish. Based on comments from participants during the Planning Phase of the Impact Statement for the Project, Lake Whitefish, Walleye, Lake Trout, and Lake Sturgeon were identified as important considerations for the Project.

Lake Sturgeon have not been observed as present in the PA waterbodies or the Chukuni River. Lake Sturgeon were not captured or observed during the baseline studies and were not detected within the 2023 baseline eDNA samples for the Project. The nearest population Management Unit (MU2; Lacho et al. 2021) is believed to exist in the English River downstream of the Manitou Falls Generating Station which is approximately 14 km downstream of the confluence of the Chukuni River with the English River. Sturgeon was known to exist in Lake St. Joseph which was partially diverted to the Root River and English River system in the 1950's, however their population status is currently unknown.

Detailed fish communities provided in Table 4-1 by waterbody, watercourse and habitat type are largely dependent on the size, permanency and physical conditions of the habitats as described in Sections 4.2 and 4.3.

Species richness indicates how diverse a fish community is by counting the number of discrete species that are present in a defined area such as an individual watercourse or waterbody. Small headwater creeks (stream orders one and two) typically support only a few species with species richness values of one or two. As the watercourses and waterbodies increase in size and habitat complexity, the species richness increases as well, and larger fish and less resilient species of fish begin to occur as summarized by habitat type in Table 4-3.

Fish abundance has been calculated as catch per unit effort (CPUE) which is a measure of how many fish were captured over a specified unit of time. The CPUE is used as a metric to compare the relative abundance of fish in different locations or between time periods. Comprehensive sampling for the Project is summarized with CPUE by habitat and gear types in Table 4-4 and within the Fisheries Resources Baseline Report (WSP 2025a). As with species richness described above, the relative abundance of fish varies between habitat types as a reflection of flow permanency, depth and habitat complexity. The CPUE also varies by capture method and as such is generally compared by gear type.

Percent species composition is a measure of species diversity, and it compares the abundance of each species to the total fish community. This community structure will be largely dependent on the habitat types being considered and the life history of the individual species present. The unnamed watercourse habitats have conditions that only a few resilient species can exist in, such as habitat types D, E and F where flow can be intermittent, and the channels are small and discontinuous. In such habitats the species composition consists mainly of resilient small bodies species such as Central Mudminnow, Brook Stickleback and Chrosomus Spp. (Finescale Dace and Northern Redbelly Dace) as summarized in Table 4-5. Larger watercourses such as Dixie Creek and the Chukuni River, and lakes such as habitat Type C support fish communities with more evenly distributed species representation.

There are no aquatic Species at Risk (including Lake Sturgeon) identified as occurring in the PA.

Table 4-1: Fish Species Present in Local Waterbodies

Fish \ Waterbody	Dixie Creek	Chukuni River	Genessee Lake	Gullrock Lake	Pakwash Lake	Dixie Lake	Unnamed Waterbody 1	Unnamed Waterbody 2	Unnamed Waterbody 3	Unnamed Waterbody 4	Unnamed Waterbody 5	Unnamed Waterbody 6	Unnamed Watercourse 1	Unnamed Watercourse 1A	Unnamed Watercourse 1B-03	Unnamed Watercourse 2	Unnamed Watercourse 3	Unnamed Watercourse 3A	Unnamed Watercourse 3B	Unnamed Watercourse 4	Unnamed Watercourse 4a	Unnamed Watercourse 5	Unnamed Watercourse 6A-1	Unnamed Watercourse 6A-2	Unnamed Watercourse 6B	Unnamed Watercourse 6B-01	Unnamed Watercourse 6B-02	Unnamed Watercourse 6C	Unnamed Watercourse 7	Unnamed Watercourse 7A-03	Unnamed Watercourse 7A-07	Unnamed Watercourse 7A-08	Unnamed Watercourse 8	Unnamed Watercourse 8B	Number of Waterbodies
Blackchin Shiner [ICI]		X	X									X																							**3**
Blacknose Shiner [ICI]	d	X^d	X^d						X			X																	d						**4**
Bluntnose Minnow			X																																**1**
Brook Stickleback	X		X						X	X			X			X	X	X	X	X		X	X		X	X	X	X			X	X	X	X	**19**
Central Mudminnow	X^d	d					X	d		X		d	X		X	X	X^d	X		X		X	X	X	X	X	X	X	d	X	X	X	X		**19**
Common Shiner [ICI]	X^d	d	d		Xi																								d						**1**
Emerald Shiner [ICI]	X^d	X^d		Xi	Xi																														**3**
Fathead Minnow	d	d	d					d	X	X		X^d								X									d				X		**5**
Finescale Dace	X^d	d	d						X	X							X					X						X	d				X	X	**7**
Golden Shiner [ICI]	d	d	X^d				X	X^d																					d						**3**
Iowa Darter	X^d	d	X^d						X			d																	d						**2**
Johnny Darter	X^d	X^d	X^d																										d						**2**
Lake Chub	d	d	d						X																				d						**1**
Creek Chub	d	d																																	
Blacknose / Longnose Dace		d																																	
Mimic Shiner [ICI]	d	d			Xi			d																					d						**1**
Northern Pearl Dace	Xi^d	Xi^d	d						X				X									X							d				X	X	**6**
Northern Redbelly Dace	d	d	d						X								X			X		X						X					X	X	**7**
Rainbow Smelt		Xi		Xi	Xi																														**3**
Slimy Sculpin	d	d	d														d												d						**0**
Spottail Shiner [ICI]	X^d	X^d	X^d	Xi	Xi			d												X									d						**5**
Trout Perch	d	d	d	Xi	Xi																								d						**2**
Mooneye	X^d	X^d	d		Xi							d					d												d						**2**
Green Sunfish	d	d																																	
Rock Bass	X^d	X^d	X^d	Xi	Xi	Xi														X															**6**
Silver Redhorse	d	X^d	d		Xi																								d						**2**
Shorthead Redhorse	d	X^d	d	Xi	Xi							d																	d						**3**
White Sucker [ICI]	X^d	X^d	X^d	Xi	Xi	Xi			X				X				X^d			X		X							d				X		**11**
Yellow Perch [ICI]	X^d	X^d	X^d	Xi	Xi	Xi			X			X^d								X									X^d						**9**
Cisco [ICI]		Xi	X	Xi	Xi																														**4**
Burbot	X^d	X^d	d	Xi	Xi												d												d			X	X		**5**
Lake Whitefish [ICI]	d	X^d	d	Xi	Xi	Xi																							d						**4**
Muskellunge* [ICI]		Xi			Xi																														**2**
Northern Pike [ICI]	X^d	X^d	X	Xi	Xi	Xi		X^d				X^d	X				d	X		X									X^d	X		X			**13**
Sauger	X^d	X^d	X^d	Xi	Xi																														**4**
Smallmouth Bass [ICI]	d	X^d		Xi	Xi																								d						**3**
Walleye [ICI]	X^d	X^d	X^d	Xi	Xi	Xi											d												d						**5**
Species Richness - Captured	**16**	**21**	**15**	**15**	**20**	**6**	**2**	**2**	**10**	**4**	**0**	**5**	**5**	**0**	**1**	**2**	**5**	**3**	**1**	**9**	**0**	**6**	**2**	**1**	**2**	**2**	**2**	**4**	**2**	**2**	**2**	**4**	**8**	**4**	
Species Richness – with DNA	**31**	**35**	**28**					**6**				**7**					**10**												**24**						
Habitat Type	**H**	**I**	**C**	**C**	**C**	**C**	**A**	**B**	**B**	**A**	**A**	**A**	**F**	**D**	**D**	**F**	**HG**	**E**	**E**	**F**	**D**	**F**	**D**	**D**	**E**	**E**	**F**	**F**	**G**	**F**	**E**	**E**	**F**	**F**	**-**

Notes:
X: indicates species presence was confirmed during field studies.
Xi: indicates species occurrence is document by the MNR through FishON-line or BsM surveys.
d / ^{d} : indicate species identified in eDNA sampling.
*: Muskellunge were recorded in the online Fish ON-line records, which has disclaimers that accuracy of the records can not be assured.
ICI : fish species and / or waterbodies identified of Indigenous community importance, including in confidential Indigenous knowledge reports provided to Great Bear Resources.

Table 4-2: Fish Habitat Type and Key Habitat Characteristics

Habitat Type Classification		Lake / Unnamed Waterbody			River / Creek / Unnamed Watercourse					
		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 • Consisting mostly of fine-grained sediment and localized sections with boulder, cobble and/or sand	• Small, deep inland lake habitat • Support a variety of forage fish and large body/sport fish • 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	• Little to no floodplain with dense shrub riparian vegetation • Steep banks • 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 river with broad floodplain • Primarily flat morphology with occasional pools • Commonly occurring as main connecting channels between inland waterbodies	• Large river with moderate flow with occasional fast flowing riffle / rapids habitat and steep banks • Soft fine-grained substrate with some localized boulder and cobble, as well as exposed bedrock
Permanence		Permanent	Permanent	Permanent	Ephemeral	Intermittent	Permanent	Permanent	Permanent	Permanent
Characteristic Morphology Features	**Bankfull Width (m)**	-	-	-	0.10 to 0.57	1.0 to 3.4 m	1.0 to 5.1 m	>5 m	>5 m	>10 m
	Bankfull Depth (m)	Total depth <4 m	Total depth >4 m	Total depth >10 m	0.1 to 0.6 m	0.1 to 1.0 m	0.1 to 0.9 m	>1 m	>1 m	>2 m
	Channel Morphology	Pool: 100%	Pool: 100%	Pool: 100%	-	Slow Riffle: 5% Glide: 95%	Flat: 80% Pool: 20%	Flat: 98% Pool: 2%	Flat: 96% Pool: 2% Slow Riffle: 2%	Fast Riffle: 20% Slow Riffle: 30% Glide: 50%
Substrate Composition (approximate %)		Boulder: 2% Cobble: 2% Fines: 96%	Boulder: 5% Cobble: 5% Fines: 90%	Bedrock: 20% Boulder: 20% Fines: 60%	Bedrock: 20% Boulder: 20% Fines: 60%	Bedrock: 20% Boulder: 60% Fines: 10% Other: 10%	Bedrock: 5% Boulder: 15% Fines: 80%	Bedrock: 5% Boulder: 15% Fines: 80%	Bedrock: 5% Boulder: 5% Fines: 90%	Bedrock: 25% Boulder: 20% Cobble: 15% Fines: 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% Other: 5%	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%
Strahler Stream Order (Figure 8.4-2)		-	-	-	Mostly stream order 1 with some stream order 2	Stream order 1 and 2	Mostly stream order 1 and 2, with occasional stream order 3	Mostly stream order 3 and 4	Mostly stream order 4 and 5	Greater than stream order 5

Notes:
- : not applicable

Table 4-3: Average Species Richness by Habitat Type

Habitat Type	Average of Species Richness
Type I	21.0
Type C	14.0
Type H	7.7
Type B	6.0
Type G	5.0
Type F	4.8
Type A	2.8
Type E	2.3
Type D	0.8

Table 4-4: CPUE by Gear and Habitat Type

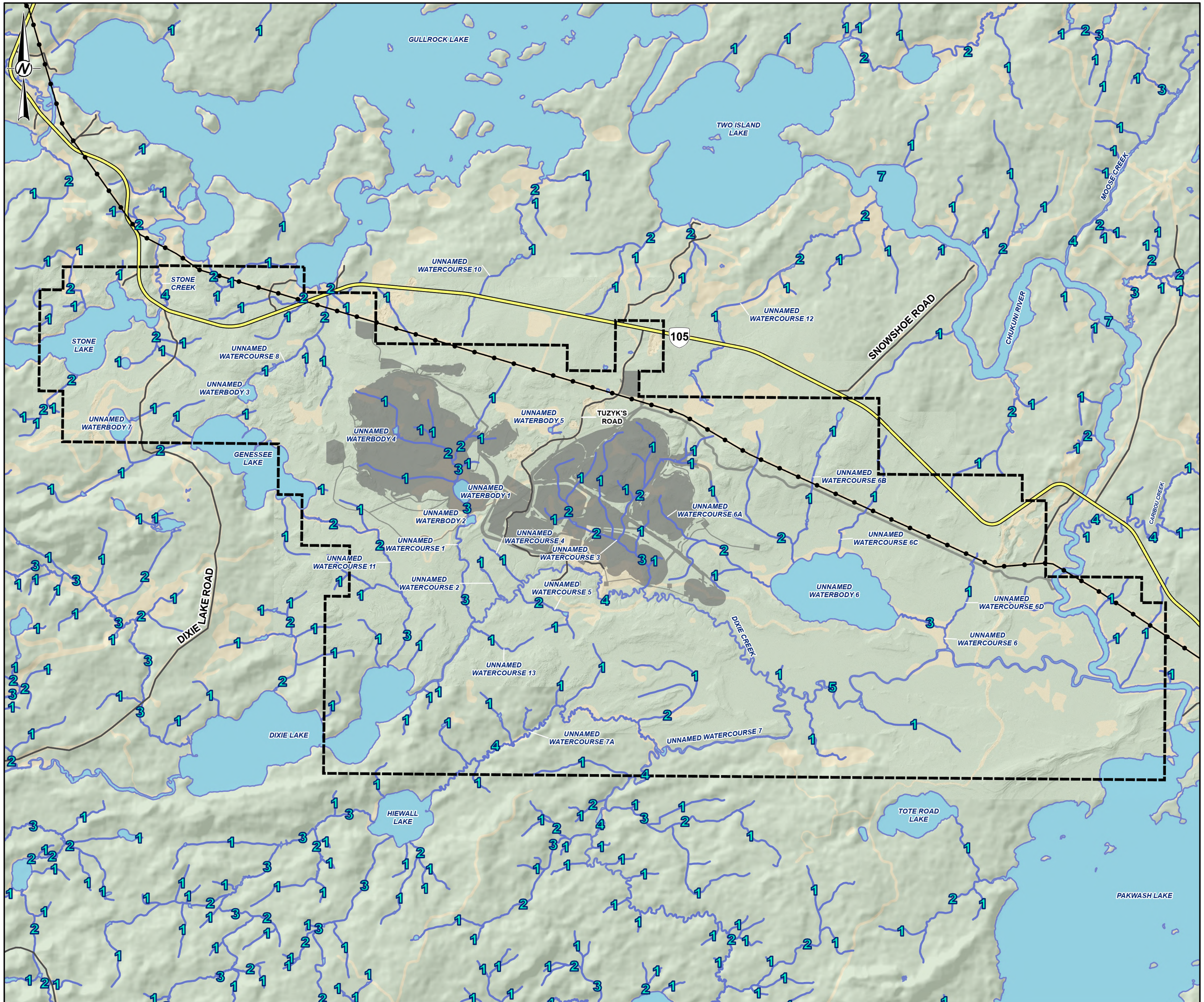
Collection Gear	Habitat Type							
	Type A	Type B	Type C	Type D	Type E	Type F	Type G/H	Type I
Dip Net	0.643	0.333	-	-	-	-	0.033	-
Electrofishing	-	-	-	0.003	0.003	0.005	0.031	0.496
Gill Net	7.240	0.450	5.990	-	-	-	1.139	9.080
Minnow Trap	0.035	0.289	0.045	0.061	0.165	0.563	0.063	0.004
Seine Net	18.917	-	266.333	-	-	-	-	86.222

Notes:
- : not applicable

Table 4-5: Percent Species Composition by Habitat Type

Species	Habitat Type (% Composition)									
	A	B	C	D	E	F	G	H	I	All
Blackchin Shiner[ICI]	10.9	-	3.8	-	-	-	-	-	-	0.6
Blacknose Shiner[ICI]	3.8	3.1	1.2	-	-	-	-	-	4.3	2.0
Bluntnose Minnow	-	-	0.1	-	-	-	-	-	-	< 0.1
Brook Stickleback	0.4	0.9	1.7	6.1	20.7	15.0	11.9	0.9	-	7.3
Burbot	-	-	-	-	-	< 0.1	-	7.5	< 0.1	0.1
Central Mudminnow	2.3	0.1	-	93.0	54.2	27.0	20.1	-	-	15.1
Cisco[ICI]	-	-	0.2	-	-	-	-	-	-	< 0.1
Common Shiner[ICI]	-	-	-	-	0.1	-	-	-	-	< 0.1
Emerald Shiner[ICI]	-	-	0.8	-	-	-	-	7.5	12.4	4.6
Fathead Minnow	5.5	0.7	-	-	-	1.2	-	-	-	0.6
Finescale Dace	2.7	63.4	-	0.9	17.5	42.8	55.8	-	-	23.2
Golden Shiner	1.7	1.5	0.7	-	-	0.2	-	-	-	0.3
Iowa Darter	-	1.9	6.8	-	-	-	-	0.9	-	0.6
Johnny Darter	-	-	0.1	-	-	-	-	0.9	0.3	0.1
Lake Chub	-	6.8	-	-	-	0.2	-	-	-	0.6
Lake Whitefish[ICI]	-	-	-	-	-	-	-	-	0.5	0.2
Mooneye	-	-	-	-	-	-	-	5.6	0.4	0.2
Mottled Sculpin	-	-	0.2	-	-	-	-	-	-	< 0.1
Northern Pearl Dace	-	12.9	-	-	-	2.7	-	-	-	1.8
Northern Pike [ICI]	17.1	0.9	1.9	-	1.4	0.1	-	33.6	0.6	1.3
Northern Redbelly Dace	-	3.6	0.5	-	5.8	6.7	8.7	-	-	3.4
Phoxinus Hybrid	-	-	-	-	-	3.3	3.2	-	-	1.2
Rock Bass	-	-	0.2	-	-	-	-	0.9	0.6	0.2
Sauger[ICI]	-	-	-	-	-	-	-	-	< 0.0	< 0.1
Shiner sp. [ICI]	-	-	0.2	-	-	-	-	-	-	< 0.1
Shorthead Redhorse	-	-	-	-	-	-	-	-	0.3	0.1
Silver Redhorse	-	-	-	-	-	-	-	-	0.1	< 0.1
Slimy Sculpin	-	-	-	-	-	< 0.0	0.1	-	-	< 0.1
Smallmouth Bass	-	-	-	-	-	-	-	-	0.1	< 0.1
Spottail Shiner[ICI]	-	-	71.7	-	-	< 0.0	-	3.7	3.1	5.5
Walleye[ICI]	-	-	0.7	-	-	-	-	0.9	1.4	0.6
White Sucker[ICI]	-	0.1	0.1	-	0.1	0.5	-	1.9	0.4	0.4
Yellow Perch[ICI]	55.6	4.3	8.9	-	-	0.0	-	35.5	75.3	30.0

Notes:
Percent compositions may not sum to exactly 100% for each habitat type due to rounding.
- : not applicable
ICI : Fish species identified as of Indigenous community importance.



LEGEND

- PROPERTY BOUNDARY
- GREAT BEAR PROJECT FOOTPRINT
- HIGHWAY
- LOCAL ROAD
- EXISTING TRANSMISSION LINE
- WATERCOURSE – LABELLED WITH STREAM ORDER NUMBER (STRAHLER METHOD)
- WATERBODY

0 0.5 1 2
1:71,000 KILOMETRES

NOTE(S)
1. ALL LOCATIONS ARE APPROXIMATE

REFERENCE(S)
1. CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENCE - ONTARIO
3. PROPERTY BOUNDARY PROVIDED BY GREAT BEAR RESOURCES, AUGUST 2024.
4. ROADS INFORMATION PROVIDED BY GREAT BEAR RESOURCES, AUGUST 2022.
5. SITE PLAN BASED ON INFORMATION PROVIDED BY GREAT BEAR RESOURCES, DECEMBER 2024 / JUNE 2025.
6. COORDINATE SYSTEM: NAD 1983 UTM ZONE 15N

CLIENT
GREAT BEAR RESOURCES

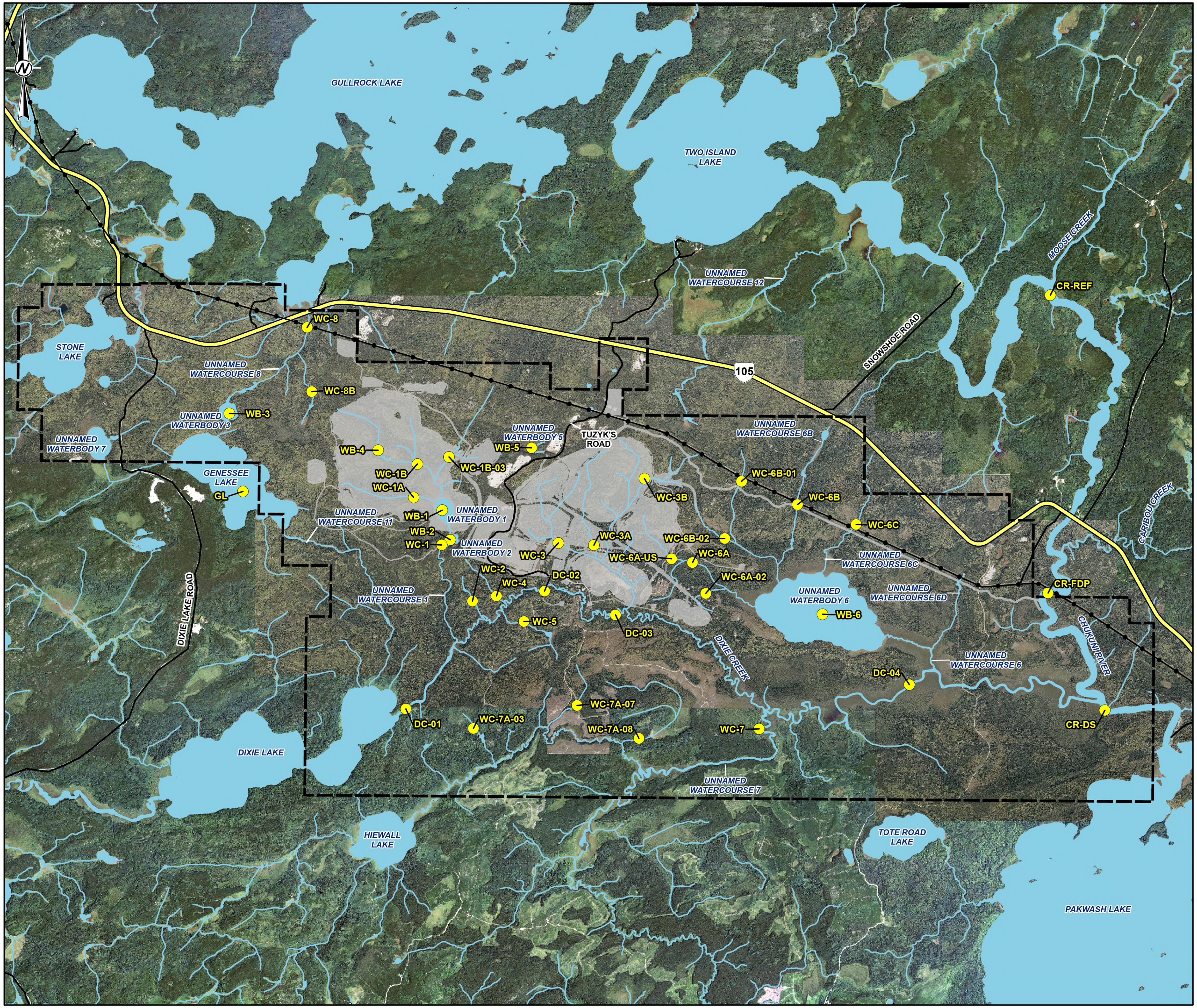
PROJECT
GREAT BEAR PROJECT

TITLE
PROJECT WATERCOURSES BY STRAHLER STREAM ORDER CLASSIFICATION

CONSULTANT

YYYY-MM-DD	2025-12-04
DESIGNED	----
PREPARED	MD
REVIEWED	----
APPROVED	----

PROJECT NO.	CONTROL	REV.	FIGURE
CA0031271	0001	A	4-1



LEGEND

- PROPERTY BOUNDARY
- GREAT BEAR PROJECT FOOTPRINT
- STATION LOCATION
- HIGHWAY
- LOCAL ROAD
- EXISTING TRANSMISSION LINE
- WATERCOURSE
- WATERBODY

NOTE(S)

1. ALL LOCATIONS ARE APPROXIMATE

REFERENCE(S)

1. CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENCE - ONTARIO
2. AERIAL IMAGERY PROVIDED BY GREAT BEAR RESOURCES (SCENE DATE: SEPTEMBER 2022).
3. PROPERTY BOUNDARY PROVIDED BY GREAT BEAR RESOURCES, AUGUST 2024.
4. ROADS INFORMATION PROVIDED BY GREAT BEAR RESOURCES, AUGUST 2022.
5. SITE PLAN BASED ON INFORMATION PROVIDED BY GREAT BEAR RESOURCES, DECEMBER 2024 / JUNE 2025.
6. COORDINATE SYSTEM: NAD 1983 UTM ZONE 15N.

CLIENT
GREAT BEAR RESOURCES

PROJECT
GREAT BEAR PROJECT

TITLE
AQUATIC BASELINE SITE LOCATIONS

CONSULTANT		
	YYYY-MM-DD	2025-12-04
	DESIGNED	----
	PREPARED	MD
	REVIEWED	----
	APPROVED	----

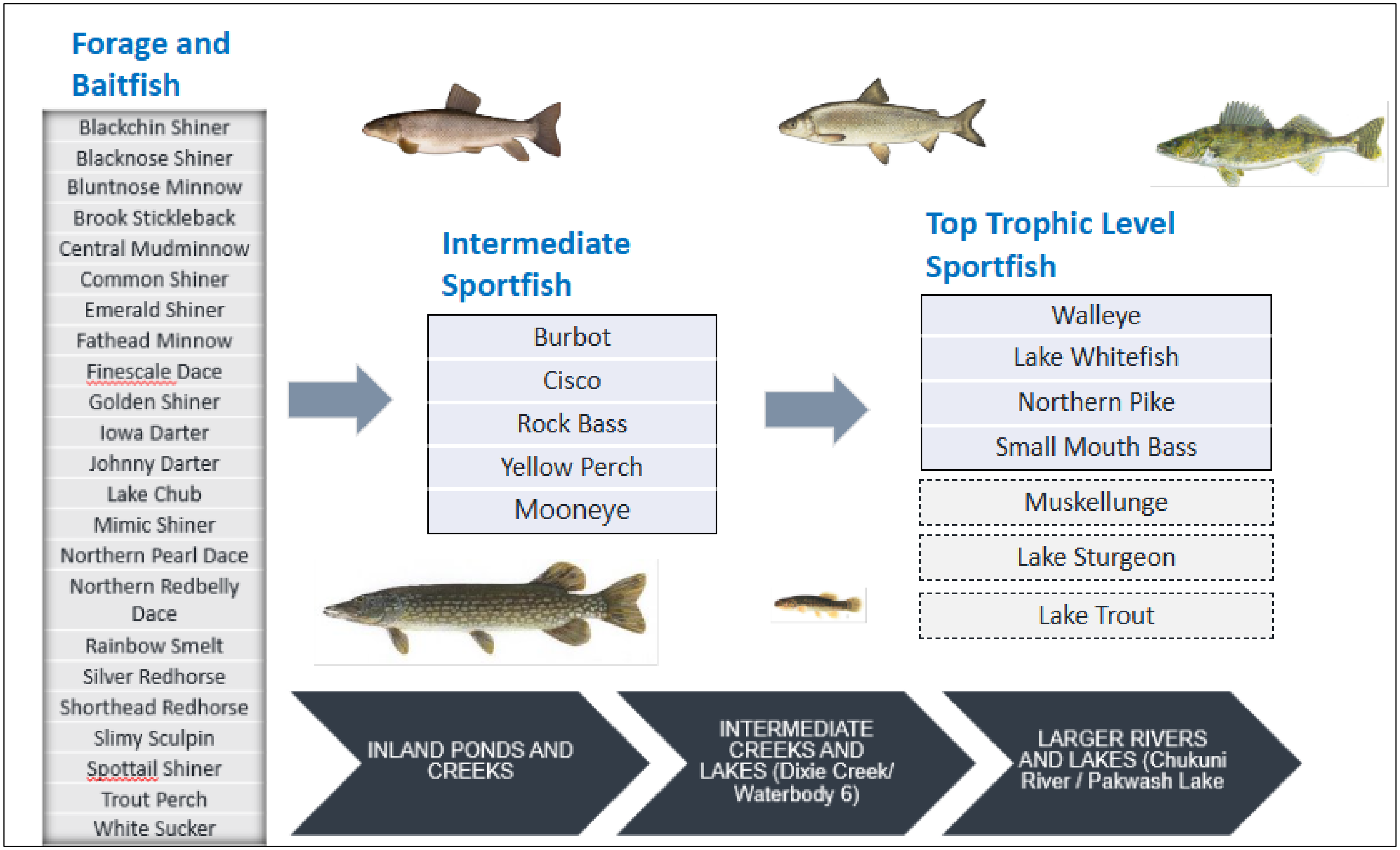
PROJECT NO.	CONTROL	REV.	FIGURE
CA0031271	0001	A	4-2

PATH: X:\CA\CAOAK300-OAK\MIS-FS1-ProjectF\2023\Projects\OMEMA2303_Kinross_Great_Bear_Envt\7_GIS\Aquatic\Offsetting_Plan\PRO\Offsetting_Plan\Offsetting_Plan.aprx PRINTED ON: AT: 12:06:42 PM

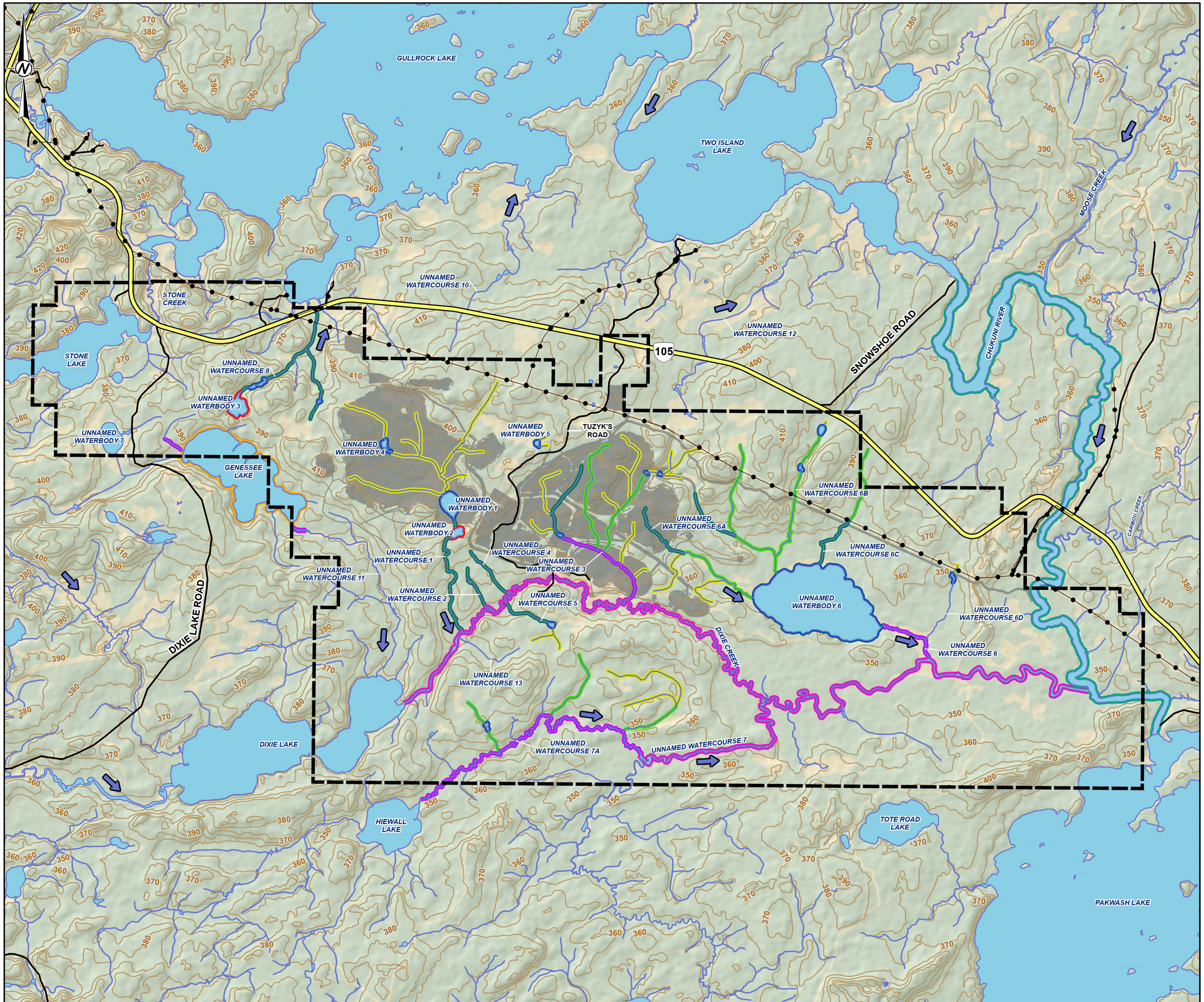
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25mm

Figure 4-3: Project Fish Communities



Note:
Muskellunge, Lake Sturgeon and Lake Trout are considered regional fish species but are not considered to be resident species within the Project Area waterbodies.



LEGEND

- PROPERTY BOUNDARY
- GREAT BEAR PROJECT FOOTPRINT
- HIGHWAY
- LOCAL ROAD
- EXISTING TRANSMISSION LINE
- WATERCOURSE (NOT ASSESSED FOR FISH HABITAT TYPE)
- WATERBODY (NOT ASSESSED FOR FISH HABITAT TYPE)
- CONTOURS (10 M INTERVAL)
- SURFACE WATER FLOW PATH

FISH HABITAT TYPE

- A
- B
- C
- D
- E
- F
- G
- H
- I

0 1,000 2,000 4,000

1:72,000 METRES

NOTE(S)

1. ALL LOCATIONS ARE APPROXIMATE

REFERENCE(S)

1. CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENCE - ONTARIO
2. PROPERTY BOUNDARY PROVIDED BY GREAT BEAR RESOURCES, AUGUST 2024.
3. SITE PLAN BASED ON INFORMATION PROVIDED BY GREAT BEAR RESOURCES, DECEMBER 2024 / JUNE 2025.
4. COORDINATE SYSTEM: NAD 1983 UTM ZONE 15N

CLIENT
GREAT BEAR RESOURCES

PROJECT
GREAT BEAR PROJECT

TITLE
FISH HABITAT TYPE BY WATERBODY

CONSULTANT

YYYY-MM-DD	2026-03-10
DESIGNED	----
PREPARED	MD
REVIEWED	----
APPROVED	----

PROJECT NO.	CONTROL	REV.	FIGURE
CA0031271	0001	A	4-4

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

The Project has the potential to directly and indirectly, affect waterbodies frequented by fish through works, activities, and undertakings. Activities such as infilling, or the displacement of waterbodies, installation of water intake or discharge structures and water crossings can all have direct effects on waterbodies with their physical footprint and inwater works. They can also indirectly affect habitat such as flow alterations or water level changes to adjacent waterbodies and downstream creek sections, or with construction methods such as blasting or ground disturbance resulting in sedimentation. Descriptions of the main Project components and their interactions with fish and fish habitat are summarized below. The locations of the effects are shown in Section 3 (Figure 3-1) with additional descriptions provided below and in Section 6.

Potential effects below are discussed by major Project component, i.e., mining (open pits and underground mine), water storage and discharge, road and pipeline crossings, TMF and stockpiles (MRS, OVB and LGO), along with avoidance and mitigation measures to avoid HADD. Residual predicted HADD and waterbodies that will require listing to Schedule 2 of the MDMER are individually and cumulatively summarized in Section 6 (Table 6-1 and Table 6-2).

5.1 MINING

Ore extraction will occur both from open pit mines (LP Central pit and Viggo pit) and an underground mine through at surface portals and a future shaft (Figure 1-2). Mining and blasting at the Viggo pit will start near the beginning of the construction phase and will continue for approximately 2.5 years. This production schedule with mining at the Viggo pit being completed during the construction phase has been established to provide non-potentially acid generating (NPAG) mine rock for use Project construction. This will limit the requirement for dedicated aggregate sources and additional environmental disturbance. It also allows the depleted Viggo pit to be available and re-used for the storage of tailings and contact water management at the start of operations.

Viggo pit will have a surface area of approximately 9.7 ha and a depth of about 110 m. Rock (ore and mine rock) will be broken at the pit wall using explosives. Conventional mining equipment (i.e., blast hole drill rigs, mining shovels, excavators, loaders, bulldozers and / or comparable equipment) will be used during mining activities at the pit, with equipment selected to meet the production requirements.

Mining of the LP Central pit is planned to start near the end of the second year of construction and will continue for a total of approximately ten years until the near surface ore is depleted. After that, only underground mining will occur on the Property. Once sufficient bedrock is exposed through overburden stripping, ore and mine rock will be extracted from the pit using explosives and conventional mining equipment (i.e., blast hole drill rigs, mining shovels, excavators, loaders, bulldozers and / or comparable equipment). The LP Central pit will have a surface area of approximately 88 ha and a depth of 255 m.

The underground mine will be used to access deeper ore that cannot be readily or reasonably extracted by open pit mining, including due to surface constraints associated with Dixie Creek. This approach will reduce the surface disturbance associated with mining activities. The current mine plan includes development of the underground workings to a depth of about 1,500 m below the surface or potentially deeper, with a peak mining rate of up to approximately 8,000 tonnes per day from combined ore zones.

No new portals at surface are proposed for the underground mine. Mine development will begin from the advanced exploration program twin declines, which will also provide ventilation and emergency egress for the early stages of underground mining. The underground ramp dimensions for the production mine will also be in the order of 6 m wide and 5.5 m high, at will have a gradient of 15%. Ore and mine rock will be extracted at the active mining face using explosives and transferred by load haul dump vehicles or scoop trams to trucks for haulage to surface, along the ramp to the primary crusher or surface stockpiles. A shaft is proposed later in the mine life to support access to deeper workings and recovery of ore to surface from depth. Some mine rock will be retained underground for use as backfilling material.

5.1.1 DIRECT EFFECTS

The LP Central pit will overprint portions of Unnamed Watercourse 3 (impact segment IS-34) and its tributaries (impact segments IS-38, IS-45, IS-53 and IS-54) as shown in Figure 3-1. Development of the Viggo pit does not directly overprint any watercourses.

There are no direct effects to fish associated with the underground mine as there are no watercourses or waterbodies within the footprint of the underground mine openings. There is an existing bridge and road crossing that provides access the south side of Dixie Creek where a vent raise is proposed. Extracted materials from the underground mine and open pit mines stockpiled on surface are discussed in Section 5.2.

5.1.2 INDIRECT EFFECTS

5.1.2.1 DEWATERING

Dewatering of the open pits and the underground mine will contribute to the alteration of the frequency and volume of flows to local watercourses by causing a reduction in baseflow withing the zone of drawdown as shown and described in the Great Bear Project groundwater modelling report (WSP 2025b). The groundwater model boundary and worst-case scenario simulated drawdown contours are shown in Figure 5-1. It is noted that the worst-case scenario is not likely to occur but rather is shown to demonstrate that even under such conditions the drawdown is still relatively localized to the Project Area. The interactions of groundwater reductions with surface water have been assessed along with watershed area capture for a combined effect and are presented in the Great Bear Project receiver water balance report (WSP 2025c). The receiver water balance modelled watersheds and assessment nodes are shown in Figure 5-2. The mine dewatering is just one element of the overall site wide water management system, and as such the effects of the mine dewatering are included in Section 5.4 (Water Management).

5.1.2.2 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 kilopascals (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•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 that 50 kPa is a preferred threshold limit for overpressure within fish habitat on the Project. These limits are applicable at the land-water interface (shoreline).

The use of explosives for mine development will progress quickly below grade which will rapidly reduce the potential for effects to adjacent fish habitat. A blasting assessment was completed for the Project and is provided in the Project blasting assessment report (Wood 2025). The assessment shows that although there is potential for blasting operations to exceed the threshold in some waterbodies, the effects of the blasting is expected to be mitigatable using measures such as reduced charges and fish exclusion as needed. A detailed blasting plan will be developed prior to construction to further reduce potential effects.

5.1.3 AVOIDANCE AND MITIGATION

The location of the ore deposit is fixed and as such the location of the open pits and underground mine can not be located elsewhere. The effects of mining the ore have been partly mitigated by transitioning from open pits to underground mining in approximately year 10 which will avoid additional effects to Dixie Creek.

A blasting plan will be developed prior to construction to mitigate potential effects due to overpressure and peak particle velocity. 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.

Fish will be relocated from the impacted watercourses prior to construction of the open pit mines.

5.2 STOCKPILES

5.2.1 DIRECT EFFECTS

There will be four primary stockpile types required on the site to store overburden (OVB), mine rock (MRS), low grade ore (LGO) and run of mine ore (ROM). Where practical, organic materials / topsoil will be stripped and stored separately close to the source, or at the overburden stockpiles for use in future reclamation activities.

Stockpiles will overprint portions of Unnamed Watercourse 1 (OVB3), Unnamed Watercourse 3 (LGO1, LGO2, OVB1, OVB2, OVB1 and MRS), and Unnamed Watercourse 6a (OVB1). Individual impact segments are listed in Section 6. In all cases the habitats are considered a permanent loss. The ore stockpile areas will be reclaimed at closure but are not proposed as reclaimed fish habitat.

5.2.2 INDIRECT EFFECTS

The development of stockpiles will include perimeter runoff and seepage collection ditches to capture contact water. Changes in flow due to a combination of drainage area reduction and changes in groundwater contribution are described in Section 5.4.

5.2.3 AVOIDANCE AND MITIGATION

The stockpiles have been designed and located to maintain a reduced footprint for the overall mine and avoid waterbodies to the extent practical. A detailed assessment of mine waste alternatives was completed under separate cover, Great Bear Project Assessment of Alternatives for Storage of Mine Waste (WSP 2025c), which follows the Environment and Climate Change Canada 2016 guideline (ECCC 2016). Ditching around the 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., potential suspended solids releases) industry-standard measures and best management practices will be implemented as per Section 7.

Fish will be relocated from the watercourses prior to establishment of the stockpiles.

5.3 AGGREGATE SUPPLY

5.3.1 DIRECT EFFECTS

The primary source of aggregate for site construction is planned to be re-purposed NPAG mine rock from open pit development. This will be supplemented during the construction and operations phases by onsite dedicated quarries, and sand and gravel pits (Figure 1-2).

Rock will be quarried from accessible bedrock areas within or near the TMF. Two potential locations have been identified within the TMF footprint, and no additional direct effects are expected from the quarries beyond those discussed in Section 5.6. A third potential quarry location west and outside of the TMF footprint has also been identified which could provide a rock source during the construction and operations phases but this location does not overprint any waterbodies. Rock will be quarried using explosives and reduced to the required size of rock using a portable crusher for placement in the TMF dams or other uses as necessary.

Additional aggregate will be required for specialized uses such as tailings dam filters, concrete manufacturing, and road construction and maintenance. Two sand and gravel sources have been identified on the Property that are currently under investigation: two raised areas located north of the TMF (Figure 1-2). If the site investigations are supportive, sand and gravel resources will be removed to above the groundwater table at one or more of the areas. A portable screening plant may be used for size control. Neither of the two potential locations will overprint watercourses or waterbodies and no direct effects to fish or fish habitat are expected.

5.3.2 INDIRECT EFFECTS

The aggregate quarry adjacent to the TMF and the sand and gravel sources will be developed to remain above the groundwater table such that dewatering (water extraction) will not be required. Site clearing and will include appropriate erosion and sediment control such that sediment mobilization to adjacent watercourses will be prevented. Surface contact water runoff will be collected and managed within the water management system. No indirect effects to fish or fish habitat are anticipated.

5.3.3 AVOIDANCE AND MITIGATION

The rock quarries and sand and gravel borrow areas have been designed and located to maintain a reduced footprint for the overall mine and avoid waterbodies. Ditching around the features will collect runoff and direct it to the water management system as needed. To protect the adjacent waterbodies from construction impacts (i.e., suspended solids) industry-standard measures and best management practices will be implemented as per Section 7.

5.4 WATER MANAGEMENT

5.4.1 DIRECT EFFECTS

Water management is necessary to collect contact water and treat to applicable water quality guidelines and approval requirements, prior to release to the environment. Some water management features will directly overprint fish habitat while others will redirect flow. Collection ditches and sumps shown in Figure 1-2 along with three collection ponds are proposed at the mine site including the TMF pond and the mine water pond (located south of the tailings facility), and the collection water pond located south of the LGO and OVB2. These ponds will overprint portions of Unnamed Watercourse 1, Unnamed Waterbody 1 and Unnamed Watercourse 3 respectively (Figure 3-1). These watercourses and waterbodies will require listing on schedule 2 of the MDMER as shown in Section 6, Table 6-1.

A fish habitat diversion will be constructed at the northeast margin of the Project Area to capture non-contact water for the purpose of providing fish habitat offset and compensation opportunities. The fish habitat diversion consists of a diversion dam (i.e., East Dam), diversion pond and diversion channel (i.e., East Pond and Channel), to redirect flows from Unnamed Watercourse 3b into the upper reaches of unnamed watercourse 6b. The East Dam will overprint and alter a portion of existing Unnamed Watercourse 3b (Figure 3-1). Habitat alterations associated with the fish habitat diversion will be considered HADD of fish habitat, as summarized in Section 6, Table 6-2

Fresh water takings are driven by the process plant and accommodations complex demand. A fresh water intake is proposed on the Chukuni River. Average fresh water takings to supply the process plant, and accommodations complex vary from 0.09 million cubic metres (Mm^3) to 0.43 Mm^3 per year during the operations phase. The water intake is expected to extend approximately 50 m into the Chukuni River, with a nominal width including the pipeline, pipe anchors and intake structure of 2 m for a total footprint of approximately 100 m^2. Habitat alterations associated with the fresh water intake will be considered HADD of fish habitat, as summarized in Section 6, Table 6-2.

A discharge pipeline and diffuser will be in place to support the advanced exploration program. A new discharge pipeline will be constructed to meet the capacity requirements of the mine. The footprint of the new pipeline and diffuser will twin the corridor that is occupied by the existing advanced exploration program discharge pipeline, thereby minimizing the area affected. The existing access road will accommodate the new pipeline to the Chukuni River. A new intake structure and discharge structure for the Project will be positioned in the vicinity of the AEX discharge location.

5.4.2 INDIRECT EFFECTS

In addition to the direct overprinting of portions of unnamed watercourses, the water management system will collect and divert runoff from the mine site footprint which when combined with the groundwater drawdown will alter the flows to the down gradient watercourses.

Changes to flow were assessed using guidance provided in Framework for Assessing the Ecological Flow Requirements to Support Fisheries in Canada (DFO 2013a) and A Desk-top Method for Establishing Environmental Flows in Alberta Rivers and Streams (Locke and Paul 2011); as well as other more recent flow classification and risk assessments, such as the Ecological Classification of Flow in Ontario (Jones et al. 2024) and the British Columbia Environmental Flow Needs Policy (British Columbia 2022). From these guidance documents it is proposed that a 10% to 15% reduction or increase in instantaneous flows is unlikely to have detectable ecological effects on downstream habitat.

WSP have used the more conservative target value of 10% as an indicator of potential HADD, based on the largest predicted annual flow reduction as shown in Table 5-1. The combined surface water and groundwater management will result in flow reductions considerably greater than 10% in the lower portions of Unnamed Watercourse 1, Unnamed Watercourse 3, and Unnamed Watercourse 6A (all greater than 60% flow reduction), and as such these watercourses have been considered HADD and have been included in Table 6-2. Other watercourses will experience an increase in flow considerably greater than 10% including Unnamed Watercourse 8b, and Unnamed Watercourse 6b, (both greater than 30%) as shown in Figure 3-1, and have also been included in Table 6-2 as HADD. In most cases the remaining watercourse and flow contribution are expected to be sufficient to retain the existing fish species; but to be conservative we have considered 100% of the remaining watercourse to be altered and included as HADD to Fish habitat in section 6 Table 6-2. With the exception of Dixie Creek, all other waterbodies are predicted to have flow gains or losses of less than the 10% target threshold, and well below the 10 to 15% range considered unlikely to have an ecological effect.

Dixie Creek was modeled to show a marginal flow reduction over the 10% target value (10.3%) at model node DIX-3 (Figure 5-2; Table 5-1). Dixie Creek has not been considered a HADD in Section 6, as the watercourses and fish community is considered resilient to flow fluctuation as shown in baseline conditions and the change is within the 10% to 15% reduction proposed as not likely to have ecological effects.

DFO comments raised a concern on review of an earlier draft of this Plan, that using a monthly or finer timestep could identify a potential for seasonal effects to Dixie Creek fish and fish habitat; and that additional consideration should be given to species that rely on riffle habitat for spawning such as Walleye and Lake Whitefish. Preliminary questions from Lac Seul First Nation and Wabauskang First Nation also suggested that additional consideration should be given to Dixie Creek flows related to Walleye and Lake Whitefish. To address these comments and questions, a supplemental analysis of Dixie Creek flows was completed and documented in WSP (2026b). The findings of the supplemental analysis included:

- At a monthly time step, flow reductions are greatest during operations at flow model node DIX-3 with the calculated flow reductions ranging from 8% in January and July to 13.6% in April.
- Using a weekly timestep, existing modeled long term average flow is above the 30% mean annual discharge in all months; and that the predicted conditions during operations also remain above the 30% mean annual discharge.
- Using a weekly timestep, the predicted water level change from existing conditions to operations during the year is less than 3 centimetres, and well within the range of natural variation (approximately 1 m) including during the spring and fall spawning seasons.
- Assessing the project monthly flow changes through the more recent British Columbia Environmental Flow Needs Policy (BC 2022) places the predicted flow reduction as "*Risk Level 1 - Where the EFN risk assessment process results in Risk Level 1, for that specific flow period (i.e., monthly) there is sufficient water available to provide for EFN as well as for proposed water diversion and use*".
- Following guidance in the recent MNR Ontario Flow Classification (Jones et al. 2024), Dixie Creek and the Project Area are within an area of northwestern Ontario known to have stable and highly stable flow regime classifications.

Despite the analysis presented in WSP (2026b) and the high confidence that the Project has a low probability of having measurable effects to fish and fish habitat in Dixie Creek, Great Bear Resources propose additional monitoring measures during the construction and operations phases of the Project to verify this conclusion.

5.4.3 AVOIDANCE AND MITIGATION

Efforts have been made to maintain a compact site footprint reducing the overall drainage area captured by the water management system. Pond locations were selected following a careful examination of site topography and facility locations. A detailed assessment of mine waste alternatives was completed to evaluate the best pond locations and is provided in WSP (2025d). Transitioning solely to underground mining methods in year ten reduces the open pit footprint and avoids encroaching on Dixie Creek. Collected contact water will be managed according to applicable provincial and federal water quality requirements and returned within the Chukuni River watershed downstream of the mine.

The water intake at the Chukuni River will include measures to avoid fish entrainment following the DFO Interim code of practice: End-of-pipe Fish Protection Screens for Small Water Intakes in Freshwater. The guidelines are considered applicable for intake flows up to 0.150 m^3/s, with the proposed Project flow rate is considerably less than this flow rate (0.014 m^3/s).

Fish will be relocated from the impacted watercourses prior to construction of the ponds and water management system.

5.5 ROADS AND PIPELINE CROSSINGS

5.5.1 DIRECT EFFECTS

There will be several roads, pipelines and ditch crossings required to support the mine site development and operations (Figure 1-2). All crossings will be located either at existing road crossings, or within the areas already identified as HADD due to infrastructure and mine components (Figure 3-1). As such the specific locations of all potential crossings in these areas have not been identified nor accounted for separately in the Plan, as they are already included in the broader zone of impacts referred to and accounted for as support infrastructure.

5.5.2 INDIRECT EFFECTS

There are no indirect effects expected from road and pipeline crossings in addition to those identified elsewhere.

5.5.3 AVOIDANCE AND MITIGATION

All crossings will be designed to provide for appropriate conveyance of natural flows and be constructed to not cause erosion and sedimentation of downstream habitats. Crossings, pipelines and intakes associated with watercourses or waterbodies, if no longer needed will be removed at closure and the areas reclaimed.

5.6 TAILINGS MANAGEMENT FACILITY

5.6.1 DIRECT EFFECTS

The TMF is located in the northwest of the Project Area and has total surface area of approximately 345 ha. The TMF will have containment dams with a rockfill shell and vertical sand and gravel filters to retain tailings solids within the facility. The dams are designed to let water pass through and allow the tailings to consolidate. The dams will be raised along the centreline with the continuation of the vertical sand and gravel filters with rockfill to support the dams in a downstream direction.

The TMF will directly overprint the upper reaches of Unnamed Watercourse 1, and Unnamed Waterbody 4 in its entirety (Figure 3-1).

The TMF dams will result in HADD to fish habitat (Section 6, Table 6-2 and Table 6-3) while the internal tailings storage area will be considered a mineral waste, and as such the overprinted waterbodies will require listing on Schedule 2 of the MDMER (Section 6, Table 6-1 and Table 6-3). In either case, the waterbodies and habitats overprinted by the TMF will be permanently lost.

5.6.2 INDIRECT EFFECTS

Collection of runoff and seepage from the TMF will be managed as contact water as per Section 5.4. The capture of the upper reaches of Unnamed Watercourse 1 will contribute to a flow reduction to the lower reaches to its confluence with Dixie Creek (Figure 3-1). Redirection of drainage to the north of the TMF will result in a flow increase to Unnamed Watercourse 8.

5.6.3 *AVOIDANCE AND MITIGATION*

One of the key objectives of the site planning has been to maintain a reduced overall footprint for the mine including the TMF. The preferred location was selected after careful assessment of environmental, technical, social, and financial factors during completion of the Assessment of Alternatives for Storage of Mine Waste (WSP 2025c) which included consideration of the overprinting of watercourses and waterbodies.

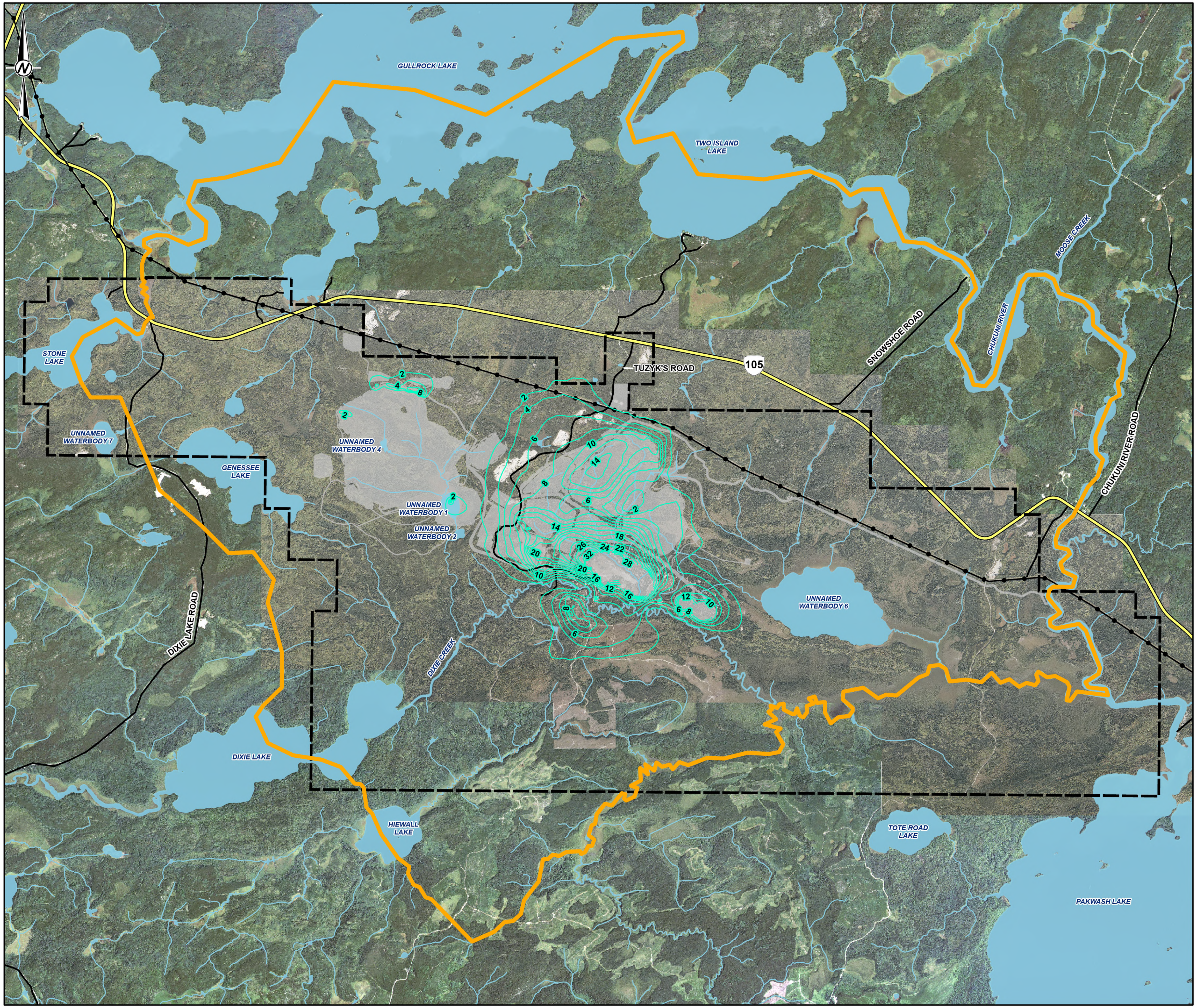
Although the TMF has been designed to make efficient use of space, the nature of the impact (overprinting) does not allow for any additional mitigation for the overprinted waterbodies. Ditching around the TMF will collect seepages and runoff from the facility. To protect the downstream Unnamed Watercourse 1 and Dixie Creek from construction impacts (i.e., suspended solids) standard measures and best management practices will be implemented as per Section 7. Efforts to relocate fish from the overprinted waterbodies will be made prior to infilling. No blasting is currently expected at the TMF location other than for the potential quarry locations. If other blasting is required during construction, measures will be taken to comply with federal blasting guidelines (Wright and Hopky 1998; Cott and Hanna 2005) and as per Section 7.

Table 5-1: Largest Annual Percent Change in Flow – Average Climate Conditions

Watercourse	UN-1	UN-2	UN-3	UN-4	UN-5	GEN-1
	Unnamed Watercourse 1	Unnamed Watercourse 6A	Unnamed Waterbody 6 Outlet	Unnamed Watercourse 8B	Unnamed Watercourse 11	Genessee Lake Outlet
Construction	-71.1%	-20.4%	4.9%	11.1%	-0.2%	-0.1%
Operations	-85.5%	-56.7%	-2.8%	11.4%	0.4%	-0.1%
Closure	-89.4%	-52.9%	-1.9%	9.5%	0.3%	0.2%
Post-Closure	5.7%	2.8%	9.4%	23.7%	0.4%	0.2%

Watercourse	DIX-1	DIX-2	DIX-3	DIX-4	DIX-5	CHK-1	CHK-2	PAK-OUT
	Dixie Creek	Dixie Creek	Dixie Creek	Dixie Creek	Dixie Creek	Chukuni River	Chukuni River	Pakwash Lake Outlet
Construction	-0.1%	-3.5%	-6.0	-3.9%	-3.4%	-0.1%	-0.2%	-0.1%
Operations	-0.1%	-4.9%	-10.3	-7.0%	-6.6%	0.8%	0.3%	0.2%
Closure	-0.2%	-4.7%	-10.1	-6.7%	-6.3%	-1.4%	-1.7%	-1.1%
Post-Closure	-0.2%	-0.5%	-0.4	-0.2%	-0.2%	0.0%	0.0%	-0.2%

Notes:
The change in flows presented are from a single year, selected within each Project phase, which produced the most substantial change in flow within the phase. The selected year will vary between nodes, and climate condition.
Grey shading indicates modelled flow reductions greater that 10% of natural flows.
Blue shading indicates modelled flow increases greater that 10% of natural flows.



LEGEND

- PROPERTY BOUNDARY
- DOMAIN OF CONCEPTUAL HYDROLOGICAL MODEL
- GREAT BEAR PROJECT FOOTPRINT
- SIMULATED DRAWDOWN CONTOURS
- HIGHWAY
- LOCAL ROAD
- EXISTING TRANSMISSION LINE
- WATERCOURSE
- WATERBODY

0 1 2 4

1:70,000 KILOMETRES

NOTE(S)

1. ALL LOCATIONS ARE APPROXIMATE

REFERENCE(S)

1. CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENCE - ONTARIO
2. AERIAL IMAGERY PROVIDED BY GREAT BEAR RESOURCES (SCENE DATE: SEPTEMBER 2022).
3. PROPERTY BOUNDARY PROVIDED BY GREAT BEAR RESOURCES, AUGUST 2024.
4. ROADS INFORMATION PROVIDED BY GREAT BEAR RESOURCES, AUGUST 2022.
5. SITE PLAN BASED ON INFORMATION PROVIDED BY GREAT BEAR RESOURCES, DECEMBER 2024 / JUNE 2025.
6. COORDINATE SYSTEM: NAD 1983 UTM ZONE 15N

CLIENT
GREAT BEAR RESOURCES

PROJECT
GREAT BEAR PROJECT

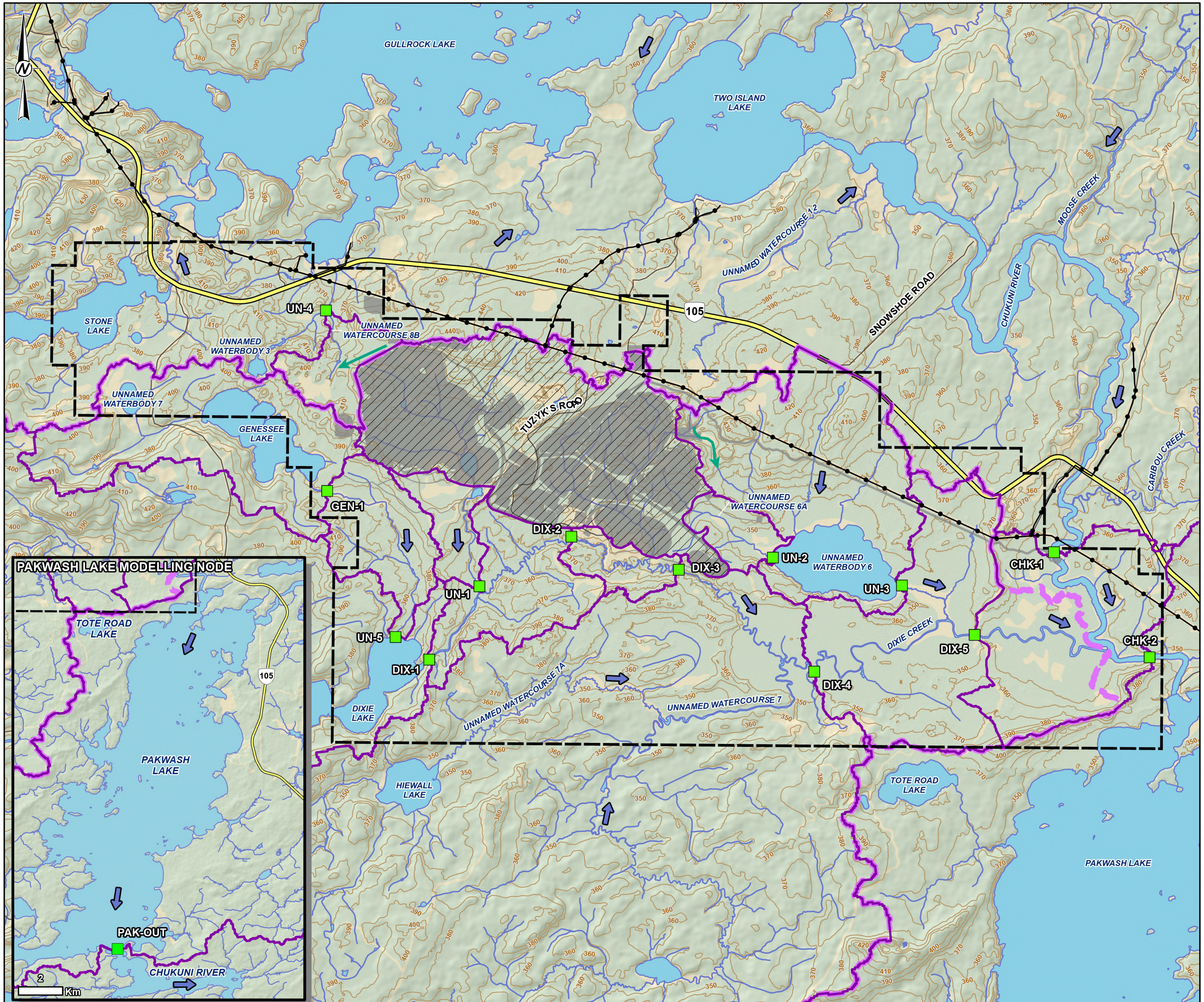
TITLE
SIMULATED DRAWDOWN CONTOURS IN GLACIAL TILL/ SHALLOW BEDROCK (SCENARIO 2)

CONSULTANT

wsp

YYYY-MM-DD	2025-12-04
DESIGNED	----
PREPARED	MD
REVIEWED	----
APPROVED	----

PROJECT NO.	CONTROL	REV.	FIGURE
CA0031271	0001	A	5-1



LEGEND

- PROPERTY BOUNDARY
- GREAT BEAR PROJECT FOOTPRINT
- CLEAN WATER DIVERSION
- HYDROLOGY MODELLING NODE
- DIXIE CREEK WATERSHED
- MODELLING NODE WATERSHED
- PROJECT WATERSHED
- HIGHWAY
- LOCAL ROAD
- EXISTING TRANSMISSION LINE
- CONTOURS (10 M INTERVAL)
- WATERCOURSE
- WATERBODY
- FLOW DIRECTION

NODE WATERSHED AREAS
(NATURAL WATERSHED AREAS, EXCLUDING THE PROJECT FOOTPRINT)

NODE ID	INCREMENTAL (KM^2)	CUMULATIVE (KM^2)
CHK-1	4413.4	4415.6
CHK-2	10.6	4767.7
DIX-1	171.4	186.8
DIX-2	5.3	194.0
DIX-3	1.7	195.7
DIX-4	118.9	314.6
DIX-5	11.6	341.5
GEN-1	11.1	11.1
PAK-OUT	3261.4	8029.1
UN-1	2.0	2.0
UN-2	1.6	1.6
UN-3	13.7	15.3
UN-4	2.2	2.2
UN-5	4.3	15.4

0 1 2 4
1:72,000 KILOMETRES

NOTE(S)
1. ALL LOCATIONS ARE APPROXIMATE

REFERENCE(S)
1. CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENCE - ONTARIO
2. PROPERTY BOUNDARY PROVIDED BY GREAT BEAR RESOURCES, AUGUST 2024.
3. CONTOURS ACQUIRED FROM LAND INFORMATION ONTARIO (MNRF), 2022 AND DERIVED FROM 2022 LIDAR PROVIDED BY GREAT BEAR RESOURCES.
4. SITE PLAN BASED ON INFORMATION PROVIDED BY GREAT BEAR RESOURCES, DECEMBER 2024 / JUNE 2025.
5. COORDINATE SYSTEM: NAD 1983 UTM ZONE 15N

CLIENT
GREAT BEAR RESOURCES

PROJECT
GREAT BEAR PROJECT

TITLE
OPERATIONS / CLOSURE MODELLING NODE WATERSHEDS

CONSULTANT

YYYY-MM-DD	2025-12-04
DESIGNED	----
PREPARED	MD
REVIEWED	----
APPROVED	----

PROJECT NO.	CONTROL	REV.	FIGURE
CA0031271	0001	A	5-2

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

Despite avoidance and mitigation measures, residual effects to fish habitat will occur. The residual effects to fish and fish habitat associated with the proposed Project are quantified below based on the proposed works, undertakings, and activities (Section 5). The residual effects have been summarized in three tables:

- Waterbodies requiring listing on Schedule 2 of the MDMER are provided in Table 6-1
- Waterbodies predicted to be affected resulting in HADD to fish and fish habitat and requiring Authorization 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 are shown in Figure 3-1 and coordinates provided in Table 3-1 and Table 3-2.

Most predicted residual effects are caused from direct overprinting (i.e., infilling or excavation) of waterbodies. Additional impacts have been predicted from changes in groundwater and surface flows resulting in alterations to small unnamed creeks or waterbodies. 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 greater than 10% to 15% to watercourses, this draft Plan makes the conservative assumption that 100% of the habitats are altered and considered HADD although the channels are expected to retain areas of functional fish habitat. This approach will enable consideration of a worst-case scenario, while additional mitigation measures and design options are considered in the Impact Statement.

Several waterbodies considered as impacted in this draft Plan, were initially classified as not fish frequented or occupied, as fish were not observed during field studies, and conditions were consider liming to fish. In response to comments received from DFO on an earlier draft of this Plan, that there was insufficient baseline data provided to support this classification, these locations have been reclassified as potentially fish frequented in Appendix L2, and considered fish frequented in this updated Plan as a precaution. As such, all waterbodies impacted by the Project were evaluated as fish frequented and included for Authorization under Paragraphs 34 and 35 of the Fisheries Act or for Schedule 2 designation under the MDMER.

The current combined residual HADD and impacts to waterbodies frequented by fish associated with the Project requiring offsetting or compensation has been calculated as 21.74 ha, the majority of which is comprised of the overprinting of Unnamed Waterbody 1 (10.44 ha) and associated tributaries. If an impact segment was categorized as a loss in one section of a watercourse, as a conservative measure the entire watercourse was classified as a loss within the impact tables (i.e., Tables 6-1 to 6-3) and within the Offset Area Accounting and Balance Summary (Table 9-1).

A HEP modeling exercise was completed to qualify and quantify the amount of usable fish habitat that will be impacted and offset by the Project. A HEP type of approach (U.S. FWS 1980, 1981) was used as an accounting system to document habitat quality and quantity and uses a standard peer reviewed method that has been a previously accepted method by regulating agencies to determine changes in habitat suitability to evaluate the loss and gain calculations of riverine and lacustrine habitats (Golder 2005; CIRNAC 2023).

Following the receipt of comments from DFO on the second draft of this Plan, considerable changes were made to the HEP model to account for DFO feedback, including assumptions to account for uncertainty in the baseline conditions and the application of lowered habitat cofactors for offsetting conditions to also account for post condition uncertainty. The model was also updated to include all Project area fish, not just target fish in the calculations, and the analyses were revised to be per waterbody and not by habitat type groupings. Comments also suggested that a single metric of impact and offset (area-based or HEP Habitat Unit) should be identified for use when comparing the amount of habitat impacted to the amount of habitat offset. Given the extensive revisions to the HEP model that is yet to be further reviewed by DFO, the more certain area-based units (ha) was selected as the primary metric for comparing the ratio of impacts to offsets and compensation. The full HEP model and analyses in Appendix A provide an additional and supplemental method to support the conclusions of the habitat accounting balance (Section 9).

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

Impact Segment ID	Watercourse / Waterbody Name	Mine Feature	Habitat Type	Flow Status	Length (m)	Wetted Width (m)	Predicted Schedule 2 Surface Area (ha)
IS-1	Unnamed Watercourse 1A	TMF	D	EP	1,155.4	2.1	0.24
IS-3	Unnamed Watercourse 1A	TMF Pond	D	EP	426.5	2.1	0.09
IS-5	Unnamed Watercourse 1B	TMF	D	EP	1,038.1	1.2	0.12
IS-6	Unnamed Waterbody 4	TMF	A	INT	-	-	1.21
IS-7	Unnamed Watercourse 1B	TMF	A	INT	-	-	0.19
IS-8	Unnamed Watercourse 1B	TMF	A	INT	-	-	0.07
IS-9	Unnamed Watercourse 1B	TMF	D	EP	1,044.7	1.2	0.13
IS-11	Unnamed Watercourse 1B	TMF	D	EP	526.0	1.2	0.06
IS-12	Unnamed Watercourse 1B-02	TMF	D	EP	449.9	1.2	0.05
IS-13	Unnamed Watercourse 1B-01	TMF	D	EP	827.2	1.2	0.10
IS-15	Unnamed Watercourse 1B-03	TMF	A	EP	-	-	0.09
IS-16	Unnamed Watercourse 1B-03	TMF	D	EP	215.4	1.2	0.03
IS-17	Unnamed Watercourse 1B-03	TMF	A	EP	-	-	0.04
IS-18	Unnamed Watercourse 1B-03	TMF	D	EP	207.1	1.2	0.02
IS-19	Unnamed Watercourse 1B-03	TMF	A	EP	-	-	0.04
IS-21	Unnamed Watercourse 1B-04	OVB3	D	EP	241.4	2.1	0.05
IS-23	Unnamed Watercourse 1B-04	TMF	D	EP	154.9	2.1	0.03
IS-24	Unnamed Watercourse 1B-05	TMF	D	EP	399.7	1.2	0.05
IS-25	Unnamed Waterbody 1	TMF	A	INT	-	-	10.44
IS-29	Unnamed Watercourse 3	MWP	D	P	593.0	1.8	0.11
IS-31	Unnamed Watercourse 3	OVB2	F	P	767.3	1.8	0.14
IS-32	Unnamed Watercourse 3	LGO	A	P	-	-	0.26
IS-33	Unnamed Watercourse 3	CWP	G	P	111.6	1.8	0.02
IS-36	Unnamed Watercourse 3A	MRS	E	INT	1410.8	1.4	0.20
IS-42	Unnamed Watercourse 3B	CWP	D	INT	130.3	2.2	0.03
IS-43	Unnamed Watercourse 3B	MRS	A	INT	-	-	0.14

Impact Segment ID	Watercourse / Waterbody Name	Mine Feature	Habitat Type	Flow Status	Length (m)	Wetted Width (m)	Predicted Schedule 2 Surface Area (ha)
IS-44	Unnamed Watercourse 3B	MRS	E	INT	919.6	2.2	0.20
IS-48	Unnamed Watercourse 3B-03	MRS	D	INT	1399.1	2.2	0.31
IS-49	Unnamed Watercourse 3B-04	MRS	D	INT	295.2	2.2	0.06
IS-50	Unnamed Watercourse 3B-05	MRS	D	EP	460.4	2.2	0.10
IS-51	Unnamed Watercourse 3C	LGO1	D	EP	551.0	1.2	0.07
IS-52	Unnamed Watercourse 3D	MRS	D	EP	300.6	2.5	0.08
IS-55	Unnamed Watercourse 3F	MRS	F	INT	595.3	1.2	0.07
IS-57	Unnamed Watercourse 3F	LGO2	F	INT	296.3	1.2	0.04
IS-58	Unnamed Watercourse 6A	OVB1	F	EP	917.0	1.4	0.13
Schedule 2 Total			-	-	**15,433.8**	-	**15.01**

Notes:
- : is not applicable
TMF: tailings management facility; LGO: low grade ore stockpile; OVB: overburden stockpile; MRS: mine rock stockpile;
MWP: mine water pond, CWP: collection water pond.
Schedule 2 waterbodies are those expected to require listing on Schedule 2 of the MDMER. Anticipated impacts summarized in this table of the draft Plan are subject to change with additional regulatory discussions / consultation.
P: permanent flow; INT: intermittent flow; EP: ephemeral flow.
Habitat Types A, B, C: lentic (lake / pond), Habitat types D, E, F, G, H, I: lotic (stream / river).
All Schedule 2 impacts from mine features were considered direct impacts to fish and fish habitat.

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

Impact Segment ID	Watercourse / Waterbody	Mine Feature	Habitat Type	Flow Status	Length (m)	Bankfull Width (m)	Predicted HADD Surface Area (ha)
IS-39	Unnamed Watercourse 3B	EP	E	INT	385.3	2.2	0.08
IS-40	Unnamed Watercourse 3B	EP	A	INT	-	-	0.21
IS-41	Unnamed Watercourse 3B	EP Dam	E	INT	86.3	2.2	0.02
IS-46	Unnamed Watercourse 3B-01	EP	E	INT	48.5	2.2	0.01
IS-47	Unnamed Watercourse 3B-02	EP	E	INT	342.8	2.2	0.08
IS-2	Unnamed Watercourse 1A	TMF Dam	D	EP	242.3	2.1	0.05
IS-4	Unnamed Watercourse 1B	TMF Dam	D	EP	107.5	2.1	0.02
IS-10	Unnamed Watercourse 1B	TMF Dam	D	EP	141.1	2.1	0.03
IS-14	Unnamed Watercourse 1B-03	Support Infrastructure	D	EP	1289.1	2.1	0.27
IS-20	Unnamed Watercourse 1B-03	TMF Dam	D	EP	275.2	2.1	0.06
IS-22	Unnamed Watercourse 1B-04	Support Infrastructure and TMF Dam	D	EP	133.5	2.1	0.03
IS-26	Unnamed Watercourse 1	MWP Dam	F	P	207.2	3.0	0.06
IS-30	Unnamed Watercourse 3	Support Infrastructure	H	P	124.6	1.8	0.02
IS-34	Unnamed Watercourse 3	Open Pit / CWP Dam	H	P	1,922.1	1.8	0.35
IS-37	Unnamed Watercourse 3A	Support Infrastructure	E	INT	284.4	1.4	0.04
IS-38	Unnamed Watercourse 3A	Support Infrastructure / Open Pit	E	INT	594.0	1.4	0.08
IS-45	Unnamed Watercourse 3B	Support Infrastructure / Open Pit	E	INT	864.5	2.2	0.19
IS-53	Unnamed Watercourse 3D	Support Infrastructure / Open Pit	D	EP	553.0	2.2	0.12
IS-54	Unnamed Watercourse 3E	Open Pit	D	EP	323.5	2.2	0.07
IS-56	Unnamed Watercourse 3F	Support Infrastructure	F	INT	188.5	1.2	0.02
IS-59	Unnamed Watercourse 6A	Support Infrastructure	D	EP	329.1	1.2	0.04
IS-61	Unnamed Watercourse 6A-1	Flow Reduction and Support Infrastructure	D	EP	578.5	1.2	0.07
IS-62	Unnamed Watercourse 6A-1	Flow Reduction	D	EP	545.7	1.2	0.07

Impact Segment ID	Watercourse / Waterbody	Mine Feature	Habitat Type	Flow Status	Length (m)	Bankfull Width (m)	Predicted HADD Surface Area (ha)
IS-63	Unnamed Watercourse 6A-2	Flow Reduction and Support Infrastructure	D	EP	1,026.9	1.2	0.12
IS-27	Unnamed Waterbody 2	Flow Reduction	B	P	-	-	2.76
IS-28	Unnamed Watercourse 1	Flow Reduction	F	P	2,297.1	3.0	0.69
IS-35	Unnamed Watercourse 3	Flow Reduction	H	P	86.0	1.8	0.02
IS-60	Unnamed Watercourse 6A	Flow Reduction	D	EP	1,730.1	1.2	0.21
IS-64	Unnamed Watercourse 6B-02	Flow Increase	F	INT	1,165.2	1.2	0.14
IS-65	Unnamed Watercourse 6B-01	Flow Increase	E	INT	923.6	2.2	0.20
IS-66	Unnamed Watercourse 6B	Flow Increase	E	INT	342.5	2.2	0.08
IS-67	Unnamed Watercourse 8B	Flow Increase	F	INT	339.8	2.2	0.07
IS-68	Unnamed Watercourse 8B	Flow Increase	A	INT	-	-	0.21
IS-69	Unnamed Watercourse 8B	Flow Increase	F	INT	1,092.0	2.2	0.24
Section 35 Total					**18,569.9**	**-**	**6.73**

Notes:
- : is not applicable
TMF: tailings management facility; EP: East Pond; MWP: mine water pond; CWP: collection water pond
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*. Anticipated impacts summarized in this table of the draft Plan are subject to change with additional regulatory discussions / consultation.
P: permanent flow; INT: intermittent flow; EP: ephemeral flow.
Habitat Types A, B, C: lentic (lake / pond); Habitat types D, E, F, G, H, I: lotic (stream / river).
All impacts from mine features were considered direct impacts to fish and fish habitat, whereas flow reductions/increases were considered as indirect impacts.

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

Effect Type	Predicted Schedule 2 and HADD Surface Area (ha)
Schedule 2 Total	15.01
Section 35 Total	6.73
Combined Schedule 2 and Section 35 Total	**21.74**

Note:
Anticipated impacts summarized in this table of the draft Plan are subject to change with additional regulatory discussions / consultation.

7 MEASURES AND STANDARDS TO AVOID OR MITIGATE DEATH OF FISH OR HADD TO FISH HABITAT DURING PLAN IMPLEMENTATION

7.1 MEASURES, STANDARDS, AND CONTINGENCIES

A combination of site-specific mitigation measures as defined in permits, approvals or Impact Statement commitments will be used to avoid or mitigate additional HADD to fish habitat during implementation of the plan, along with best management practices and DFO *Codes of Practice* 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
- Fish relocation.

These measures are to be implemented for construction of the Project facilities and during the implementation of offset and compensation measures. The offset and compensation measures will be implemented concurrently with major Project development. This approach will allow for the initial development and stabilization of the works to be achieved, and benefits from the measures to be realized by adjacent fish communities at the same time that fisheries impacts occur from the Project.

A list of typical measures, standards, codes and contingency measures that may be implemented during the Project to avoid or mitigate effects 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 Plan, as appropriate.

7.2 MONITORING AND REPORTING OF AVOIDANCE AND MITIGATION MEASURES

Project environmental monitors (or designates) will monitor construction and implementation of this plan 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.

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:

- A photographic record using consistent vantage points, and inspection reports will be kept to document measures and standards employed, and their observed effectiveness to limit HADD
- Regular environmental monitoring inspections will be made of inwater activities during construction to confirm mitigation measures such as water management and erosion and sedimentation controls are in place, functional and maintained appropriately

- A record of all fish removal efforts carried out with 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 this plan 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 reflect both coolwater and coldwater fish communities and species sensitivities. Consistent with measures to protect fish and fish habitat, the timing of inwater works should avoid restricted periods to protect fish, including their eggs, juveniles, spawning adults and / or the organisms upon which they feed (DFO 2013b).

Inwater works are to be avoided during the timing constraints of any given year as 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 2013b). 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.

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 supply 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: 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: Inwater 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.
Observe timing restrictions for inwater work.	No inwater work during restricted activity period.	Exemption from timing period may be requested from MNR and copied to DFO.
Minimize duration of inwater work to the extent practicable.	Work continues in continuous and efficient manner to completion.	Monitor contractor's effort and implement additional site planning as needed. Materials are to be available to complete the construction continuously as needed.
Develop a blasting plan so that the use of explosives near water does not result in harm to fish per PoE guidance.	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.
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.
Undertake inwater activities in isolation of open or flowing water to avoid introducing sediment into the watercourse. Follow DFO Interim standard: Inwater site isolation.	Work areas are effectively isolated from open or flowing water. Follow DFO Code of Practice or other equivalent review and assessment.	Stop works that are not isolated from open or flowing water. Isolate work area, remove fish from work area before continuing works. Maintain a sufficient supply of pumps and materials on site to isolate flows.
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.
Remove fish from areas where waterbodies are to be abandoned or isolated from the active creek channel 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 if necessary.

Measure or Standard	Success Criteria	Contingency
Screen or use other deterrents at any pump intakes to prevent entrainment or impingement of fish as per DFO Interim code of practice: End-of-pipe fish.	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.
Machinery to arrive 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.

Note:
It is anticipated that no harm or death of fish will occur during construction and operations activities with the proper implementation of the mitigations and standards applied. Fish rescue(s) will be conducted in the isolated work areas prior to construction and water draw down to reduce the risk of mortality. All inwater work will abide by the Ontario Restricted Activity Timing Windows for the Protection of Fish and Fish Habitat and avoid times of sensitive life history events for the fish species present (DFO 2013b). All pump screens will be screened according to DFO’s Interim code of practice: end-of-pipe fish protection screens for small water intakes in freshwater to prevent impingement and entrapment (DFO 2024). A detailed fish relocation plan will be developed for the Project, through collaboration with the MNR and provided to DFO for review and comment. A MNR License to Collect Fish for Scientific Purposes will be obtained to facilitate the fish rescue and relocation program. The MNR Licence to Collect Fish for Scientific Purposes application will include details on fish relocation methods, suggested release waterbodies and threshold as per the permitting application requirements. Additionally, release locations will be chosen based on reducing transport time and access. The rescue / relocation program will be completed by qualified professionals, following applicable animal safety protocols and licence conditions. Any fish captured will be released alive immediately outside of the work area. Scare tactics such as completing initial electrofishing sweeps and seine netting will be used to move fish and aquatic organisms out of the isolation area prior to isolation. Efforts will be made to minimize handling stress, through the application of the appropriate animal care protocols and DFO Species at Risk handling protocol (Portt et al. 2008) will be used for the capture, handling and release of SAR fish. Fish will be monitored for signs of stress, fish health characteristics will be recorded, monitoring of water temperatures and turbidity / total suspended solids will be completed.

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

8.1 DESCRIPTION OF OFFSETTING AND COMPENSATION MEASURES

Despite the avoidance and mitigation measures proposed as part of the Project (Section 5 and Section 7), there will be a loss of fish habitat (Section 6). 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 recognize that there are limited opportunities for fish habitat restoration in the Project Area.

This section of the Plan describes the currently proposed candidate offset and compensation measures considered for the Project and the selected measures to be implemented as part of the Project.

Recognizing that this Plan will undergo review and consultation during the Impact Assessment process, it is expected that proposed measures may be modified, expanded upon, substituted, or removed on an individual basis to reflect the comments received from Indigenous communities, the public and regulators.

8.1.1 CANDIDATE OFFSETTING AND COMPENSATION MEASURES PROPOSED

Engagement with provincial regulators (MNR) as well as fish habitat offset and compensation workshops with Indigenous communities (Lac Seul First Nation and Wabauskang First Nation) were used to develop a number of candidate measure for consideration. A ranking matrix was developed to assess the candidate measures by criteria such as design and construction simplicity / certainty, operational and ecological relevance and stakeholder interest (Table 8-1). The candidate measures were then ordered by their cumulative rank scores in Table 8-2 to determine the selected measures for implementation. Candidate measures considered in order of their final cumulative scores are as follows:

- Complimentary Measures-Fisheries Management Plan for Wabauskang Lake (score 58): Wabauskang First Nation has raised concerns regarding the fate of the Walleye population in Wabauskang Lake (i.e., 50.427N, -93.239 W) and the ability to maintain a productive population of naturally reproducing Walleye. The suggested complimentary measure would use scientific studies to compliment MNRs Broadscale Monitoring Program such as hydroacoustic surveys, isotope analysis and telemetry to determine the existing populations abundance and diversity using less lethal techniques. The results from these monitoring programs would then feed into the development of a Fisheries Management Plan (which may contain management strategies such as slot allotment and catch limits) with potential to gain regulatory approvals. The measure has been proposed as a 2 ha credit towards offsetting in this updated draft of the Plan, which is approximately 10% of the predicted impacts and offsets. This amount may be adjusted through discussion with Wabauskang First Nation and DFO.
- Fisheries East Pond (score = 55): Develop a diversion dam and an approximately 12 ha fish habitat pond (i.e, 50.872835 N, -93.595335W) at the upper reach of Unnamed Watercourse 3B to collect non-contact water upstream of the proposed mine and direct it to Unnamed Waterbody 6 through existing Unnamed Watercourse 6B. Excavation of additional pond area can increase the usable fish habitat area by an additional 3 to 7 ha. The ponds may be contoured to support the growth of Wild Rice if requested during consultation and appropriate.

- Dixie Creek Pond Complex (score = 53): Develop a pond habitat adjacent to Dixie Creek within the extensive floodplain area with connections to the main creek (i.e., 50.841334N, -93.505018W). Ponds would be contoured to provide small body and large body fish habitat with excavated material used to diversify the adjacent floodplain. The ponds can be contoured to support the growth of Wild Rice if consultation determines this to be of interest and conditions are supportive. The area and topography allows for expansion of this measure if additional habitat area is needed to offset potential impacts.
- Red Lake – Lake Trout Restoration Support (score = 49): Lake Trout populations within Red Lake (i.e., 51.096N, -93.866W) have shown a failure to reproduce for an extended period of time. MNR has been supplementing the population with hatchery reared fish in attempts to maintain the population. This offset measure would include supporting the stocking program through funding, completing habitat studies and where appropriate adding habitat enhancements.
- Territorial Waters Restoration Hatchery (score 48): This measure would involve the construction and operation of a hatchery facility in the Project area designed and operated jointly by Indigenous communities in cooperation with the MNR. The hatchery would have a mandate to produce fish in a responsible and sustainable manner with emphasis on restoring fish populations in the traditional lands of the participating communities.
- Road Crossings (score 46): Road crossings are common occurrences in northern Ontario, and it is common that historic crossings become blocked or otherwise compromised leading to localized watercourse channel failures. These crossings can be replaced or removed and the channel repaired as an offset measure. Although only one potential culvert location (Silver Dollar Road) has been identified to date, this measure remains a candidate option to pursue in the area with additional local engagement.
- Bruce Lake Basin Reconnection (score 29): Reconnect South and North Basins of Bruce Lake (i.e., 50.823N, -39.319W). Construct a 20 m wide connection channel between the North and South basins to restore connectivity within the lake.
- Invasive Species Management (score 22): Black Crappy have been introduced into waters near the Wabauskang First Nation reserve and concern has been raised of the potential for them to spread into other lakes. Double Crested Cormorant have expanded their range into local waters and are viewed as having an impact on local fisheries. The candidate measure would review and consider methods to remove or suppress the expansion of these species

Based on the ranking matrix, the top scoring measures (1. Fisheries East Pond and 2. Dixie Creek Pond Complex above) have been selected to be caried forward as measure to implement in this draft Plan. The remaining measures will be retained for further consideration and as contingency offsetting measures if needed. Further engagement and consultation may result in modifications to the selected measures.

8.1.2 SELECTED OFFSETTING AND COMPENSATION MEASURES TO BE IMPLEMENTED

The selected fish habitat offset and compensation strategy for the estimated 21.74 ha of impacted fish habitat (Section 6) is focused on replacing lost fish habitat within the Dixie Creek watershed. The habitat will be in kind replacement for the waterbodies affected by the Project. Pond habitat which represents over 71% of the impacted habitat can be readily developed, although the amount of watercourse habitat that can be developed is limited. The offsetting and compensation components of the proposed Plan are shown in Figure 8-2 and described below:

- Construct East Dam and East Pond at the upper reaches of Unnamed Watercourse 3b with an aerial expression of approximately 12.3 ha
- Excavate additional pond area to connect the East Pond and the East Channel, having a surface expression of approximately 3.6 ha (with flexibility for expansion if needed)
- Construct East Channel measuring approximately 200 m in length and an aerial expression of approximately 0.04 ha

- Reconstruct approximately 1.3 km of Unnamed Watercourse 6b2 to its confluence with Unnamed Waterbody 6b1 , having an approximate surface expression of 0.33 ha
- Excavate a new pond complex within the Dixie Creek floodplain with a combined surface expression of approximately 7 ha (with flexibility for expansion if needed)
- Fisheries research in Wabauskang Lake to determine the state of the Walleye population and future development of a Fisheries Management Plan. This complimentary measure is assumed to equivalently account for approximately 2 ha of habitat offsetting (note the assumed 2 ha equivalent area may be adjusted through discussion with Wabauskang First Nation and DFO).

The majority of the affected habitat consists of small lakes and ponds such as Unnamed Waterbody 1 (10.44 ha), Unnamed Waterbody 2 (2.76 ha) and Unnamed Waterbody 4 (1.21 ha) which make up over 71% of the fish habitat areas affected. Accordingly, most of the replacement habitat is largely lake and pond habitat as well (98%) with the amount of watercourse length constructed being limited by topography.

It is assumed that in order to populate fish within the constructed offsetting and compensation components, that fish will be transferred from fish rescue locations, or from donor sites to the newly developed offsetting locations to build initial populations within the Dixie Creek Ponds and the East Pond. This may initially include hardy forage and bait fish species and may require a time delay prior to the introduction of predatory species (e.g., Northern Pike) to allow populations to develop. Species would be selected based on their habitat preferences for the designed habitat types.

8.1.2.1 EAST POND

The East Dam will be a low permeability structure with a normal operating water level of 389 metres above sea level (masl). The piezometric (hydraulic) head pressure of the East Pond will facilitate downstream pressure such that contact water from MRS will not seep into the fish habitat complex. A shoreline habitat matrix of soil rock and logs will be placed along the toe of the dam. The rock (cobble shoal) component of the matrix will extend out into water depths ranging from greater than 5 m to less than 1 m. A vegetated soil component will be placed in water depth less than 3 m to facilitate macrophyte colonization.

The East Pond (Figure 8-2) will have a surface area of approximately 12.26 ha and water depth ranging from greater than 5 m to surface. The areas and percent distribution of depths and general characteristics of the habitat are provided in Table 8-3.

The pond will be located on and divert the upper reach of Unnamed Watercourse 3b, which currently supports Brook Stickleback and Central Mudminnow. The low species richness reflects the small channel, variable flow and limited depth associated with the headwater channels where only resilient species reside. The new East Pond is expected to have the capacity to support more species than the existing channel, consistent with the receiving drainage of Unnamed Waterbody 6. The diversion is proposed to be developed early in the Project construction phase, so that the pond may be used as a release point for the fish removal efforts, dependant on the overall construction schedule and approvals obtained. If needed, the pond will be initially populated with small bodied fish from nearby waterbodies. Additional species including fathead minnow, shiners (spp.), Northen Pike and Yellow Perch will be introduced to the new pond area consistent with species present in the downstream Unnamed Waterbody 6.

8.1.2.2 EXCAVATED EAST POND AREA

The low relief area immediately east of the impounded diversion pond will be excavated to provide additional pond habitat as part of the fish habitat diversion complex. The designed area will be approximately 3.58 ha in size and range in water depth to up to less than 3 m as shown in Figure 8-2 and summarized in Table 8-2, although the topography of this area allows for flexibility to enlarge the pond if additional area is needed. The perimeter of the area will be enhanced with anchored trees and aquatic vegetation for cover, and coarse wood piles, and boulder piles will provide fish habitat in the central portion of the excavation over approximately 15% of the area. This hard structure habitat will be supplemented with the establishment of aquatic vegetation.

8.1.2.3 EAST CHANNEL AND UNNAMED WATERCOURSE 6B

A diversion channel (i.e., East Channel) will be constructed to connect flows from the East Pond and excavated area to the uppermost reaches of existing Unnamed Watercourse 6b2. The connection will result in an additional 1.3 km^2 (130 ha) of drainage area to the natural watershed of Unnamed Watercourse 6b and the downstream areas.

A geomorphological investigation has been completed to determine if the existing Unnamed Watercourse 6b channel has sufficient capacity to attenuate and convey the increased drainage (Appendix B). The upper portions of the existing channel were determined to not have capacity to receive the additional flow without erosion of the channel. As such the Unnamed Watercourse 6B-02 channel will be reconstructed over a length of approximately 1.3 km until the confluence with main stem of Unnamed Watercourse 6B. Further downstream the channel is expected to be able to accommodate the additional flows. The additional watershed area diverted to Unnamed Waterbody 6 is less than 10% and as such reconstruction of channels downstream of the waterbody is not necessary.

The detailed design for the East Channel and reconstructed Unnamed Watercourse 6b will be informed by:

- A detailed geotechnical survey to confirm ground conditions and risk of erosion
- A detailed topographical survey to confirm grades and elevations for fish passage
- A detailed design to confirm and design channel diagnostics reflective of the modeled flow.

The East Channel would provide an additional 0.37 ha of creek habitat as part of the East Pond fish habitat measure. As the channel is existing modifications to increase its capacity and fish usage may be considered a mitigation measure instead of offsetting through further discussion with DFO.

8.1.2.4 DIXIE CREEK POND COMPLEX

The selected offsetting and compensation measures also include the development of a new pond complex in the extensive floodplain area north of Dixie Creek approximately 2 km upstream from the Chukuni River (Figure 8-3). The existing floodplain area is uniformly flat and lacking habitat diversity and open water habitat for fish. This large area provides the ability to scale the size of the ponds to reflect the needs of the Project and input from reviewers. Likewise, the morphology of the ponds is intentionally conceptual at this time, to allow for meaningful input on the individual pond size, type of fish or vegetation the developed habitat should support. For example, engagement during fish habitat compensation workshops revealed that Wild Rice habitat could be an important consideration for offset habitat. Although less useful for many fish species, this habitat feature could be incorporated into the design of portions of the complex. Such a habitat type would be similar to the current conditions in Unnamed Waterbody 1, which accounts for nearly half of the total predicted impacts.

The success criteria for the Dixie Creek Pond Complex is currently thought to be comparable to Unnamed Waterbody 6, which although significantly larger than the proposed complex, will share similar habitat traits such as depth, substrates, cover features and connectivity to Dixie Creek. The Dixie Creek Pond Complex will be designed to replace the lake and pond waterbodies impacted by the Project and to support similar species assemblages.

The excavated material from the ponds will be used to contour the lands adjacent to the open water areas to promote a more diverse terrestrial vegetation community further diversifying the habitat associated with the complex.

8.1.3 HEP OFFSETTING AND COMPENSATION MEASURES RESULTS

The HEP results of the offsetting and compensation measures in usable habitat units are presented in Appendix A. The offset condition represents improved ecological conditions and are expected to provide a similar but greater area of available, suitable habitat for fish occupation (i.e., approximately 12 ha in habitat units). The quantity and quality of these habitats were considered in the development of the offsetting designs, which specifically considered the various life history requirements of the target fish species present. These offsetting measures meet DFO's Offsetting Policy (DFO 2025c) to provide similar to better habitats than those provided within the baseline conditions.

8.2 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 as per the approved plans and are functioning as intended using the criteria outlined in Table 8-6. 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 two types of monitoring reports.

- As-constructed report(s) intended to document that the measures have been constructed according to the plans (area, depths and number of structures), and that mitigation measures during construction (fish removal, erosion and sediment protection, watercourse isolation) have been implemented effectively
- Performance monitoring reports intended to assess the ecological success of the measures such as fish presence, fish abundance, use of constructed features, and fish passage.

Reports will be submitted to DFO according to an approved schedule. The as-constructed report(s) will be due within 12 months of completing the offsetting / compensation measures. Performance monitoring reports will be due on or before June 30 following each year of monitoring. The proposed schedule for performance monitoring is years 1, 2, 3, 5 and 10 post construction, or as otherwise determined with DFO. Voluntary monitoring may be conducted in non-scheduled years to provide early confirmation that measures have met respective success criteria.

If the results of the monitoring indicate that the measures are not completed on time and / or are not functioning according to the plan, written notice will be given to DFO and Environment and Climate Change Canada and contingency measures (Table 8-7) will be implemented and additional monitoring carried out if needed.

8.3 COST ESTIMATE AND LETTER OF CREDIT OR EQUIVALENT FINANCIAL GUARANTEE

As per SOR / 2019-286 Paragraph 2(1)(b) and MDMER Paragraph 27.3 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, in the event that the Proponent fails to implement the Plan or components of the Plan.

This draft Plan 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 final Plan with the final application documents, and prior to Schedule 2 listing, respectively.

Table 8-1: Description of Candidate Offsetting Measures Ranking Criteria

Candidate Offsetting / Compensation Measure	Concept Simplicity and Pre-design Information Needs	Monitoring Simplicity and Success Certainty	*Operational Relevance	Compatibility with Existing Land Use	Percent of Total Offset Amount Required	Construction Implementation and Required controls	Construction Certainty	Land Tenure Certainty	Relative Cost per Type of Offset Measure	Stakeholder Interest (Aligns with Interests of Stakeholders and Communities)	Cumulative Score (Highest is Most Preferred)
Description of measure, representing the type of benefit (i.e., channel diversion, new lake or pond basin, existing habitat enhancement or reclamation).	Simplicity ranking with 1 representing the most complex concepts and 6 being the simplest concepts with the greatest certainty. Lower rankings (complex concepts) will require more extensive field programming and engineering studies to obtain necessary pre-design information.	Monitoring success simplicity ranking, with 1 being the most complex and 6 being the simplest. Ranking reflects the expected effort required to establish certainty of project success through monitoring and uncertainty of demonstrating success.	Relevance to the development of the Project site or to future fisheries value. High relevance (e.g., 6) means the measure also benefit site infrastructure development (e.g., freshwater diversion, borrow areas). Low relevance means the measure does not benefit site infrastructure or may sterilize or impede future development. Higher relevance awarded to options that provide a potential for future fisheries research	Brief description of existing land use and proposed offsetting measure compatibility with this land use type. Proposed offset measure relevance to the existing land use, habitat type or fishery. High compatibility (e.g., 6) means the alternative is highly compatible with existing land use. Ranking is also provided for ecological relevance, to indicate the degree to which the measure supports ecological function of the habitat.	An assumption of the percent of the total area required to be compensated that the specific measure can provide. >100% = 6 80-100% = 5 60-79% = 4 40-59%= 3 20-39= 2 0-19 = 1	Level of controls and implementation required during construction to prevent additional environmental damage. Higher ranking (6) is awarded where fewer controls are needed with lower ranking (1) for complex controls with uncertainty.	Feasibility of constructing the specific offset alternative, including access to the offset location and terrain type. High ranking (6) means the constructability is highly certain with lower rankings (1) meaning very uncertain.	Certainty that Great Bear Resources will have / holds tenure of the lands proposed to be included in the specific offsetting alternative. High certainty (6) means the lands are under control of Great Bear Resources with low certainty (1) meaning the lands are held by other private entities.	Cost of the specific offset measure relative to other proposed alternatives within the matrix. High relative cost (e.g., 1) means the cost is higher than other alternatives.	How well the specific measure aligns with the interests of different stakeholder groups, provincial and federal management objectives, and communities. Higher values (6) are awarded to alternatives with high alignment. Lower values reflect poor alignment or high uncertainty.	Cumulative score of the specific offset alternative using the rank scale (1-6).

Note:
The criteria rankings reflect current knowledge at the time of assessment and can be modified with additional information.
Higher scores are preferred for all criteria. Scores correspond with the following rankings:
1 Poor
2 Moderate to Poor
3 Moderate
4 Moderate to Good
5 Good
6 Very Good
* Operational relevance means that the proposed offset measure may have a beneficial, symbiotic or complementary result to the Project, but does not infer that measures are a standard part of project design or are operational requirements in the Proponent's industry with respect to Principle 5 of the Policy for applying measures to offset harmful impacts to fish and fish habitat (DFO 2025c)

Table 8-2: Candidate Offsetting Measures and Rankings

Candidate Offsetting / Compensation Measure	Concept Simplicity and Pre-design Information Needs	Monitoring Simplicity and Success Certainty	Operational Relevance	Compatibility with Existing Land Use	Percent of Total Offset Amount Required About 20 ha	Construction Implementation and required controls	Construction Certainty	Land Tenure Certainty	Relative Cost per Type of Offset Measure	Stakeholder Interest	Cumulative Score
Complimentary Measures-Fisheries Management Plan for Wabauskang Lake The Wabauskang First Nation has raised concerns regarding the fate of the Walleye population in the lake and the ability to maintain a productive population of naturally reproducing Walleye. Complete research to compliment Broadscale Monitoring Programs such as hydroacoustic surveys, isotope analysis and telemetry to determine the existing populations abundance and diversity using less lethal techniques. The results from these monitoring programs would then feed into the development of a Fisheries Management Plan.	Very good (6) Existing populations can be monitored in conjunction with MNR's Broad Scale Monitoring Program and Hydroacoustic to better determine the existing abundance and state of the fishery and potential limitation to the fishery. Additive to existing MNR dataset on Lakes within the Management Zone.	Very good (6) Monitoring is easily completed by professionals and relies on standard sampling procedures. The studies could be conducted early on in the Project and prior to or during construction without impacting the Project.	Very good (6) Information gathered will reflect on Walleye and other valued fish populations within the traditional lands of Wabauskang First Nation.	Very good (6) Sampling areas include existing lake habitats. **Ecological Relevance** Very good (6) Fisheries management planning plays a key role in the management of recreational / sustenance fisheries, improves upon a limited dataset, determines areas for improvements to the fisheries, minimizes the risk of invasive species, aims to maintain ecosystem health and identifies restoration opportunities, improves public knowledge and awareness and determines risk from future effects such as climate change.	Moderate to good (4) Habitat credit will need to be negotiated with DFO but it is realistic to achieve a percentage of the habitats that are inhabited by Walleye. This could accumulate to a large area depending on the effort and lakes included in the measure.	Very good (6) No construction required. Physical field studies and office level reporting required by professional fisheries biologist.	Very good (6) No construction required. The use of standard sampling programs will achieve the necessary results to inform on the management plan development.	Very good (6) No land tenure required.	Very good (6) Costs of the studies are moderate in comparison to construction projects.	Very good (6) Communities provided the initial idea and support during fish habitat offset workshops with communities. DFO typically considers these types of studies as a complimentary measure and is an acceptable where there is a lack of information or data regarding fish and fish habitat and research would be pivotal in restoration efforts. Complementary measures my comprise up to 10% of the cost of all the offset measures (i.e., 2 ha is ~10 % of impacts area as a surrogate to cost).	58
East Pond and Channel Develop a diversion dam and ~12 ha pond at the upper reach of Unnamed Watercourse 3B to collect non-contact water upstream of the proposed mine and direct it to Unnamed Waterbody 6 through existing Unnamed Watercourse 6B. Excavation of additional pond area can increase the usable fish habitat area by an additional 3-7 ha. The ponds can be	Moderate (3) Development of the East Dam and East Pond is a common construction practice. Engineering studies are required to confirm stability of the pond and channel. The East Channel will require modification to the existing Unnamed Watercourse 6B to manage the increased volume of water.	Very Good (6) Monitoring is simple and relies on demonstrating that the new pond is supporting the predicted fish species at the expected relative abundance. The diversion would be completed early in the Project such that success monitoring would be completed during operations.	Good (5) The East Pond and channel will provide new fish habitat and will reduce non-contact water from entering the mine water management system. The diversion will also retain the drainage from upper Unnamed Watercourse 3B in the Dixie Creek Channel.	Good (5) The resulting diversion is consistent with other naturally occurring lakes and ponds in the area. The feature is permanent and can be integrated into closure and reclamation plan. **Ecological Relevance** Very Good (6) The measure will provide replacement pond / lake habitat in the vicinity of the mine. Some terrestrial / riparian habitats will be developed into open water. The measure will retain the flow from	Good (5) East Pond and excavations can approach or meet the necessary area of compensation (about 20 ha). 100 % of the new pond should be credited to the compensation.	Good (5) Construction of dams and excavated ponds is a common construction practice. Risks of new dam and channel construction is known, and engineering studies and controls can be used to reduce the potential for failures.	Good (5) Good access to site via site roads and planed infrastructure.	Very good (6) Areas are under control of Great Bear Resources.	Moderate to good (4) Most cost is associated with bulk excavation to remove organics and construction of the East Dam structure. The existing channel of Unnamed Watercourse 6B will need to be enlarged until the existing channel can accommodate the increased flow.	Good (5) Local community workshops did not identify specific support or concerns for the offset measure. Workshops did express support for measures that could promote Wild Rice. The measure replaces lost pond / lake habitat in the immediate Project location which is assumed to be a preferred measure by DFO.	55

Candidate Offsetting / Compensation Measure	Concept Simplicity and Pre-design Information Needs	Monitoring Simplicity and Success Certainty	Operational Relevance	Compatibility with Existing Land Use	Percent of Total Offset Amount Required About 20 ha	Construction Implementation and required controls	Construction Certainty	Land Tenure Certainty	Relative Cost per Type of Offset Measure	Stakeholder Interest	Cumulative Score
contoured to support the growth of Wild Rice.				Unnamed Watercourse 3B within the Dixie Creek Channel.							
Dixie Creek Pond Complex Develop pond habitat adjacent to Dixie Creek within the extensive floodplain area with connections to the main creek. Ponds would be contoured to provide small body and large body fish habitat with excavated material used to diversify the adjacent floodplain. The ponds can be contoured to support the growth of Wild Rice.	Very Good (6) Excavated pond development is a simple concept. Basic Fisheries and engineering values needed from reference ponds to replicate habitat. Most information is available or readily obtainable.	Good (5) Monitoring is simple and relies on comparison to baseline reference pond values. Relatively short duration of 3 to 5 years to demonstrate that constructed ponds have improved fish habitat.	Moderate (3) No linkage to Project other than candidate offset measure but is in close proximity to the site. Some potential for fisheries research.	Good (5) Occupies existing floodplain habitat but results in diversified habitat. **Ecological Relevance** Very Good (6) Adjacent ponds within the floodplain will increase habitat for fish and semi aquatic wildlife.	Good (5) The floodplain area is extensive and allows for this measure to be scalable to the Project needs. Assume 50% or more of the required offset area can be met by this option.	Good (5) Construction of excavated ponds is a common construction practice. Proposed location is in a depositional environment and expected to have low erosion potential. Some complexity exists to working in saturated soft material and may require timing measures such as frozen conditions.	Moderate to good (4) Good access to site via site roads and planed infrastructure. New pond construction is relatively predictable. Pond complex is in soft floodplain terrain and will require winter construction and or new construction access roads.	Very good (6) Areas are under control of Great Bear Resources.	Moderate (3) Cost per unit of area will be dependent on excavation cost. Excavated material assumed to be contoured on site to enhance floodplain area for other species and diversify the local footprint. Excavated material may be used for access within pond complex.	Moderate (5) Local community workshops did not identify specific support or concerns for the offset measure. Workshops did express support for measures that could promote Wild Rice. The measure replaces lost pond / lake habitat in the immediate Project location which is assumed to be a preferred measure by DFO.	53
Red Lake – Lake Trout Restoration Support Lake Trout populations within Red Lake have shown a failure to reproduce for an extended period of time. The Ministry of Natural Resources (MNR) has been supplementing the population with hatchery reared fish in attempts to maintain the population. This offset measure would include supporting the stocking program through funding, completing habitat studies and where appropriate adding habitat enhancements.	Moderate (3) The offset concept of stocking fish is relatively simple, but this measure has complexity associated with understanding why fish are not reproducing and what measures can be taken to increase or expedite natural reproduction. The restoration plan would need to be incrementally advanced in cooperation with MNR.	Moderate (3) Monitoring would need to evaluate existing conditions that may be affecting natural reproduction as well as annual or semi-annual studies to evaluate spawning activities and spawning success. The methods and techniques to evaluate reproduction are relatively well understood.	Moderate (3) No linkage to project other than candidate offset measure but is in the Regional Study Area. Red Lake is a popular and important fishing resource to the local communities and Lake Trout has been identified as a valued species.	Very good (6) Areas are existing lake habitats. **Ecological Relevance** Very Good (6) Restoring the naturally reproducing Lake Trout population would maintain a key species within the lake.	Moderate to good (4) Habitat credit will vary depending on how much support can be provided to the ongoing restoration effort (to be determined with MNR). Assume there is potential for the offset measure to account for a large portion of the required offset if made the preferred option.	Good (5) There is currently minimal construction associated with this measure other than the potential of adding habitat to localized sections of the lake.	Good (5) In water structures are simplistic designs with straight forward installation. Red Lake has good access for barges required to place in water structures if needed.	Moderate to good (4) Lakes are under provincial and federal jurisdiction. The stocking and or transfer of fish is also under provincial jurisdiction. Agreement and support from the provincial government would be required.	Good (5) Cost of habitat enhancement materials is relatively inexpensive but overall cost varies depending on accessibility. Stocking fish is typically inexpensive when produced by an existing MNR hatchery.	Good (5) Support is anticipated from recreational anglers and the measure was received as favorable during fish habitat offset workshops with communities. DFO does not typically consider stocking an acceptable offset measure unless it can be demonstrated that the stocking effort will result in a sustainable benefit.	49
Territorial Waters Restoration Hatchery This measure would involve the construction	Moderate (3) The construction of a hatchery is a relatively	Good (5) The care and rearing of fish is well understood and	Poor to Moderate (2) No linkage to Project other	Very good (6) Does not conflict with other land uses as hatchery will be	Very good (6) The undertaking to construct and operate a hatchery for the life of	Good (4) Construction of a hatchery facility will be largely land based with minimal risk to	Very Good (6) There is a high degree of certainty that a hatchery can	Very good (6) The location of the hatchery	Poor (1) The cost of the facility will be dependent on the	Moderate (3) Support is anticipated from recreational	48

Candidate Offsetting / Compensation Measure	Concept Simplicity and Pre-design Information Needs	Monitoring Simplicity and Success Certainty	Operational Relevance	Compatibility with Existing Land Use	Percent of Total Offset Amount Required About 20 ha	Construction Implementation and required controls	Construction Certainty	Land Tenure Certainty	Relative Cost per Type of Offset Measure	Stakeholder Interest	Cumulative Score
and operation of a hatchery facility in the Project area designed and operated jointly by Indigenous communities in cooperation with the MNR. The hatchery would have a mandate to produce fish in a responsible and sustainable manner with emphasis on restoring fish populations in the Indigenous traditional areas.	predictable activity; however considerable information and knowledge needs to be included in the responsible stocking of fish.	there is a high degree of certainty that fish can be produced and stocked. Monitoring of stocked waterbodies would involve standard methods of estimating fish populations.	than candidate offset measure.	developed in an area zoned appropriately. **Ecological Relevance** Very Good (6) Restoration stocking can be an important tool in fisheries management and may benefit existing waterbodies.	mine is a large commitment with the potential to restore numerous waterbodies. It is assumed that the resulting benefit will greatly exceed the potential impacts from the Project.	adjacent waters. Care will need to be taken during operations to determine responsible stocking targets and species to prevent upsetting natural fish populations.	be designed and constructed.	would be selected in cooperation with the Indigenous Nations and MNR to comply with applicable zoning and land uses.	design; however, the cost of this measure is expected to be high and may be cost prohibitive.	anglers. Fish habitat offset workshops in local communities showed support for this measure particularly with restoring species such as Lake Sturgeon, Lake Trout and Walleye. MNR and DFO are unlikely to support this measure unless it can be shown to restore impacted populations in a responsible and sustainable manner.	
Road Crossings: Road crossings are common occurrences in northern Ontario and it is common that historic crossings become blocked or otherwise compromised leading to localized watercourse channel failures. These crossings can be replaced or removed and the channel repaired as an offset measure. Although only one potential culvert location (Silver Dollar road) has been identified to date, this measure remains a candidate option to pursue in the area with additional local engagement.	Moderate to good (4) Culvert repair / replacement are common practice, but some of the crossings may require additional channel restoration or realignment. Requires further field investigations and engineering.	Moderate to good (4) Stability monitoring of the culvert or the repaired channel can be readily done and has low complexity. Monitoring fish benefits requires physical conditions assessment (velocity / depth) as well as fish passage studies.	Poor (1) No linkage to Project other than candidate offset measure. One location has been identified but not in close proximity to the Project.	Very Good (6) Roads are used for recreational pursuits. **Ecological Relevance** Very Good (6) Degraded crossings are detrimental to the existing stream and corridor function.	Poor to moderate (2) Crossing restoration typically involves a small area of watercourse. The amount of habitat credit awarded can be dependent on linked benefits such as fish passage to a broader area. Awarded credit is a case-by-case basis. Assume less than 20% of required offsetting.	Good (5) Typical controls for crossing repair and replacements are well understood and predictable.	Good (5) Culvert repair / replacement are common practice. Some complexity may exist due to access conditions and or the need to restore or alter the adjacent channel.	Moderate (3) Crossings must be either controlled by Great Bear Resources or landowner permission is required. Currently assume Crown land but requires confirmation for each site.	Moderate (3) Varies depending on the amount of habitat credit awarded by crossing but typically the area of physical work area is small relative to construction cost.	Moderate to good (4) Crossings may be further removed from the location of the Project. Local community workshops identified one location (Silver Dollar Road) as a potential offset measure. Repairs degraded habitat and consistent with DFO preferred offset measure hierarchy.	46
Bruce Lake Reconnect South and North Basins	Poor (1) Considerable Concern was raised by a local land user that the historic	Moderate (3) Monitoring is moderate in complexity but relies on comparison of	Moderate (3) No linkage to Project other	Poor to moderate (2) Proximity to community could facilitate recreation opportunities; however increased use may	Poor to moderate (2) The measure will increase the open water area within the lake by 0.64 ha or 3%	Moderate (3) The excavation or dredging of the connection channel would be a simple and largely predictable effort.	moderate (3) Good access to site via historic site roads. Connection channel construction	Moderate Good (4) Areas are under control of province as	Good (5) Most of the connection channel would be	Poor (1) Option was originally suggested by a local land user	29

Candidate Offsetting / Compensation Measure	Concept Simplicity and Pre-design Information Needs	Monitoring Simplicity and Success Certainty	Operational Relevance	Compatibility with Existing Land Use	Percent of Total Offset Amount Required About 20 ha	Construction Implementation and required controls	Construction Certainty	Land Tenure Certainty	Relative Cost per Type of Offset Measure	Stakeholder Interest	Cumulative Score
Construct a 20 m wide connection channel between the North and South basins to restore connectivity within the lake.	tailings deposited in the south basin to become mobilized by wind and wave action. Land user also confirmed that Walleye are currently able to move between basins. The potential for fines to mobilize and enter the north basin would require further study and design and construction consideration.	fish movement to baseline reference values which do not currently exist (mark and recapture study). Relatively short duration 3 to 7 years to demonstrate the connection channel stability and fish movement between basins.	than candidate offset measure. Does not impact future use of site by local operations.	conflict with existing outfitter use of lake. Historic tailings deposition in the lake may deter use by public. **Ecological Relevance** Poor to moderate (2) The measure would be increasing connectivity between two basins. Some concern has been raised that the south basin becomes excessively turbid, and this may affect the north basin if better connected. Land user confirmed that fish can currently move between basins.	of the required total offset credit. This area alone would not make the measure cost or effort effective. Additional offsetting value for increasing the connectivity between the adjacent north and south basins would need to be agreed upon with DFO.	Concern was raised by a local land user that the historic tailings deposited in the south basin do become mobilized by wind and wave action. The potential for fines to mobilize and enter the north basin would require further study and design and construction consideration.	is relatively predictable. Considerable uncertainty was raised by land user about the potential to mobilized historically deposited tailings fines.	the former mine is considered an abandoned mine area. Although works on public lands is common, permission from the province is not guaranteed.	basic excavation or dredging. Some fine contouring and habitat placement will be required but the overall length of the channel (~375 m) is considered small.	through MNR; however further engagement with other stakeholders suggested a preference to leave the basin as is to prevent mixing of historic tailings. Also local outfitters confirmed that connection does currently exist.	
Invasive Species Management Black Crappy have been introduced into waters near Wabauskang and concern has been raised of the potential for them to spread into other lakes. Double Crested Cormorant have expanded their range into local waters and are viewed as having an impact on local fisheries.	Poor (1) Food web manipulation and population control can be complex and uncertain. Comprehensive studies are required to determine current effects of invasive species and appropriate measures of suppression. MNR does not consider Black Crappy invasive or harmful to other fish or habitats.	Poor (1) Monitoring system wide population trends of invasive species and valued species is complex and resource intensive. Natural variation and population fluctuations makes demonstrating success difficult unless metrics are simplified such as number of species observed and removed.	Poor to Moderate (2) No linkage to Project other than candidate offset measure.	Very good (6) Areas are existing lake habitats. **Ecological Relevance** Good (5) Eradication or suppression of invasive species is an acceptable measure of offsetting however the likelihood of fully extirpating a species once introduced is highly unlikely.	Moderate to good (4) Habitat credit will need to be negotiated with DFO but it is realistic to achieve a percentage of the habitats improved by species suppression. This could accumulate to a large area depending on the effort and lakes included in the measure.	Poor to moderate (2) Given the invasive species have colonized the area eradication or suppression of this species is likely extremely challenging. This can be labour intensive and may require chemical treatment. Care will be needed not to impact other desirable species. The option of suppressing their expansion to other waterbodies through outreach programs and education may have more potential for implementation.	Poor (1) Eradication and long term suppression of invasive species is highly uncertain. MNR does not consider Black Crappy or Cormorants to be invasive species and support for supressing may not be granted.	Moderate to good (4) Lakes are under provincial and federal jurisdiction but information and alignment with residents is important to avoid potential conflicts (e.g., some users value Black Crappy).	Moderate (3) Cost is unknown and variable depending on level of suppression required. Cost of biological controls while uncertain are relatively inexpensive.	Poor to Moderate (2) The measure was raised during a community fish habitat workshop so there is some support from the local community. MNR does not consider Black Crappy or Cormorants to be invasive so support is not expected.	22

Table 8-3: Summary of East Pond Fish Habitat Areas and Characteristic

Water Depth (m)	Habitat Characteristics	Surface Area (ha)	Percent of Surface Area (%)
0 to 1	• Shallow with emergent and floating macrophytes • Shoreline perimeter varies with seasonal flows and changing water levels. • Vegetation will provide dominant cover type 40 to 80% with coarse wood structures and rock piles used to supplement 5 to 10% of the area • Wood and rock piles may be partially exposed seasonally • Expected to provide spawning habitat for species such as Northern Pike and cyprinids	5.37	44
1 to 2	• Shallow with submerged and floating macrophytes • Vegetation will provide a moderate amount of cover with coarse wood structures and rock piles used to supplement 10 to 15% of the area • Wood structures and rock piles will not be exposed seasonally • Water depth will support resident fish species for general habitat requirements (rearing and feeding spawning) • Coarse wood structure and rock piles unlikely to be exposed seasonally • General habitat for all species	2.56	21
2 to 3	• Moderate depth with some submerged macrophytes • Vegetation will provide a small amount of cover with coarse wood structures and rock piles used to supplement 5 to 10% of the area • Water depth will support general habitat for all species and some thermal refuge and overwintering habitat	1.67	14
3 to 4	• Moderate to deep with minimal submerged macrophytes • Vegetation will provide a small amount of cover rock piles and cobble shoals used to supplement 5 to 10% of the area • Water depth will support general habitat for all species and provide thermal refuge and overwintering habitat	1.20	10
4 to 5	• Deep largely absent of macrophytes • Cover provided by rock piles, cobble shoals and sunken logs over 3 to 7% of the area • Water depth will support general habitat for all species and thermal refuge and overwintering habitat	8.78	7
>5		5.82	5
Total		**12.26**	**100**

Table 8-4: Summary of Excavated East Pond Area Fish Habitat Areas and Characteristic

<table>
<tr><th>Water Depth (m)</th><th>Habitat Characteristics</th><th>Surface Area (ha)</th><th>Percent of Surface Area (%)</th></tr>
<tr><td>0 to 1 m</td><td>• Shallow with emergent and floating macrophytes
• Shoreline perimeter varies with seasonal flows and changing water levels
• Vegetation will provide dominant cover type 40 to 80% with anchored trees spaced around the margin. Trees will be partially exposed and vary with season
• Expected to provide spawning habitat for species such as Northern Pike and cyprinids</td><td>1.26</td><td>35</td></tr>
<tr><td>1 to 2 m</td><td>• Shallow with submerged and floating macrophytes
• Vegetation will provide a moderate amount of cover with coarse wood structures and rock piles used to supplement 10 to 15% of the area. Wood structures and rock piles will not be exposed seasonally.
• Water depth will support resident fish species for general habitat requirements (rearing, feeding spawning)
• Coarse wood structure and rock piles unlikely to be exposed seasonally</td><td>0.70</td><td>20</td></tr>
<tr><td>2 to 3 m</td><td rowspan="2">• Moderate depth with some submerged macrophytes
• Vegetation will provide a small amount of cover with coarse wood structures and rock piles used to supplement 5 to 10% of the area.
• Water depth will support general habitat for all species and provide thermal refuge and overwintering habitat</td><td>1.04</td><td>29</td></tr>
<tr><td>>3 m</td><td>0.58</td><td>16</td></tr>
<tr><td colspan="2">Total</td><td>3.58</td><td>100</td></tr>
</table>

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

Attribute	Success Criteria [a,b]	Date (post construction / restoration)
Physical construction of offset measures	• As-constructed survey demonstrates that measures are constructed as per the approved plans [1,2]	Within 12 months
Physical function of offset measures	• 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 as per the plans (habitat quantity consistent with design) [1]	Within 12 months
Stability of structures	• Constructed habitat features remain in place (shoal structures, rock and coarse wood structures in place [3] • Banks and habitat features are stable and not eroding (considered stable in comparison to adjacent reference areas) • Riparian vegetation cover and plantings achieve good coverage of area comparable to adjacent reference areas	Years 1, 2, 3, 5 and 10
Physicochemical	• Water and sediment quality assessment consistent with baseline conditions	Years 1, 2, 3, 5 and 10
Species presence	• A comparison will be made between the newly constructed or restored on site habitat and the baseline data for the same or adjacent waterbodies or the defined target species • 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 expected) • It is expected that even at 80% species colonization, 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 and 10
Full life cycle usage	• Multiple year classes including young of the year fish are present in the offset feature	Years 1, 2, 3, 5 and 10
Fish abundance	• Average catch per unit effort / abundance consistent with baseline values (presented in WSP 2025b) and as updated with fish removal data. A memo providing the final baseline catch per unit effort values by habitat type and species with be submitted to DFO within 2 yeas of construction)	Years 1, 2, 3, 5 and 10

Notes:

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 m^2) per 1 ha (10,000 m^2).

Presence of 95% or greater of structures (i.e., boulder clusters / tree piles) at initial construction as shown in as-constructed records

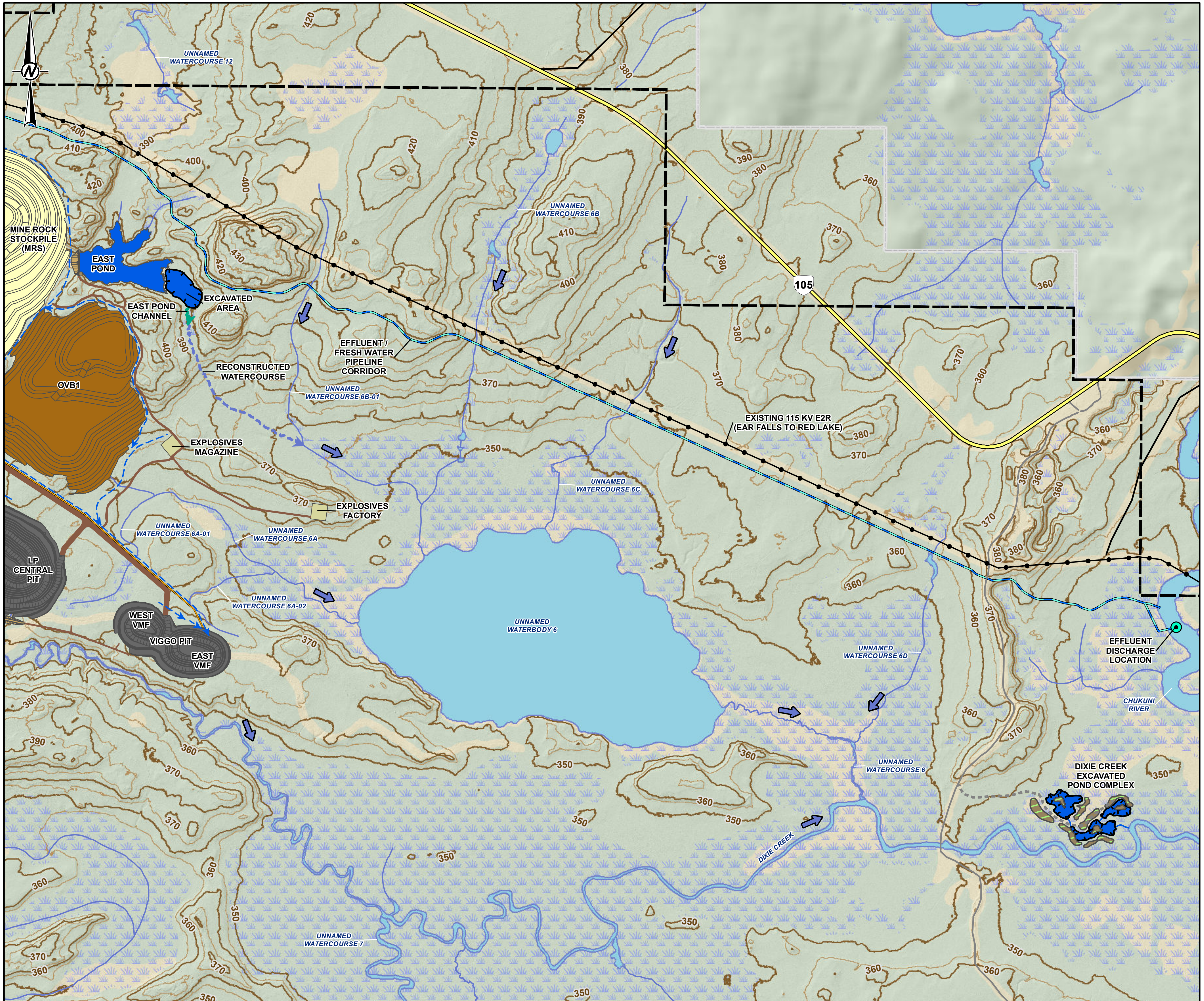
70% or greater functionality based on percent of structure available to fish use (e.g., greater than 70% of tree pile or rock pile being above sediments and usable by fish).

Success criteria to be fully implemented and functioning as anticipated for all physiochemical and biological criteria values by year 10 of monitoring (e.g., In each location, species richness success criteria is achieved at 80% of the target community [i.e., 8 out of 10 species expected], by year 10 of monitoring etc.).

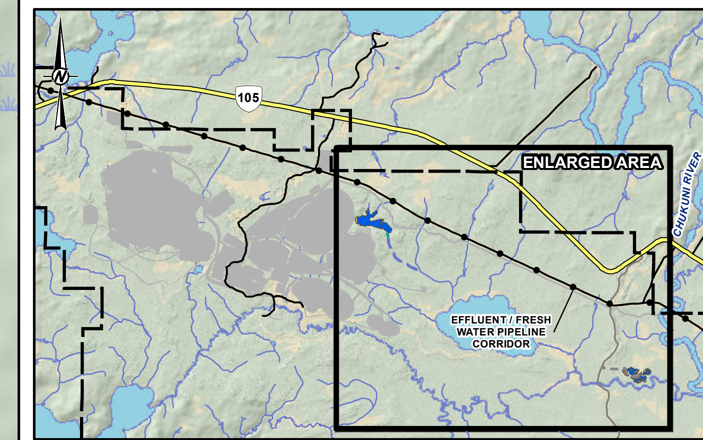
Baseline habitats of similar habitat types will be used as the standard for comparison for monitoring offsetting criteria against. Example: The creation of East Pond Dam will create type B waterbody habitat and will be comparable to other Type B habitats such as Waterbody 3 etc. The creation of the Dixie Creek Pond complex will create type A waterbody habitats and will be comparable to other Type A habitats such as the ponds of WC-6B, WC-6D, WC-5, WC-7A-03 etc.

Table 8-6: Contingency Measures for Implementation Success

Attribute	Mode of Failure	Contingency
Physical construction of offset measures	• Habitat not constructed as per plan • Water area, depths and or habitat structures not in place or present as per the plans	• Engineer / biologist to assess failure and recommend corrective actions • Proponent 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 • Proponent 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 (coarse wood, rock and vegetation structures) missing or not functional	• Repair or replace structures
	• Banks not stable (considerable difference compared to adjacent reference areas)	• Assess cause and areas of instability • Add permanent erosion control (rock or vegetation) in areas of erosion • Re-grade habitat
	• Riparian vegetation cover not present (considerable difference in abundance compared to adjacent reference areas)	• 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 • Relocate fish from adjacent doner location to stimulate population
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 catch per unit effort / 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 • Supplement plan with additional habitat development to account for deficiency



KEY MAP



SCALE 1:175,000

LEGEND

- PROPERTY BOUNDARY
- HIGHWAY (INCLUDING NATURAL GAS PIPELINE)
- LOCAL ROAD
- RESOURSE / RECREATION ROAD
- EXISTING TRANSMISSION LINE
- WETLAND AND LOW-LYING AREA
- WATERCOURSE
- WATERBODY
- EXTENT OF LIDAR SURVEY
- MAJOR CONTOUR (10 M INTERVAL)
- MINOR CONTOUR (5 M INTERVAL)
- FLOW DIRECTION

PROPOSED FISH HABITAT OFFSETTING MEASURES

- POND
- DAM
- EXCAVATED AREA
- EAST POND CHANNEL
- RECONSTRUCTED WATERCOURSE
- TREED EXCAVATED SOIL ISLAND
- ACCESS ROAD

PROPOSED MINE FEATURE

- OPEN PIT
- MINE ROCK STOCKPILE (PAG)
- OVERBURDEN STOCKPILE (OVB)
- COLLECTION DITCH
- MINE FACILITIES / INFRASTRUCTURE
- ROAD
- TAILINGS PIPELINE
- EFFLUENT / FRESH WATER PIPELINE CORRIDOR
- EFFLUENT DISCHARGE LOCATION

0 0.25 0.5 1
1:25,000 KILOMETRES

NOTE(S)
1. ALL LOCATIONS ARE APPROXIMATE
2. VMF: VIGGO MANAGEMENT FACILITY

REFERENCE(S)
1. CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENCE - ONTARIO
2. CONTOURS ACQUIRED FROM 2022 LIDAR SURVEY.
3. PROPERTY BOUNDARY PROVIDED BY GREAT BEAR RESOURCES, AUGUST 2024.
4. ROADS INFORMATION PROVIDED BY GREAT BEAR RESOURCES, AUGUST 2022.
5. SITE PLAN BASED ON INFORMATION PROVIDED BY GREAT BEAR RESOURCES, DECEMBER 2024 / JUNE 2025.
6. COORDINATE SYSTEM: NAD 1983 UTM ZONE 15N

CLIENT
GREAT BEAR RESOURCES

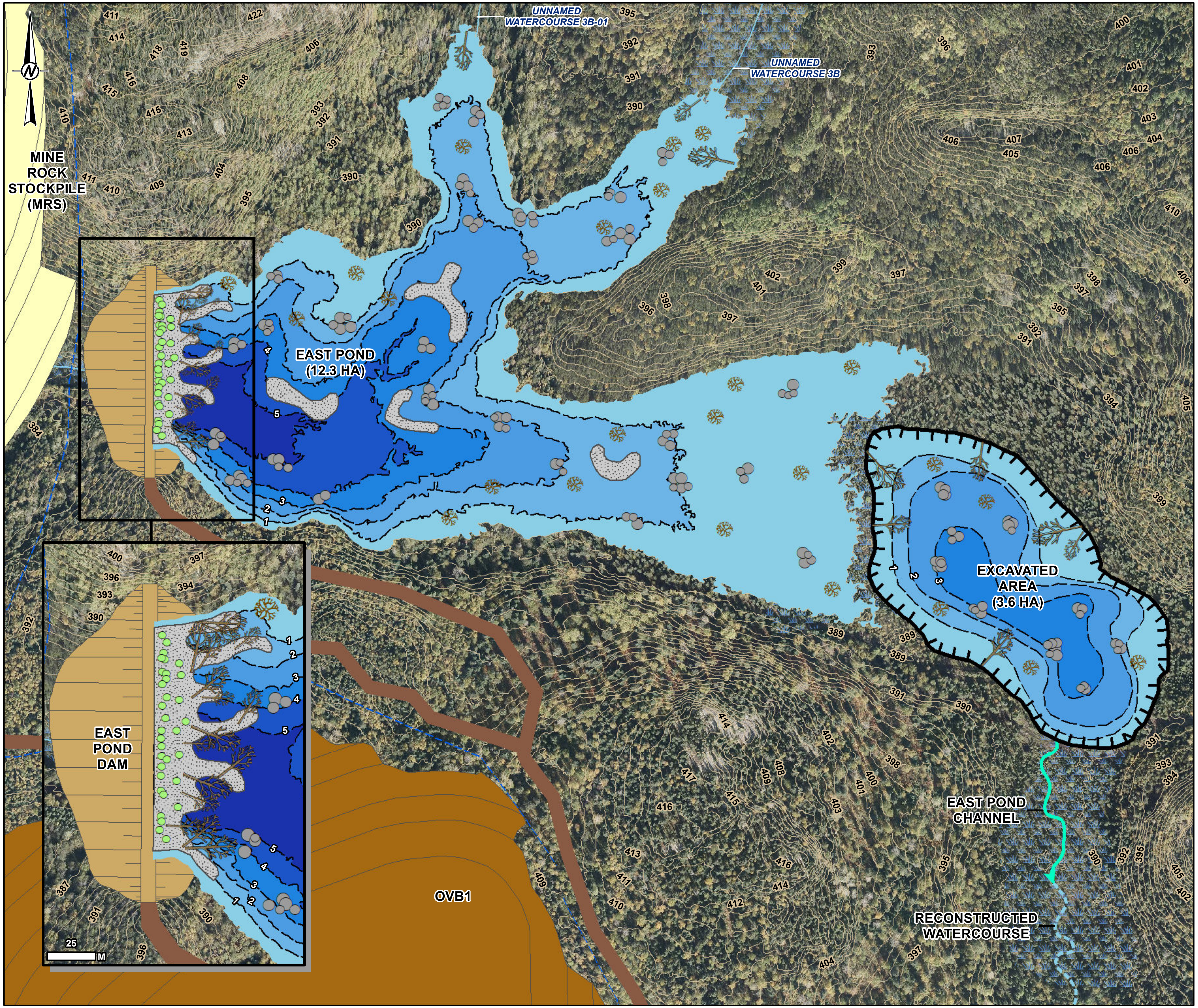
PROJECT
GREAT BEAR PROJECT

TITLE
OVERVIEW OF PROPOSED FISH HABITAT OFFSET MEASURES

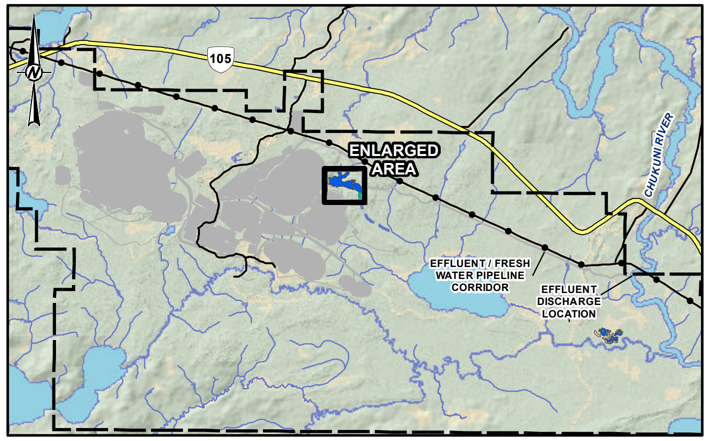
CONSULTANT
wsp

YYYY-MM-DD	2025-09-09
DESIGNED	MR
PREPARED	MD
REVIEWED	----
APPROVED	----

PROJECT NO.	CONTROL	REV.	FIGURE
CA0031271	0001	A	8-1



KEY MAP



SCALE 1:175,000

LEGEND

- WETLAND AND LOW-LYING AREA
- WATERCOURSE
- CONTOUR (1 M INTERVAL)

PROPOSED MINE FEATURE

- MINE ROCK STOCKPILE (PAG)
- OVERBURDEN STOCKPILE (OVB)
- COLLECTION DITCH
- ROAD

PROPOSED FISH HABITAT OFFSETTING MEASURES

- EAST POND DAM
- EAST POND CHANNEL
- RECONSTRUCTED WATERCOURSE
- EXCAVATED AREA
- COBBLE SHOAL
- PROPOSED BATHYMETRY CONTOURS (1 M INTERVAL)
- VEGETATED SOIL MATRIX
- BOULDER PILE
- COARSE WOOD PILE
- ANCHORED TREE

PROPOSED EAST POND AND EXCAVATED AREA WATER DEPTH (M) FILLED CONTOURS

- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- > 5

0 50 100 200
1:3,000 METRES

NOTE(S)
1. ALL LOCATIONS ARE APPROXIMATE

REFERENCE(S)
1. CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENCE - ONTARIO
2. CONTOURS ACQUIRED FROM 2022 LIDAR SURVEY.
3. AERIAL IMAGERY PROVIDED BY GREAT BEAR RESOURCES (SCENE DATE: SEPTEMBER 2022).
4. PROPERTY BOUNDARY PROVIDED BY GREAT BEAR RESOURCES, AUGUST 2024.
5. ROADS INFORMATION PROVIDED BY GREAT BEAR RESOURCES, AUGUST 2022.
6. SITE PLAN BASED ON INFORMATION PROVIDED BY GREAT BEAR RESOURCES, DECEMBER 2024 / JUNE 2025.
7. COORDINATE SYSTEM: NAD 1983 UTM ZONE 15N

CLIENT
GREAT BEAR RESOURCES

PROJECT
GREAT BEAR PROJECT

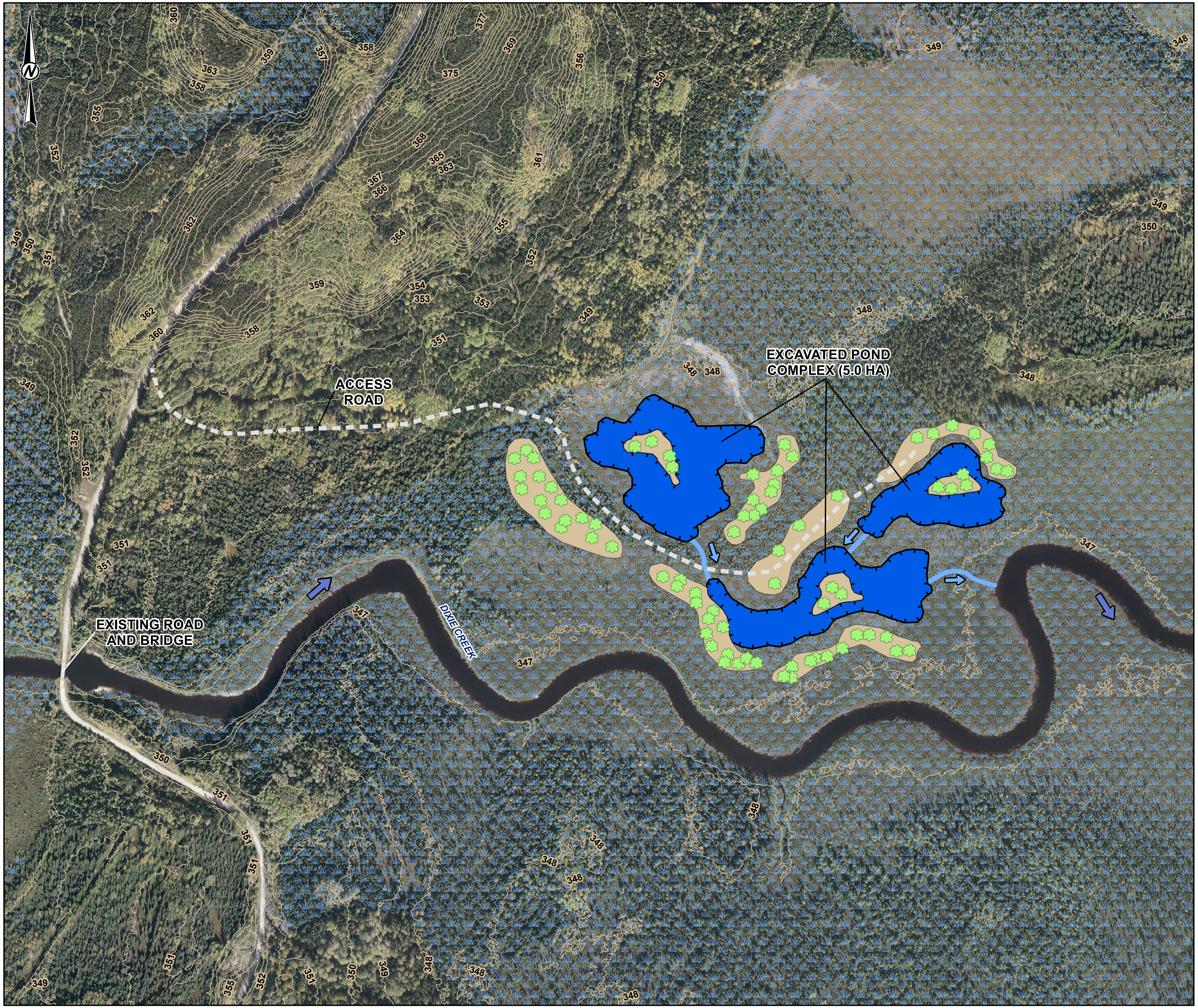
TITLE
EAST POND FISH HABITAT FEATURES

CONSULTANT

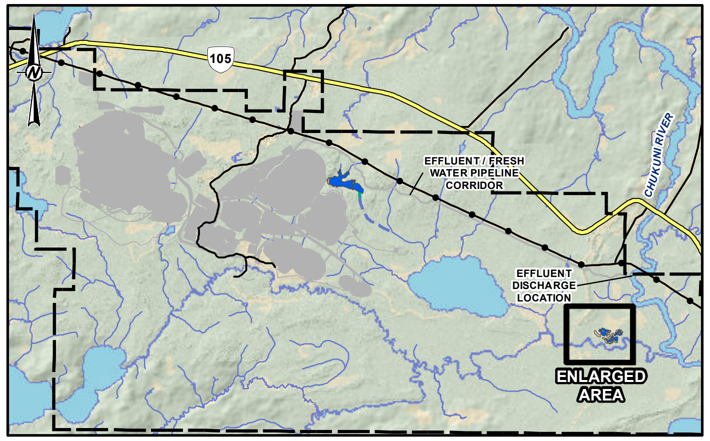
wsp

YYYY-MM-DD	2025-09-09
DESIGNED	MR
PREPARED	MD
REVIEWED	----
APPROVED	----

PROJECT NO.	CONTROL	REV.	FIGURE
CA0031271	0001	A	8-2



KEY MAP



SCALE 1:175,000

LEGEND

- PROPERTY BOUNDARY
- FLOW DIRECTION
- WETLAND AND LOW-LYING AREA
- CONTOUR (1 M INTERVAL)

PROPOSED FISH HABITAT OFFSETTING MEASURES

- EXCAVATED POND COMPLEX (5.0 HA)
- EXCAVATED POND CHANNELS (0.001 HA)
- TREE
- EXCAVATED SOIL ISLAND (4.2 HA)
- ACCESS ROAD
- EXCAVATED POND COMPLEX FLOW DIRECTION

0 50 100 200
1:5,000 METRES

NOTE(S)
1. ALL LOCATIONS ARE APPROXIMATE

REFERENCE(S)
1. CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENCE - ONTARIO
2. CONTOURS ACQUIRED FROM 2022 LIDAR SURVEY.
3. AERIAL IMAGERY PROVIDED BY GREAT BEAR RESOURCES (SCENE DATE: SEPTEMBER 2022).
4. PROPERTY BOUNDARY PROVIDED BY GREAT BEAR RESOURCES, AUGUST 2024.
5. ROADS INFORMATION PROVIDED BY GREAT BEAR RESOURCES, AUGUST 2022.
6. SITE PLAN BASED ON INFORMATION PROVIDED BY GREAT BEAR RESOURCES, DECEMBER 2024 / JUNE 2025.
7. COORDINATE SYSTEM: NAD 1983 UTM ZONE 15N

CLIENT
GREAT BEAR RESOURCES

PROJECT
GREAT BEAR PROJECT

TITLE
DIXIE CREEK EXCAVATED PONDS

CONSULTANT

wsp

YYYY-MM-DD	2025-09-09
DESIGNED	MR
PREPARED	MD
REVIEWED	----
APPROVED	----

PROJECT NO.	CONTROL	REV.	FIGURE
CA0031271	0001	A	8-3

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

9 FISHERIES OFFSET ACCOUNTING AND BALANCING

A calculated area of 21.74 ha of fish habitat will be affected 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 (69%) of impacts identified as MDMER Schedule 2 waterbody listings. Section 35 HADD impacts account for the remaining 31%.

Most of the affected habitat consists of small lakes and ponds such as Unnamed Waterbody 1 (10.44 ha), Unnamed Waterbody 2 (2.76 ha) and Unnamed Waterbody 4 (1.21 ha), and inline ponds which make up over 71% of the fish habitat by area. The remaining <29% of impacted habitat consist of small unnamed watercourses having stream order one, two and three (Strahler stream classifications) in order of frequency.

The proposed offsetting and compensation measures in this draft Plan would result in the development of approximately 25.21 ha of habitat as shown in Table 9-1, resulting in a net habitat gain or enhancement of 3.47 ha and a loss to gain ratio of 1:1.16 (1.16 ha of habitat gained for every 1 ha lost). The proposed offset habitat will consist mostly of lake / pond habitat (East Pond and Dixie Creek Pond Complex) consisted with the dominant habitat Type A that is being impacted.

Although intended to be similar and in-kind replacement to the impacted habitat the offset / compensations ponds have been designed with features that will enhance habitat conditions as follows:

- Maximum and average depth of the designed ponds will be deeper to provide improved overwintering and summer habitats for a greater number of species. The habitats are designed to support larger bodied fish in addition to the small body fish community (minnows) present in many of the impacted habitats.
- Instream cover will be designed to include a mix of hard structure (rock and Logs) as well as depth profiles to promote aquatic vegetation while maintaining areas of open water.
- In the case of the Dixie Creek Pond complex, the constructed ponds will be connected to the adjacent creek allowing connectivity with a more diverse fish community.

The designed offset habitats are expected to meet or exceed the fish productivity of the impacted habitats. For example, Unnamed Waterbody 1 makes up nearly half (48%) of the total impacts and consists of soft fine-grained sediments with a uniform depth ranging from 0.5 to 1.0 m and dense vegetation which may reduce fish habitat usage.

The offset and compensation measures will be constructed and initiated early in the Project construction schedule such that lag time between impacts and the replacement habitat becoming functional is short as per Principle 3 of the DFO offsetting policy (DFO 2025c). Given the comparison between the impacted habitat condition and the designed condition, the short time lag for habitat replacement and the expected improved habitat conditions we expect the proposed habitat offset ratio of 1:1.16 to provide sufficiency of offsetting and compensation. However, should additional area of offsetting habitat be required there is a large capacity for expansion particularly with the Dixie Creek Pond complex measure.

Comments received on the previous draft of this Plan suggested that a single metric of impact and offset (area-based or HEP Habitat Unit) should be identified for use when comparing the amount of habitat impacted to the amount of habitat offset. Given the extensive revisions to the HEP model (Appendix A) that is yet to be further reviewed by DFO, the more certain area-based units (ha) have been used in this updated Plan, as the primary metric for comparing the ratio of impacts to offsets and compensation. Accordingly, the HEP units have been removed from Table 9-1 of this updated Plan. The fully revised HEP model and analysis in Appendix A provides an additional and supplemental method to support the conclusions of the habitat accounting balance.

It is recognized that this document remains a draft Plan, and that revisions to the selected measures and quantities may be required in subsequent versions based on consultation and comments received. However, the Plan in its current state provides a descriptive account of predicted effects (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

Plan Component	Initial Impact Surface Area (ha)	Calculated Offset / Compensation Surface Area (ha)
Schedule 2, as per Table 6-1	-15.01	
Paragraph 35, HADD, as per Table 6-2	-6.73	
Fish Habitat East Pond, as per Table 8-3		12.26
Fish Habitat East Pond Excavation, as per Table 8-4		3.58
East Channel Diversion to Unnamed Watercourse 6b		0.04
East Channel Reconstruct Unnamed Watercourse 6b [1]		0.33
Dixie Creek Pond complex [2] (intentionally conceptual)		7
Fisheries Management Plan for Wabauskang Lake		2.00
Summary	-21.74	25.21
Net Difference		3.47
Net Ratio		1:1.16

Notes:

1. Reconstruction of the existing Unnamed Watercourse 6b may be considered a mitigation rather than an offset measure through further discussion with DFO.
2. Large areas adjacent to the proposed Dixie Creek Pond complex are available to increase the area of offsetting if required.

10 REFERENCES

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- WSP 2026a. Great Bear Project Impact Statement.
- WSP 2026b. Great Bear Project Fish and Fish Habitat Supplemental Report – Dixie Creek.

Appendix A
Habitat Evaluation Procedure

GREAT BEAR RESOURCES

GREAT BEAR PROJECT

HABITAT EVALUATION PROCEDURE

MARCH 2026

GREAT BEAR PROJECT

HABITAT EVALUATION PROCEDURE

GREAT BEAR RESOURCES

PROJECT NO.: OMEMA2303
MARCH 2026

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ATTACHMENTS

A HSI Data Analysis & Results

1 HABITAT EVALUATION PROCEDURE

The premise of the Habitat Evaluation Procedure (HEP) approach is that an area of aquatic habitat can be composed of a variety of habitat types (e.g., deep pools, shallow riffles, etc.) and that these habitat types will have differing levels of suitability for fish species that may occur in that habitat area. The HEP manuals published by the United States of America Fish and Wildlife Service (U.S. FWS 1980; 1981) provide the recommended steps to perform a HEP analysis include definition of the study area, delineation of cover types, selection of evaluation species, calculation of total area of available habitat, and the calculation of a HSI for available habitat per species. DFO Science and Fish and Fish Habitat Protection branches support the use of HEP models in determining the amount of usable fish habitat for determining impacts and offsetting measures (Sommer et al 2019, DFO 2016, Minns et al 2001).

A HEP type of approach to document habitat quality and quantity. Habitat quality is defined by the HSI values, as determined by application of the HSI models, which rank the importance of available habitat on a scale from 0 to 1. Habitat quantity is represented by surface areas of the waterbodies/courses (e.g., determined from stream channel length and width measurements).

The HEP model can be described, for each fish species (spp 1-n) as:

HUspp 1-n = ΣHT (Σ emb, fr, juv, ad, ot (HT x HSI emb, fr, juv, ad, ot x life function weight x species weight)]) x access factor x habitat co-factor

– Where HT= area (m^2) of habitat types present in each reach. These habitat types provide the foundation of the HEP by delineating habitat types based on substrate, cover and habitat morphology for each reach and habitat unit of the assessed data.

HSI ot, emb, fr, juv, ad = habitat suitability index for each life stage:

– emb = embryo

– fr = fry

– juv = juvenile

– ad = adult

– ot = other (important to all life stages)

The selection of habitat variables for inclusion in models developed for this analysis was driven by three factors:

1) Knowledge and availability of information on the habitat characteristics of importance to the species present and the fish species assemblages in aquatic environments.
2) The availability of published data on the habitat requirements, preferences, and tolerances for each of the target fish species.
3) The information available from habitat survey data collected for all potentially impacted waterbodies/courses during the survey period.

The HEP procedure was chosen as a standard peer reviewed method that has been a previously accepted method by regulating agencies to determine changes in habitat suitability for pre- and post-restoration conditions of riverine and lacustrine habitats.

The HEP has been updated to address the comment responses from DFO received November 19, 2025 and are included throughout the text and attachment tables. The HEP is provided to support the impact assessment process in recognition that additional analysis, design and consultation will result in adjustments to the Project looking forward. Prior to the completion of permitting and approvals for the Project, the Plan will be finalized to reflect the adjustments.

1.1 TARGET FISH SPECIES

Peer reviewed HSI models were used for the fish species for the Grear Bear Project, where available and are presented in detail in Section 1.3. Fish species considered within the HIS model were those of cultural and ecological significance , documented throughout the study area or within the greater watershed and used habitats in either the baseline, impact (loss) or restoration (gain) scenarios.

The most common sport fish species within FMZ4 include Walleye, Northern Pike, Lake Trout, Yellow Perch, Smallmouth Bass, Muskellunge, and Lake Whitefish (MNR 2014). Small-bodied fish that are abundant in the project area (i.e., account for >5% of the fish capture abundance; FHOCP Appendix L-2, Table 4-5) include: Brook Stickleback, Central Mudminnow, Finescale Dace, and Spottail Shiner.

Fish species that were captured, observed or present in eDNA samples collected for the baseline studies between 2022 and 2024 (WSP 2025a) were used in the HEP model. For waterbodies and watercourses where no fish were previously captured but they were considered potentially fish frequented, the fish species from other waterbodies/watercourses of similar habitat type was applied.

1.2 HABITAT TYPES

The foundation of the HEP is the delineation of areas that provide certain habitat variables based primarily on substrate, cover, habitat morphology as well as other physical and chemical characteristics.

Habitat assessments were conducted at representative riverine (lotic; includes streams, creeks and rivers) and ponded or lake/pond (lentic/lacustrine) locations within the Project area during the 2022 to 2024 field studies. These assessments characterized the habitats by variables and into habitat types that supported delineation of homogeneous habitat throughout the Project Area. Habitat types were classified using several criteria that included a combination of categories of natural features (e.g., waterbody type, morphology, water quality, substrates, riparian and cover features etc.). The homogenous habitat types and key components of each habitat type are presented in the 2024 Great Bear Resources, Great Bear Project Fisheries Resources Baseline Report (WSP 2025a).

The following sites were determined to not be impacted by the project and were not considered in the impact model:

- Genessee Lake
- Gullrock Lake
- Pakwash Lake

1.3 HABITAT SUITABILITY INDICES (HIS)

The habitat suitability indices (HSIs) that were used for the Project have been applied from various peer reviewed publications and protocols, where available. Habitat suitability, the term represents the relative quality of each habitat type for each life stage of each target fish species present per habitat type. In the case of HEP, the life stages of embryo, fry, juvenile and adult were considered, when variable calculations were available in the model. Habitat suitability for each life stage is indicated through a ranking of 0 to 1. HSIs for all target fish species and habitat types used in the HEP are shown per species in the subsections below, along with a list of assumptions applied to each model. Variables that represented other biological, physical, or chemical criteria, such as water quality or quantity values, were considered under the access factor and/or habitat cofactor.

The HSI calculation standard approach for most species was to retain the minimum value of the suitability index variables. As a conservative measure the mean HSI was applied as homogenous habitat types were applied to this project, various species are present in the waterbodies and watercourses of the study area and the habitats are readily available to support the various species, as such they were not a limiting factor.

The application of the mean HSI, enabled the model to be completed as a conservative assessment of habitat, while maintaining a moderate assessment of loss and gains due to the Project's potential impacts. If the lowest HSI was applied during the model, it would reflect an unfair distribution of the potential losses (i.e., resulted in lower areas of loss).

Locations with data limitations (i.e., water quality values not collected at the correct time of the year, number of degree days at certain temperature ranges etc.) were assumed to provide sufficient characteristics to support the aquatic life of the species as the species were present in the waterbodies/watercourses of the study area and were assumed not to be a limiting variable. If alternatives were available to be used in cases where data limitations occurred, they were applied (e.g., the variable required late winter dissolved oxygen [DO] but used lowest DO values). Data limitations are described below in the model overview for each species through an assumption statement, where applicable.

1.3.1 BLACKCHIN SHINER

The HEP analysis was completed using the using the HSI criteria for Blackchin Shiner as presented in Golder 2008. The HSI criteria were developed based off existing literature including Coker 2001, Lane 1996, Scott and Crossman 1998, Fishbase 2013 and Page and Burr 1991. The HSI is to be set equal to the lowest of the SI values for the variables included in the model, although since this species is prevalent within the region the mean HSI value was applied and also to capture a moderate potential loss/gain scenario.

The riverine model includes the following habitat variables:

- V1 Substrate, where sand, and silt substrates were assigned an SI of 1.0; silt/clay substrates were assigned an SI of 0.5; and boulder, bedrock, cobble, and rubble substrates were assigned an SI of 0.25. Due to data limitations, fines were defined as a combination of gravel, sand, and silt/clay. Where all three fine substrate components were represented in the model, the full fines percentage was applied. Where only one component (e.g., sand only) was represented, the fines value was reduced to one third, and where two components (e.g., gravel and sand) were represented, two thirds of the fines value was applied.
- V2 Instream Cover, where macrophytes (submergent and emergent vegetation) were assigned an SI of 1.0, while cobble and rubble substrates were assigned an SI of 0.25. The dominant cover type was applied, with an SI of 1.0 assigned where macrophytes were dominant and an SI of 0.25 assigned where rock (e.g., cobble or boulder) was dominant.
- V3 Dominant Channel Morphology, where characterized by flats, pools, and backwaters were assigned an SI of 1.0; runs were assigned an SI of 0.5; riffles were assigned an SI of 0.25; and rapids, chutes, and falls were assigned an SI of 0.0.
- V4 Percent Instream Cover, where an SI of 1.0 was assigned where instream cover was above 50%; an SI of 0.75 where instream cover was > 30% but < 50%; an SI of 0.5 where instream cover was > 20% and ≤ 30%; an SI of 0.25 where instream cover > 0% but less than 20%; and an SI of 0.0 where instream cover was absent (0%).
- V5 Late Winter Dissolved Oxygen: An SI of 1.0 was assigned where dissolved oxygen concentrations were ≥2 mg/L, and an SI of 0.5 where concentrations were <2 mg/L. Late winter DO criteria are based on the assumptions that if measured late winter DO is greater than the indicated concentration, DO is not limiting at any time of year, and if measured late winter DO is less than the indicated concentration, DO may be limiting in winter but not during the open-water period. In addition, since DO is not measured in all areas within a watercourse or waterbody, there may exist some local areas where late winter DO is greater than the measured concentrations. [Applied average DO values collected through site-specific monitoring; where winter dissolved oxygen data was unavailable, it was assumed sufficient where existing populations were present.]

- V6 pH, where an SI of 1.0 was assigned where pH ranged from 6.0 to 7.5; an SI of 0.5 where pH ranged from 5.0 to < 6.0; and an SI of 0.0 where pH values were < 5.0 or > 9.0. Average pH values were applied; where data were unavailable, conditions were assumed to be sufficient where existing populations were present (SI = 0.5).

The lacustrine model includes all the same habitat variables except for the following changes:

- Dominant Channel Morphology variable was omitted from the model.
- V3 % Littoral Zone Cover replaced % Instream Cover, where SI = 1 for instream cover >50%, SI = 0.75 when instream cover >30% but <50%, SI = 0.5 when instream cover is >20% and <30% and SI = 0.25 when instream cover is >0% but <20%.

1.3.2 BLACKNOSE SHINER

The HEP model was developed for the Project for Blacknose Shiner as presented below. The HSI criteria were developed based off of DFO HEAT habitat suitability matrices (DFO 2025) and existing literature (Becker 1983, Stauffer et al. 2016, Carlson et al. 2016, New York Natural Heritage Program 2016). The HSI is to be set equal to the lowest of the SI values for the variables included in the model, although since this species is prevalent within the region the mean HSI value was applied and also to capture a moderate potential loss/gain scenario.

The riverine model includes the following habitat variables:

- V1 Substrate, where gravel, sand, silt/clay, and rubble/cobble substrates were assigned an SI of 1.0, while boulder and bedrock substrates were assigned an SI of 0.25.
- V2 Instream Cover, where macrophytes (e.g., emergent and submergent vegetation) and rock (e.g., cobble or boulder) were assigned an SI of 1.0, while wood, rock, and other cover types (e.g., banks) were assigned an SI of 0.25. The dominant cover type was applied, with an SI of 1.0 assigned where macrophytes and/or rock were dominant and an SI of 0.25 assigned where rock, wood and/or other cover types were dominant.
- V3 Dominant Channel Morphology, where areas characterized by flats, pools, and backwaters were assigned an SI of 1.0; runs were assigned an SI of 0.5; riffles were assigned an SI of 0.25; and rapids, chutes, and falls were assigned an SI of 0.0.
- V4 % Instream Cover, where an SI of 1.0 was assigned where instream cover was above 50%; an SI of 0.75 where instream cover was greater than 30% but less than 50%; an SI of 0.5 where instream cover was greater than 20% and less than or equal to 30%; an SI of 0.25 where instream cover was greater than 0% but less than 20%; and an SI of 0.0 where instream cover was absent.
- V5 Late Winter Dissolved Oxygen, where an SI of 1.0 was assigned where dissolved oxygen concentrations were ≥2 mg/L, and an SI of 0.25 where concentrations were <2 mg/L. Average dissolved oxygen values from site specific monitoring were applied; where late winter dissolved oxygen data were unavailable, conditions were assumed to be sufficient where existing populations were present.
- V6 pH, where an SI of 1.0 was assigned where pH ranged from 6.0 to 7.5; an SI of 0.5 where pH ranged from 5.0 to less than 6.0; and an SI of 0.0 where pH values were less than 5.0 or greater than 9.0. Average pH values were applied; where data were unavailable, conditions were assumed to be sufficient where existing populations were present (SI = 0.5).

The lacustrine model includes all the same habitat variables except for the following changes:

- Dominant Channel Morphology variable was omitted from the model.
- V3 % Littoral Zone Cover replaced % Instream Cover, with an SI of 1.0 where cover was above 50%; an SI of 0.75 where cover was greater than 30% but less than 50%; an SI of 0.5 where cover was greater than 20% but less than 30%; and an SI of 0.25 where cover was greater than 0% but less than 20%.

1.3.3 BLUNTNOSE MINNOW

The HEP model was developed for the Project for Bluntnose Minnow as presented below. The HSI criteria were developed based off DFO HEAT habitat suitability matrices (DFO 2025) and existing literature adapted fromHabitat Suitability Matrices (Becker 1983, Smith 1985, Holm et al. 2021, Houston 2001 and Iowa Department of Natural Resources 2026). The HSI is to be set equal to the lowest of the SI values for the variables included in the model, although since this species is prevalent within the region the mean HSI value was applied and also to capture a moderate potential loss/gain scenario.

The riverine model includes the following habitat variables:

- V1 Substrate, where gravel, sand, silt/clay, and rubble/cobble substrates were assigned an SI of 1.0, while clay, boulder, and bedrock substrates were assigned an SI of 0.25.
- V2 Instream Cover, where macrophytes, rock, and woody material were assigned an SI of 1.0, while other cover types (e.g., overhanging banks) were assigned an SI of 0.25. The dominant cover type was applied, with an SI of 1.0 assigned where macrophytes, rock, and/or wood were dominant, and an SI of 0.25 assigned where other cover types were dominant
- V3 Dominant Channel Morphology, where areas characterized by flats, pools, and backwaters were assigned an SI of 1.0; runs were assigned an SI of 0.5; riffles were assigned an SI of 0.25; and rapids, chutes, and falls were assigned an SI of 0.0.
- V4 Percent Instream Cover, where an SI of 1.0 was assigned where instream cover was > 50%; an SI of 0.75 where instream cover was > 30% but < 50%; an SI of 0.5 where instream cover was > 20% and ≤ to 30%; an SI of 0.25 where instream cover was >0% but < 20%; and an SI of 0.0 where instream cover was absent (0%).
- V5 Late Winter Dissolved Oxygen, where an SI of 1.0 was assigned where dissolved oxygen concentrations were ≥2 mg/L, and an SI of 0.25 where concentrations were <2 mg/L. Average dissolved oxygen values from site specific monitoring were applied; where late winter dissolved oxygen data were unavailable, conditions were assumed to be sufficient where existing populations were present.
- V6 pH, where an SI of 1.0 was assigned where pH ranged from 6.0 to 7.5; an SI of 0.5 where pH ranged from 5.0 to less than 6.0; and an SI of 0.0 where pH values were less than 5.0 or greater than 9.0. Average pH values were applied; where data were unavailable, conditions were assumed to be sufficient where existing populations were present.

The lacustrine model includes all the same habitat variables except for the following changes:

- Dominant Channel Morphology variable was omitted from the model.
- V3 % Littoral Zone Cover replaced % Instream Cover, where an SI of 1.0 was assigned where cover was above 50%; an SI of 0.75 where cover was greater than 30% but less than 50%; an SI of 0.5 where cover was greater than 20% but less than 30%; and an SI of 0.25 where cover was greater than 0% but less than 20%.

1.3.4 BROOK STICKLEBACK

The HEP analysis was completed using the HSI criteria for Brook Stickleback as presented in Golder 2008. The HSI criteria were developed base off existing literature (Smiley 1972; Moodie 1986; Nelson and Paetz 1992; Abrahams 1996; Lane et al 1996; Scott and Crossman 1998; Bradbury et al. 1999; Portt et al. 1999; Langhorne et al. 2001; Richardson et al. 2001), professional expertise and workshop outcomes (Golder 2008). The HSI is to be set equal to the lowest of the SI values for the variables included in the model, although since this species is prevalent within the region the mean HSI value was applied and also to capture a moderate potential loss/gain scenario.

The riverine model includes the following habitat variables:

- V1 Substrate, where gravel, sand, clay/silt substrates the SI =1, whereas boulder, bedrock, cobble, and rubble substrates are ranked as SI = 0.25. [Due to data limitations, dominant substrate type was applied, where SI = 1 if fines (e.g., clay, silt, organics) and SI = 0 if another substrate type is dominant.]
- V2 Nesting materials, where algae submergent vegetation were ranked as SI = 1, emergent plants as SI = 0.75, inundated vegetation was ranked as SI = 0.5, and woody debris/other as SI = 0.25. [Due to data limitations, the dominant instream cover type was applied, where macrophytes were ranked as SI = 0.75, and woody debris as SI = 0.25.]
- V3 Channel Unit, where the area having flats pools and backwaters were ranked as SI = 1, Percent area of runs as SI = 0.5, riffles as SI = 0.25; rapids, chutes and falls were ranked as SI = 0.
- V4 Percent Instream Cover, where SI = 1 for instream cover >50%, SI = 0.75 instream cover >30% but <50%, SI = 0.5 when instream cover is >20% and <30% and SI = 0.25 when instream cover is >0% but <20%.
- V5 Late winter dissolved oxygen, SI = 1.0 when ≥1 mg/L and SI= 0.5 when <1 mg/L. Late winter DO criteria are based on the assumptions that if measured late winter DO is greater than the indicated concentration, DO is not limiting at any time of year, and if measured late winter DO is less than the indicated concentration, DO may be limiting in winter but not during the open-water period. In addition, since DO is not measured in all areas within a watercourse or waterbody, there may exist some local areas where late winter DO is greater than the measured concentrations. [Applied average winter DO values collected through site-specific monitoring; where winter dissolved oxygen data was unavailable, it was assumed sufficient where existing populations were present.]
- V6 pH, where the SI 1 when pH 6 to 9 and SI = 0.5 for pH range of 5.5 to <6 and SI = 0 when pH values are <5.0 or >9.0. [Applied average pH; if no data was available, it was assumed sufficient where existing populations were present.]

The lacustrine model includes all the same habitat variables except for the following changes:

- V3 Depth, where SI = 1.0 for habitats ≤2 m depth, SI = 0.5 for >2 m to 5 m depth and SI = 0.25 for >5 m depths.
- V4 Percent Littoral Zone Cover, where SI = 1 for instream cover >50%, SI = 0.75 instream cover >30% but <50%, SI = 0.5 when instream cover is >20% and <30% and SI = 0.25 when instream cover is >0% but <20%.

1.3.5 BURBOT

The HEP analysis was completed using the HSI criteria for Burbot as presented in Golder 2008. The HSI criteria were developed base off existing literature (Bradbury et al. 1999; McPhail and Paragamian 2000), professional expertise and workshop outcomes (Golder 2008). The HSI is to be set equal to the lowest of the SI values for the variables included in the model, although since this species is prevalent within the region the mean HSI value was applied and also to capture a moderate loss/gain scenario. The riverine and lacustrine HSI models are separated into spawning, rearing, and feeding habitat components, each with their own set of habitat variables and suitability criteria.

The riverine model includes the following spawning habitat variables:

- V1 Substrate, where gravel, sand, and clay/silt substrates were assigned an SI of 1.0; boulder, cobble, and rubble substrates were assigned an SI of 0.5; and bedrock and detritus substrates were assigned an SI of 0. [Due to data limitations, fines were considered to consist of gravel, sand, silt/clay and detritus. Where al four fine-substrate components were present in the model, the full fines percentage was applied. Where only one component (e.g., sand only) was present in the model, the fines value was multiplied by one fourth, where two components (e.g., gravel and sand) were present, two fourths of the fines value was applied and where one component was present (e.g., detritus), one-fourth of the fines value was applied.]

– V2 Channel Unit, where areas characterized by snye, pools, and backwaters were assigned an SI of 1.0; flats were assigned an SI of 0.75; runs and glides were assigned an SI of 0.5; riffles were assigned an SI of 0.25; and chutes and falls were assigned an SI of 0.

– V3 Late winter dissolved oxygen, where an SI of 1.0 was assigned where dissolved oxygen concentrations were ≥6 mg/L; an SI of 0.5 where concentrations were ≥2 and <6 mg/L; and an SI of 0 where concentrations were <2 mg/L. Late winter DO criteria are based on the assumptions that if measured late winter DO is greater than the indicated concentration, DO is not limiting at any time of year, and if measured late winter DO is less than the indicated concentration, DO may be limiting in winter but not during the open-water period. In addition, since DO is not measured in all areas within a watercourse or waterbody, there may exist some local areas where late winter DO is greater than the measured concentrations. [Applied average DO values collected through site-specific monitoring; where winter dissolved oxygen data was unavailable, it was assumed sufficient where existing populations were present (SI = 0.5).]

The riverine model includes the following rearing habitat variables:

– V1 Substrate, where Gravel, boulder, and cobble/rubble substrates were assigned an SI of 1.0; sand substrates were assigned an SI of 0.5; clay/silt substrates were assigned an SI of 0.25; and detritus substrates were assigned an SI of 0. Fines were defined and applied using the same proportional approach described for spawning habitat.

– V2 Channel Unit, where areas characterized by snye, pools, and backwaters were assigned an SI of 1.0; flats were assigned an SI of 0.75; runs and glides were assigned an SI of 0.5; riffles were assigned an SI of 0.25; and chutes and falls were assigned an SI of 0.

– V3 Late winter dissolved oxygen, where an SI of 1.0 was assigned where dissolved oxygen concentrations were ≥6 mg/L; an SI of 0.5 where concentrations were ≥2 and <6 mg/L; and an SI of 0 where concentrations were <2 mg/L. Average DO values from site specific monitoring were applied; where winter DO data were unavailable, conditions were assumed to be sufficient where existing populations were present.

– V4 Summer Average Maximum Temperature, where an SI of 1.0 was assigned where temperatures were <12 °C; an SI of 0.75 where temperatures were ≥12 and <15 °C; an SI of 0.5 where temperatures were >15 and ≤18 °C; and an SI of 0.25 where temperatures were >18 °C. Average summer temperature values from site specific monitoring were applied; where summer temperature data were unavailable, conditions were assumed to be sufficient where existing populations were present (SI = 0.5).

– V5 Percent Instream Cover, where an SI of 1.0 was assigned where in stream cover was >30% and ≤ 50%; an SI of 0.75 where cover was >20% and ≤30% or >50% and ≤65%; an SI of 0.5 where cover was >10% and ≤20% or >65% and ≤75%; an SI of 0.25 where cover was >0% and ≤10% or >75% and ≤100%; and an SI of 0 where in stream cover was absent.

The riverine model for feeding habitat includes all the same habitat variables as the rearing habitat except for the following changes:

– V2 Channel Unit, where areas characterized by snye, pools, and backwaters were assigned an SI of 1.0; flats and runs/glides were assigned an SI of 0.75; riffles were assigned an SI of 0.5; and chutes and falls were assigned an SI of 0.

– V3 Late winter dissolved oxygen where an SI of 1.0 was assigned where dissolved oxygen concentrations were ≥7 mg/L; an SI of 0.5 where concentrations were ≥5 and ≤7 mg/L or ≥2 and <5 mg/L; an SI of 0.25 where concentrations were ≥1 and <2 mg/L; and an SI of 0 where concentrations were <1 mg/L. Average DO values from site specific monitoring were applied; where winter DO data were unavailable, conditions were assumed to be sufficient where existing populations were present (SI = 0.5).

The lacustrine models evaluate the of spawning habitats for Burbot based on the following variables:

- V1 Substrate, where gravel, sand, and clay substrates were assigned an SI of 1.0; boulder substrates were assigned an SI of 0.5; and bedrock, clay/silt, and detritus substrates were assigned an SI of 0.25.
- V2 Late winter dissolved oxygen, where an SI of 1.0 was assigned where dissolved oxygen concentrations were ≥7 mg/L; an SI of 0.5 where concentrations were ≥5 and ≤7 mg/L or ≥2 and <5 mg/L; an SI of 0.25 where concentrations were ≥1 and <2 mg/L; and an SI of 0 where concentrations were <1 mg/L. Late winter DO criteria assume that concentrations above the indicated thresholds are not limiting at any time of year, while concentrations below these thresholds may be limiting during winter but not during the open water period. Localized areas with higher DO may occur where measurements are unavailable.

Average DO values from site specific monitoring were applied; where winter dissolved oxygen data were unavailable, conditions were assumed to be sufficient where existing populations were present.

- V3 Depth, where an SI of 1.0 was assigned where depths ranged from ≥1 to 3 m; an SI of 0.75 where depths were >3 to 5 m; an SI of 0.5 where depths were >5 to 7 m; an SI of 0.25 where depths were >7 to 10 m; and an SI of 0 where depths were <1 m or >10 m.

The lacustrine model for rearing habitat includes all the same habitat variables as the spawning habitat except for the following changes:

- V1 Substrate, where boulder, gravel, rubble, and clay substrates were assigned an SI of 1.0; sand substrates were assigned an SI of 0.5; clay/silt substrates were assigned an SI of 0.25; and detritus substrates were assigned an SI of 0.
- V3 Summer Average Maximum Temperature, where an SI of 1.0 was assigned where temperatures were <12 °C; an SI of 0.75 where temperatures were ≥12 and <15 °C; an SI of 0.5 where temperatures were >15 and ≤18 °C; and an SI of 0.25 where temperatures were >18 °C. Average temperature values from site specific monitoring were applied; where summer temperature data were unavailable, conditions were assumed to be sufficient where existing populations were present.
- V4 Percent Littoral Cover, where an SI of 1.0 was assigned where littoral cover was >30% and ≤50%; an SI of 0.75 where cover was >20% and ≤30% or >50% and ≤65%; an SI of 0.5 where cover was >10% and ≤20% or >65% and ≤75%; an SI of 0.25 where cover was >0% and ≤10% or >75% and ≤ 100%; and an SI of 0 where littoral cover was absent.
- V5 Depth, where n SI of 1.0 was assigned where depths were >0 to 2 m; an SI of 0.5 where depths were >2 to 3 m; an SI of 0.25 where depths were >3 to 5 m; and an SI of 0 where depths > 5 m.

The lacustrine feeding habitat model includes all rearing habitat variables, except that percent littoral cover and depth variables were omitted.

1.3.6 CENTRAL MUDMINNOW

The HEP analysis was completed using the HSI criteria for Central Mudminnow as presented in New Gold Rainy River Project Fish Habitat No Net Loss Plan (AMEC 2013). The HSI criteria were developed base off existing literature including Coker 2001, Lane 1996, Scott and Crossman 1998, Fishbase 2013 and Page and Burr 1991.

The riverine model includes the following habitat variables:

- V1 Substrate, where clay silt and organic substrates the SI =1, whereas gravel and sand substrates are ranked as SI = 0.25. [Due to data limitations, dominant substrate type was applied, where SI = 1 if fines (e.g., clay, silt, organics) and SI = 0 if another substrate type is dominant.]
- V2 Instream Cover, where submergent and emergent vegetation were ranked as SI = 1, and cobble/rubble as SI = 0.25. [Applied dominant cover type, where SI = 1 if macrophytes and SI = 0.25 if rock (e.g., cobble or boulder).]

- V3 Channel Unit, where percent area having flats pools and backwaters were ranked as SI = 1, Percent area of runs as SI = 0.5, Precent area of riffles as SI = 0.25.
- V4 Percent Instream Cover, where SI = 1 for instream cover >50%, SI = 0.75 instream cover >30% but <50%, SI = 0.5 when instream cover is >20% and <30% and SI = 0.25 when instream cover is >0% but <20%.
- V5 Late winter dissolved oxygen, SI = 1.0 when ≥2 mg/L and SI= 0.25 when <2 mg/L. Late winter DO criteria are based on the assumptions that if measured late winter DO is greater than the indicated concentration, DO is not limiting at any time of year, and if measured late winter DO is less than the indicated concentration, DO may be limiting in winter but not during the open-water period. In addition, since DO is not measured in all areas within a watercourse or waterbody, there may exist some local areas where late winter DO is greater than the measured concentrations. [Applied average winter DO values collected through site-specific monitoring; where winter dissolved oxygen data was unavailable, it was assumed sufficient where existing populations were present.]
- V6 pH, where the SI 1 when pH ≥6 to 7.5 and SI = 0.5 for pH range of 5 to <6 and SI = 0 when pH values are <5.0 or >9.0. [Applied average pH.]

For the lacustrine model, the riverine variables listed above were applied although V2/V4-instream cover values were applied to in water cover and V3 channel units were applied to all lake areas were considered equivalent to pools (i.e., SI – 1.0).

The Mean HSI value was applied to the model, since this species is prevalent within the region and to capture a moderate potential loss/gain scenario.

1.3.7 CISCO

The HEP model was developed for the Project for Cisco as presented below. The HSI criteria were developed based off DFO HEAT habitat suitability matrices (DFO 2025) and existing literature (ECCC 2018, Scott and Crossman 1998 and Paufve et al. 2022). The HSI is to be set equal to the lowest of the SI values for the variables included in the model, although since this species is prevalent within the region the mean HSI value was applied and also to capture a moderate potential loss/gain scenario.

The riverine model includes the following habitat variables:

- V1 Substrate, where gravel and rubble/cobble substrates were assigned an SI of 1.0; boulder substrates were assigned an SI of 0.5; and bedrock, silt, sand, and clay/silt substrates were assigned an SI of 0.25. Due to data limitations, fines were defined as a combination of gravel, sand, and silt/clay. Where all three fine substrate components were represented, the full fines percentage was applied. Where only one component (e.g., sand only) was represented, the fines value was multiplied by one third; where two components (e.g., gravel and sand) were represented, two thirds of the fines value was applied.
- V2 Depth, where an SI of 1.0 was assigned where depths were >10 m; an SI of 0.75 where depths were ≥5 to 10 m; and an SI of 0.25 where depths were <5 m.
- V3 Cover, where an SI of 1.0 was assigned where no cover was present; an SI of 0.75 where vegetation and/or rock were present; and an SI of 0.25 where wood or other cover types were present.
- V4 Summer water temperature, where an SI of 1.0 was assigned where temperatures were <10 °C; an SI of 0.75 where temperatures were ≥10 and <15 °C; and an SI of 0.25 where temperatures were <5 °C. Average summer temperature represents the mean water temperature measured in July and August. Average temperature values from site specific monitoring were applied; where summer temperature data were unavailable, conditions were assumed to be sufficient where existing populations were present.
- V5 Late winter dissolved oxygen, where an SI of 1.0 was assigned where dissolved oxygen concentrations were ≥6.5 mg/L; and an SI of 0.25 where concentrations were <6.5 mg/L. Average DO

values from site specific monitoring were applied; where winter dissolved oxygen data were unavailable, conditions were assumed to be sufficient where existing populations were present.

- V6 pH, where an SI of 1.0 was assigned where pH ranged from 6.5 to 9.0; and an SI of 0.25 where pH values were <6.5 or >9.0. Average pH values were applied; where data were unavailable, conditions were assumed to be sufficient where existing populations were present.

The lacustrine model includes all the same habitat variables.

1.3.8 COMMON SHINER

The HEP model was developed for the Project for Common Shiner as presented below and was prepared in a comparable fashion to other HIS models for Golder 2008 and Golder 2014. The HSI criteria were developed based off DFO HEAT habitat suitability matrices (DFO 2025), as well as USFWS Habitat Suitability Index Model (Trial et al. 1983), species information outlined by the New Hampshire Fish and Game Department and Wyoming Game and Fish Department (NHFG 2026; WGFD 2017) and existing literature (Scott and Crossman 1998, Becker 1983 and Page & Burr 1991). The HSI is to be set equal to the lowest of the SI values for the variables included in the model, although since this species is prevalent within the region the mean HSI value was applied and also to capture a moderate potential loss/gain scenario.

The riverine model includes the following habitat variables:

- V1 Substrate, where gravel and cobble/rubble substrates are ranked as SI = 1, sand substrates are ranked as SI = 0.5, boulder and bedrock substrates were ranked as SI = 0.25 and silt/clay and detritus are ranked as SI = 0. [Due to data limitations, fines were considered to consist of gravel, sand, silt/clay and detritus. Where all three fine-substrate components were present in the model, the full fines percentage was applied. Where only one component (e.g., sand only) was present in the model, the fines value was multiplied by one-fourth, and where two components (e.g., silt/clay and detritus) were present, one half of the fines value was applied.]
- V2 Instream Cover, where vegetation, woody debris and rock were ranked as SI = 1, other as SI = 0.25. [Applied dominant cover type, where SI = 1 if macrophytes, wood and/or rock and SI = 0.25 if other (e.g., undercut banks, no cover).]
- V3 Dominant Channel Morphology, where the area having flats, pools and/or backwaters were ranked as SI = 1, riffle areas as SI = 0.75, glides/runs were ranked as an SI =0.5, and rapids, chutes or falls were ranked as SI = 0.
- V4 Percent Instream Cover, where SI = 1 for instream cover >30% but <50%, SI = 0.75 where instream cover >50%, SI = 0.5 when instream cover is >20% and <30% and SI = 0.25 when instream cover is ≥0% but <20%.
- V5 Average water temperature in spawning habitat, where an SI of 1.0 was assigned where average spring temperatures were ≥15 and ≤17°C ; SI = 0.75 where temperatures were >12 and <15 °C or >17 and ≤19.5 °C; and an SI of 0 where temperatures were <12 °C or >19.5°C. Average spring temperature values from site specific monitoring were applied; where spring temperature data were unavailable, conditions were assumed to be sufficient where existing populations were present (SI = 0.5).
- V6 pH, where SI = 1 for pH values between 6.5 and 8.5; SI = 0.5 for pH values ≥12 and <15, or >17 and ≤19.5; SI = 0.25 for pH values >9 and <10; and SI = 0 for pH values ≤5.5 or ≥10. [Applied average pH; if no data was available, it was assumed sufficient where existing populations were present.]

The lacustrine model includes all the same habitat variables except for the following change:

- Dominant Channel Morphology variable was omitted from the model.
- Instream cover values were reassigned to in-water cover variables (V2).

1.3.9 CREEK CHUB

The HEP analysis was completed using the published HSI model available for assessment of the quality of riverine and lacustrine habitats for Creek Chub (McMahon 1982). The model includes habitat variables believed to be important in limiting distribution, abundance and survival of Creek Chub and represents all life stages. McMahon (1982) notes the models are applicable to any riverine environment within the range of Creek Chubs. Slight modifications were made to the lacustrine models. The Mean HSI value was applied to the models, since this species is prevalent within the region and to capture a moderate potential loss/gain scenario.

The riverine model includes the following habitat variables:

- V1 Percent pools during average summer flow, where an SI of 1.0 was assigned where pool habitat comprised ≥30% and ≤70% of the reach. An SI of 0.75 was assigned where pool habitat comprised ≥ 20% and <30% or >70% and ≤80%. An SI of 0.5 was assigned where pool habitat comprised ≥10% and <20% or >80% and ≤90%. An SI of 0 was assigned where pool habitat comprised <10% or >90%.
- V2 Pool dominance during average summer flow, where an SI of 0.6 was assigned where pools comprised ≥50% of the reach, and an SI of 0 was assigned where pools comprised <50%. Because detailed pool measurements were unavailable, all pools were assumed to be second class pools of sufficient size and depth to provide low velocity resting habitat for Creek Chub.
- V3 Percent cover during summer within pools and runs, where an SI of 1.0 was assigned where in stream cover was above 40%; an SI of 0.75 where cover was >20% and ≤40%; an SI of 0.5 where cover was >10% and ≤20%; an SI of 0.25 where cover was ≥0% and ≤10%; and an SI of 0 where no pool or run habitat was present.
- V4 Winter stream cover, where cover suitability was calculated as (V1×V2×V3)^(1/3)+0.2┤ , or 1.0, whichever was lower. It was assumed that access to larger, warmer streams was within 5 km of the study area.
- V5 Stream gradient within the sampling reach. [Assumed sufficient where existing populations were present (SI = 0.5).]
- V6 Average stream width during summer flow. [Assumed sufficient where existing populations were present (SI = 0.5).]
- V7 Maximum monthly average turbidity. [Assumed sufficient where existing populations were present (SI = 0.5).]
- V8 pH, where an SI of 1.0 was assigned where pH ranged from 6.0 to 7.5; an SI of 0.8 where pH ranged from 5.0 to 9.5; an SI of 0.5 where pH ranged from 6.0 to 9.0; an SI of 0.4 where pH ranged from 4.5 to 10.0; and an SI of 0 where pH values were <5.0 or >9.0. Average pH values were applied; where data were unavailable, conditions were assumed to be sufficient where existing populations were present.
- V9 Vegetation index, where the vegetation index was calculated as [2(% shrubs) + 1.5(% grasses) + (% trees) + 0(% bare ground)]. Due to data limitations, vegetation index was assumed sufficient where existing populations were present (SI = 0.5).
- V10 Food production potential by substrate type during summer flow, where an SI of 1.0 was assigned where vegetation in pool habitats was ≥30% and rubble/cobble substrates dominated riffle habitats, with some gravel and/or boulders present. An SI of 0.75 was assigned where pool vegetation ranged from 10–30% and rubble, gravel, and fines occurred in roughly equal proportions in riffle habitats. An SI of 0.5 was assigned where pool vegetation was <10% and rubble and gravel were present, but fines or boulders dominated. An SI of 0.2 was assigned where little to no vegetation

was present and fines or bedrock were the dominant substrates. Vegetation cover was assumed to be applicable across all channel unit types.

- V11 Average summer water temperature, where an SI of 1.0 was assigned where summer temperatures ranged from ≥16 to ≤24 °C. An SI of 0.5 was assigned where temperatures ranged from ≥10 to <16 °C or >24 to ≤28 °C. An SI of 0.2 was assigned where temperatures were >28 and <32 °C, and an SI of 0 where temperatures were ≥32 °C or <10 °C. Average summer temperature represents the mean water temperature measured in July and August. Average temperature values from site specific monitoring were applied; where data were unavailable, conditions were assumed to be sufficient where existing populations were present.
- V12 Minimum summer dissolved oxygen, where an SI of 1.0 was assigned where DO was ≥4 mg/L; an SI of 0.75 where DO was ≥3 and <4 mg/L; an SI of 0.4 where DO was ≥2 and <3 mg/L; an SI of 0.2 where DO was ≥1 and <2 mg/L; and an SI of 0 where DO was <1 mg/L.
- V13 Average current velocity during summer. [Assumed sufficient where existing populations were present (SI = 0.5).]
- V14 Average spring water temperature (embryo), where an SI of 1.0 was assigned where temperatures ranged from ≥14 to ≤20 °C; an SI of 0.75 where temperatures were >20 and ≤24 °C; an SI of 0.4 where temperatures were ≥10 and <14 °C; an SI of 0.2 where temperatures were >24 and <28 °C; and an SI of 0 where temperatures were ≥28 °C or <10 °C. Average spring temperature values from site specific monitoring were applied; where data were unavailable, conditions were assumed to be sufficient where existing populations were present.
- V15 Minimum spring dissolved oxygen, where an SI of 1.0 was assigned where DO was ≥6 mg/L; an SI of 0.8 where DO was ≥4 and <6 mg/L; an SI of 0.6 where DO was ≥3 and <4 mg/L; an SI of 0.4 where DO was ≥2 and <3 mg/L; an SI of 0.2 where DO was ≥1 and <2 mg/L; and an SI of 0 where DO was <1 mg/L.Minimum spring DO values from site specific monitoring were applied; where data were unavailable, conditions were assumed to be sufficient where existing populations were present (SI = 0.5).
- V16 Average current velocity during spring. [Assumed sufficient where existing populations were present (SI = 0.5).]
- V17 Substrate composition in riffle/run areas during spawning (embryo), where ann SI of 1.0 was assigned where the substrate index was ≥60; an SI of 0.75 where the index was ≥40 and <60; an SI of 0.5 where the index was ≥25 and <40; an SI of 0.25 where the index was ≥10 and <25; and an SI of 0 where the index was <10. The substrate index was calculated as: 2(% gravel) + (% cobble and boulders) + 0(% fines or bedrock). Where riffles or runs were absent, substrate suitability was assumed to be insufficient (SI = 0).
- V18 Velocity along stream margins during summer flow (fry). [Assumed sufficient where existing populations were present (SI = 0.5).]
- V19 Percent stream shading during midsummer (1000‑1500 h), where an SI of 1.0 was assigned where ≥60% of the stream was shaded; an SI of 0.75 where <60% was shaded; an SI of 0.5 where <40% was shaded; an SI of 0.25 where <25% was shaded; and an SI of 0 where <10% of the stream was shaded. Only trees and shrubs were assumed to contribute to shading; where riparian cover data were unavailable, shading was assumed not limiting (SI = 0.5).
- V20 Average maximum stream depth during average summer flow, where an SI of 1.0 was assigned where depths ranged from ≥0.8 to ≤1.2 m; an SI of 0.9 where depths were ≥1.2 and <1.6 m; an SI of 0.5 where depths were >1.6 and ≤2.0 m or >0.3 and <0.8 m; an SI of 0.3 where depths were above 2.0 m; and an SI of 0 where depths were ≤0.3 m.

For the lacustrine model, the riverine variables listed above were applied, with the following modifications: in-stream cover values were reassigned to in-water cover variables (V3 and V4), and all lake areas were treated as equivalent to pools (SI = 1.0). An SI value of 1.0 was also assumed for substrate-based food production potential (V10) across all waterbodies. Variables V5 and V6 were excluded from the lacustrine model, as they are specific to riverine conditions (i.e., stream gradient and channel width).

1.3.10 EMERALD SHINER

The HEP analysis was completed using the HSI criteria for Emerald Shiner as presented in Golder 2008. The HSI criteria were developed base off existing literature (McPhail and Lindsey 1970; Lee et al. 1980; Jude and Pappas 1992; Nelson and Paetz 1992; Jenkins and Burkhead 1993; Mayo et al. 1998; Scott and Crossman 1998; Bradbury et al. 1999; Portt et al. 1999; Langhorne et al. 2001; Richardson et al. 2001; Franzin et al. 2003), professional expertise and workshop outcomes (Golder 2008). The HSI is to be set equal to the lowest of the SI values for the variables included in the model, although since this species is prevalent within the region the mean HSI value was applied and also to capture a moderate loss/gain scenario.

The riverine model includes the following habitat variables:

- V3 Channel Unit, where the area having flats/pools were ranked as SI = 1, runs as SI = 0.5, runs were ranked as an SI =0.5, riffles as SI = 0.25; rapids were ranked as SI = 0.
- V5 Late winter dissolved oxygen, SI = 1.0 when >4 mg/L and SI= 0.5 when ≥2 to 4 mg/L and SI = 0 when <2 mg/L. Late winter DO criteria are based on the assumptions that if measured late winter DO is greater than the indicated concentration, DO is not limiting at any time of year, and if measured late winter DO is less than the indicated concentration, DO may be limiting in winter but not during the open-water period. In addition, since DO is not measured in all areas within a watercourse or waterbody, there may exist some local areas where late winter DO is greater than the measured concentrations. [Applied average winter DO values collected through site-specific monitoring; where winter dissolved oxygen data was unavailable, it was assumed sufficient where existing populations were present.]
- V6 pH, where the SI 1 when pH 6.5 to 8.5 and SI = 0.5 for pH range of >6 to 6.5 and >8.5 to 9.5 and SI = 0 when pH values are ≤6.0 or >9.0. [Applied average pH; if no data was available, it was assumed sufficient where existing populations were present.]

The lacustrine model includes all the same habitat variables except for the following changes:

- V3 Depth, where SI = 1.0 for habitats > 3m depth, SI = 0.5 for >1 m to 3m depth and SI = 0.25 for >0 to 1 m depths.

1.3.11 FATHEAD MINNOW

The HEP analysis was completed using the HSI criteria for Fathead Minnow as presented in Golder 2014. The HSI criteria were developed base off existing literature including Bradbury et al. 1999, Coker 2001, Lane 1996a and 1996b, Scott and Crossman 1998, Fishbase 2012 and Page and Burr 1991. The HSI is to be set equal to the lowest of the SI values for the variables included in the model, although since this species is prevalent within the region the mean HSI value was applied and also to capture a moderate loss/gain scenario.

The riverine model includes the following habitat variables:

- V1 Substrate, where gravel, sand, and silt/clay substrates were assigned an SI of 1.0; boulder and cobble/rubble substrates were assigned an SI of 0.5; and bedrock substrates were assigned an SI of 0.25.
- V2 In stream cover, where macrophytes (e.g., emergent and submergent vegetation) were assigned an SI of 1.0, while other cover types (e.g., woody debris and rock) were assigned an SI of 0.5.
- V3 Spawning material, where an SI of 1.0 was assigned where rocks, logs, debris, and/or vegetation were present; an SI of 0.5 was assigned where only vertical surfaces of emergent vegetation were

present; and an SI of 0 was assigned where no suitable spawning material was present. Vegetation included both submergent and emergent plants.

- V4 Channel unit, where pools, backwater areas, and flats were assigned an SI of 1.0; runs and glides were assigned an SI of 0.75; riffles were assigned an SI of 0.25; and rapids, chutes, and falls were assigned an SI of 0.
- V5 Percent in stream cover, where an SI of 1.0 was assigned where in stream cover was above 50%; an SI of 0.75 where cover was >30% and <50%; an SI of 0.5 where cover was >20% and ≤30%; an SI of 0.25 where cover was >0% and <20%; and an SI of 0 where in stream cover was absent.
- V6 Late winter dissolved oxygen, where an SI of 1.0 was assigned where dissolved oxygen concentrations were ≥1 mg/L, and an SI of 0.5 where concentrations were <1 mg/L.

Average DO values from site specific monitoring were applied; where winter dissolved oxygen data were unavailable, conditions were assumed to be sufficient where existing populations were present.

- V7 pH, where an SI of 1.0 was assigned where pH ranged from 6.0 to 9.0; an SI of 0.5 where pH ranged from 5.5 to <6.0; and an SI of 0 where pH values were <5.5 or >9.0.Average pH values were applied; where data were unavailable, conditions were assumed to be sufficient where existing populations were present.

The lacustrine model includes all the same habitat variables except for the following changes:

- Channel unit variable was omitted from the model.
- Instream cover values were reassigned to in-water cover variables (V2 and V5)

1.3.12 FINESCALE DACE

The HEP analysis was completed using the HSI criteria for Finescale Dace as presented in Golder 2008. The HSI criteria were developed base off existing literature (Das and Nelson 1990; Scott and Crossman 1998; Schlosser et al. 1998; Langhorne et al. 2001; Richardson et al. 2001; Stasiak and Cunningham 2006), professional expertise and workshop outcomes (Golder 2008). The HSI is to be set equal to the lowest of the SI values for the variables included in the model, although since this species is prevalent within the region the mean HSI value was applied and also to also to capture a moderate potential loss/gain scenario.

The riverine model includes the following habitat variables:

- V1 Substrate, where gravel, sand, clay/silt substrates the SI =1, whereas cobble, rubble substrates are ranked as SI = 0.5, boulder and bedrock was ranked as SI = 0.25. [Due to data limitations, dominant substrate type was applied, where SI = 1 if fines (e.g., clay, silt, organics) and SI = 0 if another substrate type is dominant.]
- V2 Instream Cover, where submergent and emergent vegetation, woody debris and inundated vegetation were ranked as SI = 1, boulder/cobble/rubble as SI = 0.5 and bedrock as SI = 0.25. [Applied dominant cover type, where SI = 1 if macrophytes and SI = 0.25 if rock (e.g., cobble or boulder).]
- V3 Channel Unit, where the area having flats pools and backwaters were ranked as SI = 1, Percent area of runs as SI = 0.5, runs were ranked as an SI =0.5, riffles as SI = 0.25; rapids, chutes and falls were ranked as SI = 0.
- V4 Percent Instream Cover, where SI = 1 for instream cover >50%, SI = 0.75 instream cover >30% but <50%, SI = 0.5 when instream cover is >20% and <30% and SI = 0.25 when instream cover is >0% but <20%.
- V5 Late winter dissolved oxygen, SI = 1.0 when ≥1 mg/L and SI= 0.5 when <1 mg/L. Late winter DO criteria are based on the assumptions that if measured late winter DO is greater than the indicated concentration, DO is not limiting at any time of year, and if measured late winter DO is less than the

indicated concentration, DO may be limiting in winter but not during the open-water period. In addition, since DO is not measured in all areas within a watercourse or waterbody, there may exist some local areas where late winter DO is greater than the measured concentrations. [Applied average winter DO values collected through site-specific monitoring; where winter dissolved oxygen data was unavailable, it was assumed sufficient where existing populations were present.]

- V6 pH, where the SI 1 when pH 6 to 9 and SI = 0.5 for pH range of 5.5 to <6 and SI = 0 when pH values are <5.0 or >9.0. [Applied average pH; if no data was available, it was assumed sufficient where existing populations were present.]

The lacustrine model includes all the same habitat variables except for the following changes:

- V3 Depth, where SI = 1 when depth is ≤2 m; SI = 0.5 when depth is >2 m to 5 m and SI = 0.25 when depth is >5 m.
- V4 percent littoral zone cover, where SI = 1 for instream cover >50%, SI = 0.75 instream cover >30% but <50%, SI = 0.5 when instream cover is >20% and <30% and SI = 0.25 when instream cover is >0% but <20%.

1.3.13 GREEN SUNFISH

The HEP model was developed for the Project for Green Sunfish as presented below and was prepared in a comparable fashion to other HSI models for Golder 2008 and Golder 2014. The HSI criteria were developed based off DFO HEAT habitat suitability matrices (DFO 2025), as well as USFWS Habitat Suitability Index Model (Stuber et al. 1982), species information outlined by the Alberta Invasive Species Council and Oregon State University (Alberta Invasive Species Council 2018; OSU 2026) and existing literature (Scott and Crossman 1998, Becker 1983 and Page & Burr 1991). The HSI is to be set equal to the lowest of the SI values for the variables included in the model, although the mean HSI value was applied and also to capture a moderate loss/gain scenario.

The riverine model includes the following habitat variables:

- V1 Channel Morphology, where pool habitats were assigned an SI of 1.0; runs, glides, and flats were assigned an SI of 0.75; riffles were assigned an SI of 0.5; and rapids, chutes, and falls were assigned an SI of 0.25.
- V2 Substrate, where fine substrates (sand, silt, and gravel) were assigned an SI of 1.0; coarse substrates (boulder and cobble/rubble) were assigned an SI of 0.25; and bedrock substrates were assigned an SI of 0.0.
- V3 Instream Cover, where macrophytes (e.g., emergent and submergent vegetation), rock, and woody material were assigned an SI of 1.0, while other cover types (e.g., undercut banks) were assigned an SI of 0.25.
- V4 Late winter dissolved oxygen, where an SI of 1.0 was assigned to dissolved oxygen concentrations ≥5 mg/L, and an SI of 0.25 where concentrations were <5 mg/L. [Applied average DO values collected through site-specific monitoring; where winter dissolved oxygen data was unavailable, it was assumed sufficient where existing populations were present.]
- V5 pH, where pH ranging from 6.5 to 8.5 was assigned an SI =1 and an SI of 0.25 was assigned for pH values <6.5 or >8.5. [Applied average pH; if no data was available, it was assumed sufficient where existing populations were present.]

The lacustrine model includes all the same habitat variables except for the following changes:

- Channel morphology variable was omitted from the model.
- Instream cover values were reassigned to in-water cover variables (V2)

1.3.14 GOLDEN SHINER

The HEP analysis was completed using the HSI criteria for Golden Shiner as presented in Golder 2008. The HSI criteria were developed base off existing literature (Coker 2001, Lane 1996a, Portt 1999, Scott and Crossman 1998, Fishbase 2012, and Page and Burr 1991), professional expertise and workshop outcomes (Golder 2008). The HSI is to be set equal to the lowest of the SI values for the variables included in the model, although the mean HSI value was applied and also to capture a moderate potential loss/gain scenario.

The riverine model includes the following habitat variables:

- V1 Substrate, where gravel or sand substrates were assigned an SI = 1, clay/silt substrates were assigned an SI = 0.5, and boulder, bedrock, cobble or rubble substrates were assigned an SI = 0.25. [Due to data limitations, fines were considered to consist of gravel, sand, and silt/clay. Where all three fine-substrate components were present in the model, the full fines percentage was applied. Where only one component (e.g., clay/silt only) was present in the model, the fines value was multiplied by one third, and where two components (e.g., gravel and sand) were present, two thirds of the fines value was applied.]
- V2 Instream Cover where vegetation (e.g., emergent/submergent vegetation and filamentous algae), was assigned an SI = 1.0, while rock cover types (e.g., rubble or cobble) were assigned an SI of 0.25.
- V3 Dominant Channel Morphology, where flats, pools and backwater areas were assigned an SI = 1, runs were assigned an SI = 0.5 riffles were assigned an SI =0.25 and rapids, chutes and falls were assigned an SI = 0.
- V4 Percent Instream Cover, where SI = 1 for instream cover >50%, SI = 0.75 instream cover >30% but <50%, SI = 0.5 when instream cover is >20% and <30% and SI = 0.25 when instream cover is >0% but <20%.
- V5 Late winter dissolved oxygen, where SI = 1.0 when DO was ≥2 mg/L and SI= 0.25 when DO <2 mg/L. Late winter DO criteria are based on the assumptions that if measured late winter DO is greater than the indicated concentration, DO is not limiting at any time of year, and if measured late winter DO is less than the indicated concentration, DO may be limiting in winter but not during the open-water period. In addition, since DO is not measured in all areas within a watercourse or waterbody, there may exist some local areas where late winter DO is greater than the measured concentrations. [Applied average winter DO values collected through site-specific monitoring; where winter dissolved oxygen data was unavailable, it was assumed sufficient where existing populations were present.]
- V6 pH, where the SI = 1 when pH ranged from 6 to 7.5, SI = 0.5 when pH values were 5 to <6 and SI = 0 when pH values were <5.0 or >9.0. [Applied average pH; if no data was available, it was assumed sufficient where existing populations were present.]

The lacustrine model includes all the same habitat variables except for the following changes:

- Dominant channel morphology variable was omitted from the model (V2).
- Instream cover values were reassigned to in-water cover variables (V3 and V4).

1.3.15 IOWA DARTER

The HEP analysis was completed using the HSI criteria for Iowa Darter as presented in Golder 2008. The HSI criteria were developed base off existing literature (Portt 1999, Scott and Crossman 1998, Bradbury et al. 1999, Lane 1996a and Lane 1996b), professional expertise and workshop outcomes (Golder 2008). The HSI is to be set equal to the lowest of the SI values for the variables included in the model, although since this species is prevalent within the region the mean HSI value was applied and to capture a moderate potential loss/gain scenario.

The riverine model includes the following habitat variables:

- V1 Dominant substrate type, where gravel or sand substrates were assigned an SI = 1, clay/silt and detritus substrates were assigned an SI = 0.5, cobble or rubble substrates were assigned an SI = 0.25, and bedrock and boulder substrates were assigned an SI = 0. [Due to data limitations, fines were considered to consist of gravel, sand, silt/clay and detritus. Where two fine-substrate components were present in the model (e.g., gravel and sand), one-half of the fines value was applied.
- V2 Cover type, where vegetation and undercut banks were assigned an SI = 1.0, while other cover types (e.g., rock, wood) were assigned an SI of 0.25.
- V3 Dominant Channel Morphology, pool habitats were assigned an SI = 1, flats and backwater areas were assigned an SI = 0.75, runs/glides were assigned an SI =0.25 and riffles and rapids were assigned an SI = 0.
- V4 Late winter dissolved oxygen, where SI = 1.0 when DO was >4 mg/L, SI= 0.5 when DO ≥2 and < 4 mg/L and SI = 0.25 when DO <2. Late winter DO criteria are based on the assumptions that if measured late winter DO is greater than the indicated concentration, DO is not limiting at any time of year, and if measured late winter DO is less than the indicated concentration, DO may be limiting in winter but not during the open-water period. In addition, since DO is not measured in all areas within a watercourse or waterbody, there may exist some local areas where late winter DO is greater than the measured concentrations. [Applied average winter DO values collected through site-specific monitoring; where winter dissolved oxygen data was unavailable, it was assumed sufficient where existing populations were present.]
- V5 pH, where the SI = 1 when pH ranged from 6.5 to 8.5, SI = 0.5 when pH values were >6 to 6.5 or >8.5 to 9.5 and SI = 0 when pH values were ≤6.0 or >9.5. [Applied average pH; if no data was available, it was assumed sufficient where existing populations were present.]

The lacustrine model includes all the same habitat variables except for the following changes:

- Dominant channel morphology variable was omitted from the model.
- Instream cover values were reassigned to in-water cover variables (V2).

1.3.16 JOHNNY DARTER

The HEP analysis was completed using the HSI criteria for Johnny Darter as presented in Golder 2008. The HSI criteria were developed base off existing literature (Portt 1999, Scott and Crossman 1998, Bradbury et al. 1999, Lane 1996a and Lane 1996b), professional expertise and workshop outcomes (Golder 2008). The HSI is to be set equal to the lowest of the SI values for the variables included in the model, although the mean HSI value was applied and to capture a moderate potential loss/gain scenario.

The riverine model includes the following habitat variables:

- V1 Dominant substrate type, where gravel or sand substrates were assigned an SI = 1, clay/silt, boulder, cobble or rubble were assigned an SI = 0.5 and bedrock and detritus substrates were assigned an SI = 0.25. [Due to data limitations, fines were considered to consist of gravel, sand, silt/clay and detritus. Where two fine-substrate components were present in the model (e.g., gravel and sand), one-half of the fines value was applied and when one component was present (e.g., detritus), one-fourth of the value was applied.
- V2 Cover type, where vegetation, wood, and substrate were assigned an SI = 1.0, while other cover types (e.g., undercut banks) were assigned an SI of 0.25.
- V3 Dominant Channel Morphology, pool, run and flat habitats were assigned an SI = 1, riffle and backwater areas were assigned an SI = 0.25, and rapids were assigned an SI = 0.
- V4 Late winter dissolved oxygen, where SI = 1.0 when DO was >4 mg/L, SI= 0.5 when DO ≥2 and < 4 mg/L and SI = 0.25 when DO <2. Late winter DO criteria are based on the assumptions that if measured late winter DO is greater than the indicated concentration, DO is not limiting at any time of

year, and if measured late winter DO is less than the indicated concentration, DO may be limiting in winter but not during the open-water period. In addition, since DO is not measured in all areas within a watercourse or waterbody, there may exist some local areas where late winter DO is greater than the measured concentrations. [Applied average winter DO values collected through site-specific monitoring; where winter dissolved oxygen data was unavailable, it was assumed sufficient where existing populations were present.]

- V5 pH, where the SI = 1 when pH ranged from 6.5 to 8.5, SI = 0.5 when pH values were >6 to 6.5 or >8.5 to 9.5 and SI = 0 when pH values were ≤6.0 or >9.5. [Applied average pH; if no data was available, it was assumed sufficient where existing populations were present.]

The lacustrine model includes all the same habitat variables except for the following changes:

- Dominant channel morphology variable was omitted from the model.
- Instream cover values were reassigned to in-water cover variables (V2).

1.3.17 LAKE CHUB

The HEP analysis was completed using the HSI criteria for Lake Chub as presented in Golder 2014. The HSI criteria were developed base off existing literature including Bradbury et al. 1999, Coker 2001, Lane 1996a and 1996b, Scott and Crossman 1998, Fishbase 2012 and Page and Burr 1991. The HSI is to be set equal to the lowest of the SI values for the variables included in the model, although since this species is prevalent within the region the mean HSI value was applied and to capture a moderate potential loss/gain scenario.

The riverine model includes the following habitat variables:

- V1 Substrate, where boulder, cobble, rubble or gravel substrates were assigned an SI = 1 and sand, silt/clay and boulder substrates were assigned an SI = 0.5. [Due to data limitations, fines were considered to consist of gravel, sand, and silt/clay. Where two fine-substrate components were present in the model (e.g., sand and silt/clay), two-thirds of the fines value was applied and when one component was present (e.g., gravel), one-third of the value was applied.
- V2 Instream cover, where vegetation, wood, or substrate (rubble, cobble, and boulders) were assigned an SI = 1.0.
- V3 Channel unit, where pool, run and flat habitats were assigned an SI = 1, riffles were assigned an SI = 0.5, and rapids were assigned an SI = 0.
- V4 % Instream cover, where instream coverage >20 to 50% was assigned an SI of 1, coverage of >10 to 20% or >50 to 65% was assigned an SI of 0.75, coverage of >5 to 10% and >65 to 75% was assigned an SI of 0.5, and coverage of 0 to 5 % and >75 to 100% was assigned an SI of 0.25.
- V5 Late winter dissolved oxygen, where SI = 1.0 when DO was ≥1 mg/L and SI= 0.25 when DO <1. Late winter DO criteria are based on the assumptions that if measured late winter DO is greater than the indicated concentration, DO is not limiting at any time of year, and if measured late winter DO is less than the indicated concentration, DO may be limiting in winter but not during the open-water period. In addition, since DO is not measured in all areas within a watercourse or waterbody, there may exist some local areas where late winter DO is greater than the measured concentrations. [Applied average winter DO values collected through site-specific monitoring; where winter dissolved oxygen data was unavailable, it was assumed sufficient where existing populations were present.]
- V6 pH, where the SI = 1 when pH ranged from 6 to 9, SI = 0.5 when pH values ranged from 5.5 to <6 and SI = 0 when pH values were <5.5 or >9. [Applied average pH; if no data was available, it was assumed sufficient where existing populations were present.]

The lacustrine model includes all the same habitat variables except for the following changes:

- Instream cover values were reassigned to in-water cover variables (V2).

– Channel unit variable was omitted from the model.
– V2 Depth, where a waterbody depth of ≤ 2 m was assigned an SI of 1, depth of >2 to 5 m was assigned an SI of 0.75 and a depth > 5 m was assigned an SI of 0.25.
– Instream cover values were reassigned to % littoral cover (V4).
– V5 Late winter dissolved oxygen, where SI = 1.0 when DO was >2 mg/L, SI = 0.75 when DO was 1 to 2 mg/L and SI= 0.25 when DO <1.

1.3.18 LAKE WHITEFISH

The HEP analysis was completed using the published HEP models available for assessment of the quality of lacustrine habitats for Lake Whitefish, that was based on literature review and discussions with DFO (Golder 2008). An HEP model is not available for riverine habitats; however, due to Lake Whitefish presence in the Chukuni River, habitat quality was assessed using lacustrine variables. Any other habitat conditions not considered below, are considered as suitable where species are present and are not included in the model. As per the model, the SI is to be the minimum criteria value, although the species and suitable habitats are prevalent in the study area and therefore the mean SI for all variables were calculated to capture a moderate potential loss/gain scenario.

The lacustrine model evaluates the of habitats for Lake Whitefish based on the following variables:

– V1 spawning materials (NB: assumes depth of >1 to 5 m and exposure to wind and wave action) [SI value of 1 = boulders, cobble, rubble and gravel; 0.5 = sand, 0.25 = clay/silt and 0 = bedrock, mud, detritus/organics]
– V2 late winter dissolved oxygen levels (mg/L) (SI = 1, DO>7; SI = 0.75 DO >5 and <7; SI = 0.5, DO>4 and <5; SI = 0.25, DO >3 and <4; and SI = 0, DO≤3). [Assumed sufficient where existing populations were present.]

1.3.19 LONGNOSE DACE

The HEP analysis was completed using the HSI criteria for Longnose Dace as presented in Golder 2008. The HSI criteria were developed base off existing literature (Portt 1999, Scott and Crossman 1998, Bradbury et al. 1999, Lane 1996a and Lane 1996b), professional expertise and workshop outcomes (Golder 2008). The HSI is to be set equal to the lowest of the SI values for the variables included in the model, although the mean HSI value was applied and to capture a moderate potential loss/gain scenario.

The riverine model includes the following habitat variables:

– V1 Dominant substrate type, where boulder, rubble or cobble substrates were assigned an SI = 1, gravel substrates were assigned an SI = 0.75 and sand substrates were assigned an SI = 0.25 and clay/silt substrates were assigned an SI = 0. [Due to data limitations, fines were considered to consist of gravel, sand, and silt/clay. Where only one fine-substrate component was present (e.g., gravel), one-third of the value was applied.
– V2 Instream cover, where rock (boulder, bedrock, rubble, cobble) were assigned an SI = 1.0, while woody debris was assigned an SI = 0.25 and vegetation (emergent, submergent and inundated vegetation) were assigned an SI = 0.
– V3 Channel unit, where riffle habitats were assigned an SI = 1, rapids were assigned an SI = 0.75, runs were assigned an SI = 0.5, flats and pools were assigned an SI = 0.25, and chutes and falls were assigned an SI = 0.
– V4 % Instream cover, where instream coverage >25 to 75% was assigned an SI of 1, coverage of >10 to 25% or >75 to 90% was assigned an SI of 0.75, coverage of >5 to 10% and >90 to 100% was assigned an SI of 0.5, and coverage of 0 to 5 % was assigned an SI of 0.25.

- V5 Late winter dissolved oxygen, where SI = 1.0 when DO was ≥2 mg/L and SI = 0. 5 when DO <2. Late winter DO criteria are based on the assumptions that if measured late winter DO is greater than the indicated concentration, DO is not limiting at any time of year, and if measured late winter DO is less than the indicated concentration, DO may be limiting in winter but not during the open-water period. In addition, since DO is not measured in all areas within a watercourse or waterbody, there may exist some local areas where late winter DO is greater than the measured concentrations. [Applied average winter DO values collected through site-specific monitoring; where winter dissolved oxygen data was unavailable, it was assumed sufficient where existing populations were present.]
- V6 pH, where the SI = 1 when pH ranged from 6 to 9, SI = 0.5 when pH values were 5.5 to <6 and SI = 0 when pH values were < 5.5 or >9.5. [Applied average pH; if no data was available, it was assumed sufficient where existing populations were present.]

The lacustrine model includes all the same habitat variables except for the following changes:

- Instream cover values were reassigned to in-water cover variables (V2 and V3).
- Channel unit variable was omitted from the model.

1.3.20 MIMIC SHINER

The HEP analysis was completed using the HSI criteria for Mimic Shiner as presented in Golder 2008. The HSI criteria were developed base off existing literature (Coker 2001, Portt 1999, Scott and Crossman 1998, Fishbase 2012, Page and Burr 19991, Bradbury et al. 1999, Lane 1996a and Lane 1996b), professional expertise and workshop outcomes (Golder 2008). The HSI is to be set equal to the lowest of the SI values for the variables included in the model, although since this species is prevalent within the region the mean HSI value was applied and to capture a moderate potential loss/gain scenario.

The riverine model includes the following habitat variables:

- V1 Substrate, where gravel, sand or clay/silt substrates were assigned an SI = 1, and bedrock, boulder, cobble or rubble substrates were assigned an SI = 0.25. [Due to data limitations, fines were considered to consist of gravel, sand, and silt/clay. Where all three fine-substrate components were present in the model, the full fines percentage was applied.]
- V2 Instream cover, where vegetation (submergent or emergent) was assigned an SI = 0.75, while rock coverage (boulder and cobble) was assigned an SI = 0.25.
- V3 Dominant channel morphology, where riffle or pool habitats were assigned an SI = 1, flats and runs were assigned an SI = 0.5, and rapids, chutes and falls were assigned an SI = 0.
- V4 % Instream cover, where instream coverage >50% was assigned an SI of 1, coverage of >30 to 50% was assigned an SI of 0.75, coverage of >20 to 30% was assigned an SI of 0.5, coverage of 0 to 20% was assigned an SI of 0.25 and 0% coverage was assigned an SI of 0.
- V5 Late winter dissolved oxygen, where SI = 1.0 when DO was ≥2 mg/L and SI = 0. 25 when DO <2. Late winter DO criteria are based on the assumptions that if measured late winter DO is greater than the indicated concentration, DO is not limiting at any time of year, and if measured late winter DO is less than the indicated concentration, DO may be limiting in winter but not during the open-water period. In addition, since DO is not measured in all areas within a watercourse or waterbody, there may exist some local areas where late winter DO is greater than the measured concentrations. [Applied average winter DO values collected through site-specific monitoring; where winter dissolved oxygen data was unavailable, it was assumed sufficient where existing populations were present.]
- V6 pH, where the SI = 1 when pH was ≥ 6.0 to 7, SI =0.5 when pH values were 5.0 to < 6.0 and SI = 0 when pH values were < 5.0 or >9. [Applied average pH; if no data was available, it was assumed sufficient where existing populations were present.]

The lacustrine model includes all the same habitat variables except for the following changes:

- Instream cover values were reassigned to in-water cover variables (V2 and V4).

- Channel unit variable (V3) was omitted from the model.

1.3.21 MOONEYE

The HEP model was developed for the Project for Mooneye as presented below. The HSI criteria were developed based off DFO HEAT habitat suitability matrices (DFO 2025), the Mooneye species status assessment (New York Department of Environmental Conservation 2023) and existing literature (Scott & Crossman 1998, Page & Burr 1991, Minns et al. 2010). The HSI is to be set equal to the lowest of the SI values for the variables included in the model, although the mean HSI value was applied and to capture a moderate loss/gain scenario.

The riverine model includes the following habitat variables:

- V1 Depth, where an SI of 1.0 was assigned to depths ranging from 2 to 5 m, an SI of 0.75 was assigned to depths ranging from 5 to 10 m and an SI of 0.25 was assigned to depths < 2 m or > 10 m.
- V2 Substrate, where fine substrates (sand, silt, and gravel) were assigned an SI of 1.0; coarse substrates (boulder and cobble/rubble) were assigned an SI of 0.25; and bedrock substrates were assigned an SI of 0.0.
- V3 Channel Morphology, where pool habitats were assigned an SI of 1.0; runs, glides, and flats were assigned an SI of 0.75; riffles were assigned an SI of 0.5; and other habitat areas (rapids, chutes, and falls) were assigned an SI of 0.25.
- V4 Instream Cover, where no cover was assigned an SI of 1.0, vegetation was assigned an SI of 0.5, rock was assigned an SI of 0.25 and other (i.e., undercut banks, woody debris) was assigned an SI of 0.25.
- V5 Spawning temperature, where average spring temperatures ranging from 10 to 13°C were assigned an SI of 1 and spring temperatures <10 or >13°C were assigned an SI of 0.25. [Applied average spring temperature values collected through site-specific monitoring; where spring temperature data was unavailable, it was assumed sufficient where existing populations were present (SI = 0.5)].
- V6 Late winter dissolved oxygen, where an SI of 1.0 was assigned to dissolved oxygen concentrations ≥6.5 mg/L, and an SI of 0.25 where concentrations were <6.5 mg/L. [Applied average DO values collected through site-specific monitoring; where winter dissolved oxygen data was unavailable, it was assumed sufficient where existing populations were present.]
- V7 pH, where pH ranging from 6.5 to 9 was assigned an SI =1 and an SI of 0.25 was assigned for pH values <6.5 or >9. [Applied average pH; if no data was available, it was assumed sufficient where existing populations were present.]

The lacustrine model includes all the same habitat variables except for the following changes:

- Channel morphology variable (V3) was omitted from the model.
- Instream cover values were reassigned to in-water cover variables.

1.3.22 MUSKELLUNGE

The HEP analysis was completed using the published HSI model available for assessment of the quality of lacustrine habitats for Muskellunge (Cook and Solomon 1987). The model is designed to determine the highest HIS’s possible for lacustrine systems capable of producing muskellunge biomass on a sustained basis and is applicable to lacustrine habitats (lakes and reservoirs) anywhere in North America (Cook and Solomon 1987). Although developed for lacustrine habitats, the same variables and assumptions were applied to the riverine models. The Mean HSI value was applied to the models, since this species is prevalent within the region and to capture a moderate potential loss/gain scenario.

The lacustrine model includes the following habitat variables:

- V1 Secchi disk water transparency. [Assumed sufficient where existing populations are present (i.e., SI = 0.5).]
- V2 Relative abundance of forage fish (<12 cm) during spring and summer. [Assumed sufficient where existing populations are present (i.e., SI = 0.5).]
- V3 Size diversity of forage fish. [Assumed sufficient where existing populations are present (i.e., SI = 0.5).]
- V4 Late winter dissolved oxygen, where an SI of 1.0 was assigned to dissolved oxygen concentrations ≥6 mg/L, and an SI of 0.25 where concentrations were <6 mg/L. [Applied average DO values collected through site-specific monitoring; where winter dissolved oxygen data was unavailable, it was assumed sufficient where existing populations were present.]
- V5 Maximum water temperature epilimnion, where average summer temperatures ≥ 20 and ≤ 28° C were assigned an SI of 1, SI = 0.5 when temperatures ranged from 15 to 20° C or 28 to 32° C, and SI = 0 for temperatures < 15° C or > 32° C. [Applied average summer temperature values collected through site-specific monitoring; where summer temperature data was unavailable, it was assumed sufficient where existing populations were present (SI = 0.5)].
- V6 % of midsummer area with emergent or submergent aquatic vegetation and terrestrial plants, where an SI of 1 was assigned to areas with >25 and ≤ 75% vegetation coverage, and SI of 0.75 was assigned to areas with >10 and ≤25% or >75% and ≤100% vegetation coverage, and an SI of 0 when vegetation coverage was ≤10%.
- V7 Minimum dissolved oxygen levels in spawning and nursery areas (spring), where SI = 1 where minimum spring DO levels were ≥5.5 mg/L, and SI=0.5 where DO levels were <5.5 mg/L. [Applied minimum spring DO values collected through site-specific monitoring; where spring dissolved oxygen data was unavailable, it was assumed sufficient where existing populations were present. (SI=0.5)].
- V8 Drop in water level during embryo and early larval stages. [Assumed sufficient where existing populations are present (i.e., SI = 0.5).]
- V9 Ratio of spawning habitat to summer habitat. [Assumed sufficient where existing populations are present (i.e., SI = 0.5).]
- V10 Northern Pike density. [Assumed sufficient where existing populations are present (i.e., SI = 0.5).]
- V11 Waterbody Size, where waterbodies ≥ 100 ha were assigned an SI of 1.0, waterbodies ≥ 10 and <100 ha were assigned an SI of 0.5 and waterbodies <10 ha were assigned an SI of 0. [Where size data was unavailable, it was assumed sufficient where existing populations were present. (SI=0.5)].

1.3.23 NORTHERN PEARL DACE

The HEP analysis was completed using the HSI criteria for Slimy Sculpin as presented in Golder 2008. The HSI criteria were developed base off existing literature (Nelson and Paetz 1992; Ford et al. 1995; Lane et al. 1996; Scott and Crossman 1998; Bradbury et al. 1999; Portt et al. 1999; Langhorne et al. 2001; Richardson et al 2001). The HSI was to be set equal to the lowest of the SI values for the variables included in the model, although since this species is prevalent within the region the mean HSI value was applied and also to capture a moderate potential loss/gain scenario.

The riverine model includes the following habitat variables:

- V1 Substrate, where gravel, sand, clay/silt substrates (i.e., fines) are ranked as SI =1, whereas rubble and cobble substrates ranked as SI = 0.25 and boulder and bedrock were ranked as SI = 0.25.
- V2 Instream Cover, where vegetation, woody debris, submergent and emergent plants were ranked as SI = 1, rubble and cobble as SI = 0.5 and boulder and bedrock as SI = 0.25.

- V3 Channel Unit, where percent area having pools, runs, flats were ranked as SI = 1, percent area of riffles as SI = 0.5 and rapids as SI = 0.
- V4 Percent Instream Cover, where SI = 1 for instream cover >20% to <50%, SI = 0.75 instream cover >10% to <20% or >50% to <65%, SI = 0.5 when instream cover is >5% and <10%or >65% to <75% and SI = 0.25 when instream cover is >0% to 5% or >75% to <100%.
- V5 Late winter dissolved oxygen, SI = 1.0 when ≥1 mg/L and SI= 0.5 when <1 mg/L. [Applied average winter DO values collected through site-specific monitoring; where winter dissolved oxygen data was unavailable, it was assumed sufficient where existing populations were present.]
- V6 pH, where values between 6 to 9 were ranked as SI = 1, values from 5.5 to <6 were ranked as SI = 0.5 and values <5.5 or >9 were ranked as 0.

The lacustrine model includes all the same habitat variables except for the following changes:

- V3 Depth, where SI = 1 when depth is ≤2 m; SI = 0.5 when depth is >2 m to 5 m and SI = 0.25 when depth is >5 m.
- V4 Littoral Cover, where SI = 1 for instream cover >20% to <50%, SI = 0.75 instream cover >10% to <20% or >50% to <65%, SI = 0.5 when instream cover is >5% and <10%or >65% to <75% and SI = 0.25 when instream cover is >0% to 5% or >75% to <100%.

1.3.24 NORTHERN PIKE

The HEP analysis was completed using the published HEP model available for assessment of the quality of riverine and lacustrine habitats for Northern Pike (Inskip 1982; Casselman and Lewis 1996). The model includes variables that are believed to be of general importance in determining habitat suitability for Northern Pike and represents all life stages (spawning, embryo, fry, juveniles and adults). Inskip (1982) notes that the model is applicable to lakes, reservoirs, rivers and streams throughout North America (Golder 2008).

The riverine model evaluates the suitability of habitats for Northern Pike based on the following ten variables:

- V1 Ratio of spawning habitat area to summer habitat area (This ratio was determined based on the estimated proportion of the area that would be less than 1 m deep during spring and with aquatic vegetation or debris). [Assumed sufficient where existing populations are present.]
- V2 Drop in water level (m) during embryo and fry stages (defined as the period from spawning through to the end of June). [Applied average depths and water level observations taken during site-specific monitoring.]
- V3 Percent of midsummer area with emergent or submergent aquatic vegetation. [Due to data limitations, applied percent macrophyte cover.]
- V4 Log10 of total dissolved solids concentration in surface waters during midsummer. [Assumed sufficient where existing populations are present.]
- V5 Least suitable pH in spawning habitat during embryo and fry stages. [Due to data limitations, applied least suitable pH across all seasons.]
- V6 Average length of the frost-free season (days). [Assumed sufficient where existing populations are present.]
- V7 Maximal weekly average temperature (°C) of surface waters (using the warmest week (7 days) of the year, take the average of the 7 daily peak temperatures during that period). [Applied average summer water temperature based on site-specific monitoring.]
- V8 Area of backwaters, pools or standing water (< 5 cm/s) during summer, as a percent of the total surface area. [Due to data limitations, applied percent pools and flats.]

- V9 Stream gradient (m/km) (assume reaches with gradients >5m/km have no habitat suitable for northern pike). [Assumed sufficient where existing populations are present.]
- V10 Late winter dissolved oxygen (DO) (if DO is greater than 2mg/L, SI = 1; if DO is less than 2 mg/L, SI = 0.5). Late winter DO criteria are based on the assumptions that if measured late winter DO is greater than the indicated concentration, DO is not limiting at any time of year, and if measured late winter DO is less than the indicated concentration, DO may be limiting in winter but not during the open-water period. In addition, since DO is not measured in all areas within a watercourse or waterbody, there may exist some local areas where late winter DO is greater than the measured concentrations. [Applied winter DO values collected through site-specific monitoring; where winter dissolved oxygen data was unavailable, it was assumed sufficient where existing populations were present.]

The lacustrine model evaluates the suitability of habitats for Northern Pike uses the same variations as above, with the exception of V8 and V9.

Inskip (1982) provides a series of graphs for determining suitability index (SI) values, corresponding to each of the variables V1 to V9, for the habitat being assessed. The SI is to be the minimum criteria value, although the species are prevalent in the study area and therefore the mean SI for all variables were calculated to capture a moderate potential loss/gain scenario.

1.3.25 NORTHERN REDBELLY DACE

The HEP analysis was completed using the HSI criteria for Northern Redbelly Dace as presented in Golder 2008. The HSI criteria were developed base off existing literature (Das and Nelson 1990; Schlosser 1995; Scott and Crossman 1998; Schlosser and Kallemeyn 2000; Langhorne et al. 2001; Richardson et al. 2001; Stasiak 2006), professional expertise and workshop outcomes (Golder 2008). The HSI was to be set equal to the lowest of the SI values for the variables included in the model, although since this species is prevalent within the region the mean HSI value was applied and also to capture a moderate potential loss/gain scenario.

The riverine model includes the following habitat variables:

V1 Substrate, where gravel, sand, clay/silt substrates the SI =1, whereas boulder, cobble, rubble substrates are ranked as SI = 0.5 and bedrock was ranked as SI = 0.25. [Due to data limitations, dominant substrate type was applied, where SI = 1 if fines (e.g., clay, silt, organics) and SI = 0 if another substrate type is dominant.]

- V2 Instream Cover, where submergent and emergent vegetation, woody debris and inundated vegetation were ranked as SI = 1, cobble/rubble as SI = 0.5 and boulder/bedrock as SI = 0.25. [Applied dominant cover type, where SI = 1 if macrophytes and SI = 0.25 if rock (e.g., cobble or boulder).]
- V3 Channel Unit, where percent area having flats pools and backwaters were ranked as SI = 1, Percent area of runs as SI = 0.5, Precent area of riffles as SI = 0.25; rapids, chutes and falls were ranked as SI = 0.
- V4 Percent Instream Cover, where SI = 1 for instream cover >50%, SI = 0.75 instream cover >30% but <50%, SI = 0.5 when instream cover is >20% and <30% and SI = 0.25 when instream cover is >0% but <20%.
- V5 Late winter dissolved oxygen, SI = 1.0 when ≥1 mg/L and SI= 0.5 when <1 mg/L. Late winter DO criteria are based on the assumptions that if measured late winter DO is greater than the indicated concentration, DO is not limiting at any time of year, and if measured late winter DO is less than the indicated concentration, DO may be limiting in winter but not during the open-water period. In addition, since DO is not measured in all areas within a watercourse or waterbody, there may exist some local areas where late winter DO is greater than the measured concentrations. [Applied average winter DO values collected through site-specific monitoring; where winter dissolved oxygen data was unavailable, it was assumed sufficient where existing populations were present.]

- V6 pH, where the SI 1 when pH 6 to 9 and SI = 0.5 for pH range of 5.5 to <6 and SI = 0 when pH values are <5.0 or >9.0. [Applied average pH; if no data was available, it was assumed sufficient where existing populations were present.]

The lacustrine model includes all the same habitat variables except for the following changes:

- V3 Depth, where SI = 1 when depth is ≤2 m; SI = 0.5 when depth is >2 m to 5 m and SI = 0.25 when depth is >5 m.
- V4 percent littoral zone cover, where SI = 1 for instream cover >50%, SI = 0.75 instream cover >30% but <50%, SI = 0.5 when instream cover is >20% and <30% and SI = 0.25 when instream cover is >0% but <20%.

1.3.26 RAINBOW SMELT

The HEP model was developed for the Project for Rainbow Smelt as presented below. The HSI criteria were developed based off existing literature including DFO HEAT habitat suitability matrices (DFO 2025), COSEWIC 2018, Coker 2001, Lane 1996a , and Scott and Crossman 1998.

The riverine model includes the following habitat variables:

- V1 Depth, where water depths >10 m were ranked as SI = 1, SI = 0.75 for water depths between 5m to 10 m, SI = 0.5 for water depths between 2 m to 5 m and SI = 0.25 for water depths <2m .
- V2 Substrate, where cobble, rubble substrates the SI =1, whereas boulder, gravel substrates are ranked as SI = 0.75, silt, sand, clay (i.e., fines) were ranked as SI = 0.5 and bedrock substrates were ranked as 0.25.
- V4 Instream Cover, where no cover areas were ranked as SI = 1, whereas areas with vegetation were ranked as SI = 0.5, rocky areas were ranked as SI = 0.25.
- V5 Stream size, where watercourses with bankfull widths of >5 m were considered to have SI = 1 and those that were <5 m were considered to have SI = 0.25
- V6 Spawning water temperature (i.e., fall), where temperatures are between 4°C to 9°C, were ranked as an SI = 1, whereas temperatures above 9°C or below 4°C were ranked as an SI = 0.25.
- V5 Late winter dissolved oxygen, SI = 1.0 when ≥6.5 mg/L and SI= 0.5 when <6.5 mg/L. [Applied average winter DO values collected through site-specific monitoring; where winter dissolved oxygen data was unavailable, it was assumed sufficient where existing populations were present.]
- V6 pH, SI = 1 when pH values are between >6.0 to <7.0, SI = 0.5 when pH values are >5 to <6, SI value of 0.25 when pH values were >7.5 but <9 and SI = 0 for values <5 or >9.

No lacustrine model was previously developed for Rock Bass, as such the riverine model applied and included all the above habitat variables with the exception of stream size.

1.3.27 ROCK BASS

The HEP analysis was completed using the HSI criteria for Rock Bass as presented in AMEC 2013. The HSI criteria were developed base off existing literature including Coker 2001, Lane 1996a and 1996b, Scott and Crossman 1998, Fishbase 2012 and Page and Burr 1991.

The riverine model includes the following habitat variables:

- V1 Substrate adult, where cobble, rubble, gravel substrates the SI =1, whereas bedrock, boulder, sand substrates (i.e., fines) are ranked as SI = 0.5.and silt and clay substrates were ranked as 0.
- V2 Substrate nursery, where gravel with silt substrates the SI =1, whereas rubble, sand and silt substrates (i.e., fines) are ranked as SI = 0.5.and bedrock and/or clay substrates were ranked as 0.

- V3 Substrate spawning, where cobble, rubble, gravel substrates the SI =1, whereas sand, silt, clay substrates (i.e., fines) are ranked as SI = 0.5.and bedrock substrates were ranked as 0.
- V4 Instream Cover, where boulder, logs (i.e., wood), submergent vegetation were ranked as SI = 1, whereas emergent and submergent vegetation were ranked as SI = 0.5.
- V5 Dominant Channel Morphology, pools were ranked as SI = 1, percent area of flats and runs as SI = 0.5 and areas dominated by rapids, chutes and falls and rapids, SI = 0.
- V6 Percent Instream Cover, where SI = 1 for instream cover >50%, SI = 0.75 when instream cover is >30% and <50%, when instream cover is between >20% to <30% SI = 0.5 and SI = 0.25 when instream cover is >0% but <20%.
- V5 Late winter dissolved oxygen, SI = 1.0 when ≥2 mg/L and SI= 0.5 when <2 mg/L. [Applied average winter DO values collected through site-specific monitoring; where winter dissolved oxygen data was unavailable, it was assumed sufficient where existing populations were present.]
- V6 pH, SI = 1 when pH values are between >6.0 to <7.5, SI = 0.5 when pH values are >5 to <6 and SI = 0 for values <5 or >9.[Applied an SI value of 0.25 when pH values were >7.5 but <9, as no condition was previously listed in the model for that range.].

No lacustrine model was previously developed for Rock Bass, as such the riverine model applied and included all the above habitat variables with the exception of channel morphology.

1.3.28 SILVER REDHORSE AND SHORTHEAD REDHORSE

The HEP analysis was completed using the HSI criteria for Shorthead Redhorse as presented in AMEC 2013. The HSI criteria were developed base off existing literature .The HSI criteria were developed base off existing literature including Coker 2001, Lane 1996a and 1996b, Scott and Crossman 1998, Fishbase 2012 and Page and Burr 1991.

As summarized in Reid et al. 2006, information on life history requirements for Silver Redhorse is limited, they occupy slow, low gradient rivers and some lakes. They are associated with gravel substrates while avoiding silt and fine substrates, turbid areas and pollution. Spawning occurs in <1 m of water on gravel and rubble substrates. YOY will vegetated shorelines with hard or soft substrates up to 2 m water depth. Adult lake populations will occupy waters up to 5 m deep over a variety of substrates. Similarly, Shorthead Redhorse, are associated with shallow clear waters of lakes or rivers but can tolerate sand or gravel substrates with limited siltation. Spawning takes place over gravel riffles. Adult and juvenile Shorthead Redhorse occupy depths <5m with submerged vegetation. As such the same model variables have been applied to both species. In the Project area, the two species were captured/observed/sampled mainly within the same larger waterbodies/watercourses (i.e., Dixie Creek, Genese Lake, Gullrock Lake, Pakwash Lake, Chukuni River etc.). The same model was applied to both species.

The riverine model includes the following habitat variables:

- V1 Substrate, where rubble, gravel, sand substrates the SI =1, whereas cobble, sand and silt substrates (i.e., fines) are ranked as SI = 0.5.and bedrock and clay substrates were ranked as 0.
- V2 Instream Cover, where rubble, cobble (i.e., rock) were ranked as SI = 1, cobble/rubble with submerged vegetation as SI = 0.5 and emergent and submergent vegetation as SI = 0.
- V3 Channel Unit, where percent area having pools and runs were ranked as SI = 1, percent area of flats as SI = 0.5 and present area dominated by riffles and rapids, SI = 0.
- V4 Percent Instream Cover, where SI = 1 for instream cover >20% to <30%, SI = 0.5 when instream cover is >30% and <50% and SI = 0.25 when instream cover is >0% but <20%.
- V5 Late winter dissolved oxygen, SI = 1.0 when ≥2 mg/L and SI= 0.5 when <2 mg/L. [Applied average winter DO values collected through site-specific monitoring; where winter dissolved oxygen data was unavailable, it was assumed sufficient where existing populations were present.]

- V6 pH, SI = 1 when pH values are between >6.0 to <7.5, SI = 0.5 when pH values are >5 to <6 and SI = 0 for values <5 or >9.[Applied an SI value of 0.25 when pH values were >7.5 but <9, as no condition was previously listed in the model for that range.].

The lacustrine model includes all the same habitat variables except for the following changes:

- V3 Depth, where SI = 1 when depth is ≤2 m; SI = 0.75 when depth is >2 m to 5 m and SI = 0.5 when depth is >5 m.

1.3.29 SLIMY SCULPIN

The HEP analysis was completed using the HSI criteria for Slimy Sculpin as presented in Golder 2014. The HSI criteria were developed base off existing literature (Nelson and Paetz 1992; Ford et al. 1995; Gibbons et al. 1996; Lane et al. 1996; Scott and Crossman 1998; Bradbury et al. 1999; Portt et al. 1999; Langhorne et al. 2001; Richardson et al. 2001), professional expertise and workshop outcomes (Golder 2008). The HSI was to be set equal to the lowest of the SI values for the variables included in the model, although since this species is prevalent within the region the mean HSI value was applied and also to capture a moderate potential loss/gain scenario.

The riverine model includes the following habitat variables:

- V1 Substrate, where boulder, rubble, cobble, gravel, rocks or logs substrates the SI =1, whereas sand and clay/silt substrates (i.e., fines) are ranked as SI = 0.25.
- V2 Instream Cover, where rubble, cobble, boulder (i.e., rock), woody debris were ranked as SI = 1, vegetation as SI = 0.5 and no cover as SI = 0.
- V3 Channel Unit, where percent area having runs, riffles and rapids were ranked as SI = 1, percent area of flats and pools as SI = 0.25.
- V4 Percent Instream Cover, where SI = 1 for instream cover >30%, SI = 0.75 instream cover >20% but <30%, SI = 0.5 when instream cover is >10% and <20% and SI = 0.25 when instream cover is >0% but <10%.
- V5 Late winter dissolved oxygen, SI = 1.0 when ≥2 mg/L and SI= 0.5 when <2 mg/L. [Applied average winter DO values collected through site-specific monitoring; where winter dissolved oxygen data was unavailable, it was assumed sufficient where existing populations were present.]

The lacustrine model includes all the same habitat variables except for the following changes:

- V3 Depth, where SI = 1 when depth is ≤2 m; SI = 0.75 when depth is >2 m to 5 m and SI = 0.5 when depth is >5 m.

1.3.30 SMALLMOUTH BASS

The HEP analysis was completed using the HSI criteria for Trout as presented in Edwards et al 1983. The model is applicable through the native and introduced range of Smallmouth Bass in North America. The HSI criteria were developed base off existing literature (Bradbury et al. 1999, Scott and Crossman 1998), and professional expertise. The HSI was to be set equal to the lowest of the SI values for the variables included in the model, although since this species is prevalent within the region the mean HSI value was applied and also to capture a moderate potential loss/gain scenario.

The riverine model includes the following habitat variables:

- V1 Dominant substrate type within pool, backwater (Riverine), or shoal area (Lacustrine), where SI = 0.2 for silt, sand and/or rooted vegetation, SI = 0.3 where pebbles (0.2 cm to 1.5 cm) are present, SI =
- V2 Percent pools, where SI = 1 for >50% to <75%, SI = 0.75, where >30 % to <50% and >75% and <80%, SI = 0.5 where >25% to <30% and >80% to <90%, SI = 0.25, where <25 % and >90%.

- V4 Average depth of pools during midsummer, where SI = 1 for 1 m to 5 m, SI = 0.75, where depths are >5m and <8m SI = 0.25 where depths are <1m.
- V5 Percent cover in the form of boulders, stumps, dead trees, and crevices (adults) or vegetation and rocks (fry), SI = 1 for >25% to <50%, SI = 0.75, where >23 % to <25% and >50% and <75%, SI = 0.5 where <75%, and SI = 0 for <20.
- V6 Average pH level during the year, SI = 1 for pH 8, SI = 0.5 for pH of >5 to <8 and >8 to <9, SI = 0.2 for pH <5 or >9.
- V7 Average Total Dissolved Solids level during the growing season (May to October) [Assumed sufficient where existing populations are present (i.e., SI = 0.5).]
- V8 Minimum DO levels throughout the year, where SI = 1 for values >6mg/L, SI = 0.75 for values > 5 to <6 mg/L, SI = 0.5 for values >4mg/L to <5mg/L, SI = 0.25 for values >2 to <4 mg/L, SI = 0 for <2 mg/L.
- V9 Maximum monthly average turbidity level during the summer [Assumed sufficient where existing populations are present (i.e., SI = 0.5).]
- V10 Water temperature in selected habitat during the growing season (May to October) (adults), where SI = 1 for >25°C to <29°C, SI = 0.75 if >18°C to <25°C and >29°C to 31°C , SI = 0.5 for >12°C to <18°C, SI = 0.25 for >6°C to <12°C, SI = 0 for <6°C or >31°C [Assumed sufficient selected habitat where existing populations are present]
- V11 Water temperature in selected habitat during spawning and for 45 days afterwards (embryo) where SI = 1 for >11°C to <28°C, SI = 0 for <11°C or >28°C [Assumed sufficient selected habitat where existing populations are present]
- V12 Water temperature in selected habitat during the growing season (May to October) (fry) where SI = 1 for temperatures ≥22°C to <30°C, SI = 0.75 if ≥16°C to <20°C or ≥30°C to 32°C , SI = 0.5 for ≥ 12°C to <16°C, SI = 0.25 for≥8°C to <12°C or ≥32 to <34, and SI = 0 for <8°C or >34°C [Assumed sufficient selected habitat where existing populations are present for the average water temperature]
- V13 Water temperature in selected habitat during the growing season (May to October) (juvenile)
- V14 Water level fluctuations during spawning and for 45 days after spawning [Assumed sufficient for selected habitat where existing populations are present (i.e., SI = 0.5)]
- V15 Stream gradient within representative reach [Assumed sufficient for selected habitat where existing populations are present (i.e., SI = 0.5)]

The lacustrine model includes all the above with the following exceptions:

- V3 Average depth of lake or reservoir during midsummer, where SI = 1 for depth >9 to <10 m, SI = 0.75 for depths between >7 to <9 m and >10 m to <15 m, SI = 0.5 for depths between >5 to <7 m and >15m to 20m, SI = 0.25 for depths <5m.

1.3.31 SPOTTAIL SHINER

The HEP analysis was completed using the HSI criteria for Trout as presented in Golder 2014. The HSI criteria were developed base off existing literature (McPhail and Lindsey 1970; Lee et al. 1980; Jude and Pappas 1992; Nelson and Paetz 1992; Jenkins and Burkhead 1993; Mayo et al. 1998; Scott and Crossman 1998; Bradbury et al. 1999; Portt et al. 1999; Langhorne et al. 2001; Richardson et al. 2001; Franzin et al. 2003), and professional expertise. The HSI was to be set equal to the lowest of the SI values for the variables included in the model, although since this species is prevalent within the region the mean HSI value was applied and also to capture a moderate potential loss/gain scenario.

The riverine model includes the following habitat variables:

- V1 Substrate, where gravel, sand, clay/silt substrates (i.e., fines) the SI =1, whereas cobble, rubble, boulder, bedrock substrates are ranked as SI = 0.5.

- VS Instream Cover, where vegetation, woody debris, submergent and emergent plants were present the SI = 1, where as where rubble, cobble with no cover were present the SI = 0.25.
- V3 Channel Unit, where percent area having flats, pools were ranked as SI = 1, riffle, runs areas as SI = 0.5, Precent area of rapids as SI = 0.
- V3 Percent Instream Cover, where SI = 1 for instream cover >20% to <50%, SI = 0.75 instream cover >10 to <20% and > 50 % to 65%, but SI = 0.5 when instream cover is >5% to <10% and >65% to <70%, SI = 0.25 when instream cover is >0% to <5% and >75% to <100%.
- V5 Late winter dissolved oxygen, SI = 1.0 when ≥4 mg/L and SI= 0.5 when >2 mg/L but <4 mg/L and SI = 0.25 for <2 mg/L. Late winter DO criteria are based on the assumptions that if measured late winter DO is greater than the indicated concentration, DO is not limiting at any time of year, and if measured late winter DO is less than the indicated concentration, DO may be limiting in winter but not during the open-water period. In addition, since DO is not measured in all areas within a watercourse or waterbody, there may exist some local areas where late winter DO is greater than the measured concentrations. [Applied average winter DO values collected through site-specific monitoring; where winter dissolved oxygen data was unavailable, it was assumed sufficient where existing populations were present (i.e., SI = 0.5).]
- V6 pH, SI = 1 when pH values are between >6.5 to 8.5, SI = 0.5 when pH values are >6 to <6.5 or >8.5 to <9.5 and SI = 0 for values <6 or >9.

The lacustrine model includes all the same habitat variables except for the following changes:

- V3 Depth, where SI = 1 when depth is <2 m; SI = 0.75 when depth is >2 m to 5 m and SI = 0.25 when depth is >5 m.
- V3 Percent Litoral Zone Cover, where SI = 1 for instream cover >20% to <50%, SI = 0.75 instream cover >10 to <20% and > 50 % to 65%, but SI = 0.5 when instream cover is >5% to <10% and >65% to <70%, SI = 0.25 when instream cover is >0% to <5% and >75% to <100%.

1.3.32 TROUT PERCH

The HEP analysis was completed using the HSI criteria for Trout as presented in Golder 2008 and Hatfield Consultants & Ecofish Research Ltd. 2018. The HSI criteria were developed base off existing literature (Bradbury et al. 1999, Scott and Crossman 1998; Schlosser and Kallemeyn 2000; Langhorne et al. 2001; Richardson et al. 2001; Stasiak 2006), professional expertise. The HSI was to be set equal to the lowest of the SI values for the variables included in the model, although since this species is prevalent within the region the mean HSI value was applied and also to capture a moderate potential loss/gain scenario.

The riverine model includes the following habitat variables:

- V1 Substrate, where gravel, sand, clay/silt substrates the SI =1, whereas cobble, rubble substrates are ranked as SI = 0.75 and boulder and / or bedrock was ranked as SI = 0.5.
- V2 Channel Unit, where percent area having run/glide, flats were ranked as SI = 1, Percent area of pools, backwater areas as SI = 0.5, Precent area of riffles, rapids, chutes as SI = 0.25.
- V3 Percent Instream Cover, where SI = 1 for instream cover 0%, SI = 0.75 instream cover >0% but <20%, SI = 0.5 when instream cover is >20% and <30%, SI = 0.25 when instream cover is >30% but <50% and SI = 0 when instream cover is >50%.
- V5 Late winter dissolved oxygen, SI = 1.0 when ≥2 mg/L and SI= 0.5 when <2 mg/L. Late winter DO criteria are based on the assumptions that if measured late winter DO is greater than the indicated concentration, DO is not limiting at any time of year, and if measured late winter DO is less than the indicated concentration, DO may be limiting in winter but not during the open-water period. In addition, since DO is not measured in all areas within a watercourse or waterbody, there may exist some local areas where late winter DO is greater than the measured concentrations. [Applied average winter DO values collected through site-specific monitoring; where winter dissolved oxygen

data was unavailable, it was assumed sufficient where existing populations were present (i.e., SI = 0.5).]

The lacustrine model includes all the same habitat variables except for the following changes:

- V2 Depth, where SI = 1 when depth is >0 m to <7 m; SI = 0.75 when depth is >7 m to 15 m and SI = 0.25 when depth is >15 m.
- V3 spawning material, where SI = 1 for sand and gravel (i.e., fines) with vegetation, SI = 0.75 for sand and gravel where vegetation is absent and SI = 0 for bedrock, boulder, where vegetation is absent.

1.3.33 WALLEYE

The HEP analysis was completed using the published HEP model available for assessment of the quality of riverine and lacustrine habitats for Walleye (McMahon et al. 1984). The model includes habitat variables believed to be important in limiting distribution, abundance and survival of Walleye and represents all life stages. McMahon et al. (1984) notes that the model is applicable throughout the range of Walleye in North America.

The riverine model evaluates the suitability of habitats for Walleye based on the following 13 variables:

- V1 Average transparency (Secchi depth) during summer. [Assumed not limiting due to species presence in the study area; assigned SI = 1.0.]
- V2 Relative abundance of small forage fishes during spring and summer (mg of prey/m3). [Assumed not limiting due to species presence in the study area; assigned SI = 1.0.]
- V3 Percent of waterbody with instream cover and adequate dissolved oxygen during the spring and summer.
- V4 Least suitable pH during the year.
- V5 Minimum dissolved oxygen level in pools and runs, or above the thermocline, in summer.
- V6 Minimum dissolved oxygen level during summer and fall along shallow shoreline areas.
- V7 Minimum dissolved oxygen level measured in spawning areas during spring.
- V8 Mean weekly water temperature in pools, or above the thermocline, during summer. [Due to data limitations the average summer temperature was applied]
- V10 Mean weekly water temperature during spawning in spring. [Due to data limitations the average spring water temperature was applied]
- V11 Degree days between 4 and 10 °C from October 30 to April 15. [Assumed appropriate to support the species, assigned SI =1.0]
- V12 Spawning Habitat Index = (proportion of riffle or littoral areas) x (substrate index), where substrate index = 2 (% gravel/rubble) + (% boulders/bedrock) + 0.5 (% sand) + 0.5 (% vegetation).
- V13 Water level during spawning and embryo development. [Established levels based on depths and qualitative field notes taken during site-specific monitoring]

McMahon et al. (1984) provide a series of graphs for determining suitability index (SI) values, corresponding to each of these 13 variables, for the habitat being assessed. For determination of the HSI, the 13 variables are grouped into four components (food, cover, water quality and reproduction). As per the model, the SI is to be the minimum criteria value, although the species and suitable habitats are prevalent in the study area and therefore the mean SI for all variables were calculated to capture a moderate potential loss/gain scenario.

1.3.34 WHITE SUCKER

The HEP analysis was completed using the published HEP model available for assessment of the quality of riverine and lacustrine habitats for the White Sucker (Twomey et al. 1984). This model includes habitat variables that represent habitat quality for all life stages of White Sucker. Twomey et al. (1984) note that the model is applicable throughout North America where white suckers occur. The standard of comparison for each individual variable SI is the optimum value that occurs anywhere within this geographic range.

The riverine model provides a measure of habitat suitability for White Sucker on the basis of the following 10 habitat variables:

- V1 Maximum monthly average turbidity during the year. [Assumed sufficient as existing populations are present within the study area; assigned SI = 1.0.]
- V2 Weekly average pH during the year under stable conditions. [Due to data limitations the overall average pH was applied]
- V3 Minimum dissolved oxygen levels (mg/L) during May through August in areas of most suitable water temperature.
- V4 Average of mean weekly water temperatures (°C) during July and August (for adults and juveniles).
- V5 Average of mean weekly water temperatures (°C) during July and August (for fry).
- V6 Average of mean weekly water temperatures (°C) during spawning and incubation (April through July). [Applied average spring/summer water temperature based on site-specific monitoring.]
- V7 Average riffle velocity (cm/s) during spawning and incubation. [Where riffles with suitable spawning substrates were present, assigned SI = 1; where no riffles with suitable spawning substrates were present, assigned SI = 0.5; where no riffles present, assigned SI = 0.]
- V8 Average riffle depth (cm) during spawning and incubation. [Assumed riffle habitats had sufficient depth. Where riffles with suitable spawning substrates were present, assigned SI = 1; where no riffles with suitable spawning substrates were present, assigned SI = 0.5; where no riffles present, assigned SI = 0.]
- V9 Percent instream and overhanging shoreline cover.
- V10 Percent pools during average summer flows. [Due to data limitations, the overall percent pools was applied.]

The lacustrine model provides a measure of habitat suitability for White Sucker on the basis of the following 10 habitat variables:

- V1 Maximum monthly average turbidity during the year (JTU). [Assumed sufficient as existing populations are present within the study area; assigned SI = 1.0.]
- V2 Weekly average pH during the year under stable conditions. [Due to data limitations, applied overall average pH.]
- V3 Minimum dissolved oxygen levels (mg/L) during May through August in areas of most suitable water temperature.
- V4 Average of mean weekly water temperatures (°C) during July and August (for adults and juveniles).
- V5 Average of mean weekly water temperatures (°C) during July and August (for fry).
- V6 Average of mean weekly water temperatures (°C) during spawning and incubation (April through July). [Applied average spring/summer water temperature based on site-specific monitoring.]

– V11 Littoral spawning substrate. [The SI criteria were revised from the published model. For boulder, cobble and gravel, SI = 1; for sand, SI = 0.5; for clay/silt or bedrock, SI = 0.05.]

Graphs for determining SI values, corresponding to each of these variables are included in Twomey et al. (1984). For determination of the HSI, the above variables are grouped into components (e.g., water quality, reproduction and cover that differs between riverine and lacustrine models). The SI is to be the minimum criteria value, although the species are prevalent in the study area and therefore the mean SI for all variables were calculated to capture a moderate potential loss/gain scenario.

1.3.35 YELLOW PERCH

The HEP analysis was completed using the published HSI model is available for assessment of the quality of riverine and lacustrine habitats for Yellow Perch (Krieger et al. 1983). The model includes habitat variables believed to be important in limiting distribution, abundance and survival of Yellow Perch and represents all life stages. Kreiger et al. (1983) note the models are applicable throughout the 48 contiguous United States. Some variables and SI criteria were considered and discussed further in Golder 2008. Variable V10 was added to the lacustrine model following workshop discussions with DFO (Golder 2008).

The riverine model is based on the following seven variables:

– V2 Percent pool and backwater areas during average summer flow. [Applied percent pools. Due to data limitations, where the existing populations were present, the percent of pools was assumed to be at least 10%].
– V3 Percent cover during summer within pools and backwater areas. [Applied percent macrophyte cover where pool habitat was present.]
– V4 Most suitable water temperature within the water column during midsummer (adult, juvenile and fry). [Due to data limitations, the average summer water temperature was applied.]
– V5 Most suitable water temperatures within pools and backwaters during spawning and embryo development. [Due to data limitations, the average summer water temperature was applied where pool habitat was present.]
– V6 Minimum dissolved oxygen level at the two locations selected for the most suitable temperature for variables V3 and V4. [Due to data limitations, the minimum summer dissolved oxygen was applied.]
– V7 Degree-days (between 4 and 10oC) from Oct. 30 to April 1. [Assumed appropriate to support the fish population regionally; assigned SI = 1.0.]
– V8 pH range during the year. [As yellow perch have high acidity tolerance, assumed not limiting and assigned SI= 1.0.]

The lacustrine model is based on the variables 3 to 8 listed above and the following variables:

– V1 Percent littoral area during summer. [Assumed sufficient where existing populations are present.]
– V9 Trophic status of lake or lake section. [Assumed sufficient where existing populations are present.]
– V10 Late winter DO. Should be measured at the deepest location in the lake. If DO is greater than or equal to 3 mg/L, SI = 1; if DO is >1 and <3 mg/L, SI = 0.5; if DO is less than 1 mg/L, SI = 0. [Applied average winter DO values collected through site-specific monitoring; where winter dissolved oxygen data was unavailable, it was assumed sufficient where existing populations were present.]

Graphs for determining the SIs for each of the applicable variables are presented in Krieger et al. (1983). The HSI equation is set to calculate the minimum SI value for habitat variables, although since this species is prevalent within the region the mean HSI value was applied to capture a moderate potential loss/gain scenario.

1.4 LIFE FUNCTION WEIGHTS

Life function weights are used to “weight” or influence the results of the HSI according to use by each species and life stage habitat criteria. The proportion of the weights across each species must equal one. As multiple life stages exist within the waterbodies and watercourses of the project and habitats available to support a variety of life processes all life stages have been applied the same life function weight (Table 1).

Table 1: Life Function Weights

HSI Variable	All Species
Spawning	0.25
YOY	0.25
Juveniles	0.25
Adults	0.25
Total	1.00

Notes:

YOY = young of the year

1.5 SPECIES WEIGHTS

Within each reach assessed, species weights were based by presence / absence within the waterbodies/watercourses of the Project. For all waterbodies/watercourses that were fish frequented, at minimum one target fish species was present. All species present, were equally weighted (i.e., value of 1). If a species were absent (i.e., not collected, observed, sampled) from a specific habitat, that species weight was set equal to 0 (i.e., Brook stickleback were present = 1, Cisco were absent = 0). In instances where no fish species were captured, observed or present within eDNA samples, the collective species of the similar habitat type were applied (i.e., Unnamed Waterbody 5 [habitat type A], no fish captured/observed/sampled, therefore fish species from other habitat type As (i.e., Unnamed Waterbodies 1, 4 and 6 etc. were applied).

1.6 ACCESS FACTOR

The access factor typically accounts for restraints related to water quantity (i.e., depth, velocity). Access factors are defined as 1 for any species present in the habitat area, and 0 for any species not present (Minns, 2012).

All waterbodies and watercourses were considered as potential fish frequented or fish frequented and as a precaution, these waterbodies were included for Authorization under Paragraphs 34 and 35 of the Fisheries Act or Schedule 2 designation under the MDMER to take into consideration long term natural variation and climate change as they may be or become frequented by fish.

If no species had been captured/observed in previous baseline surveys or through eDNA sampling efforts, as a conservative measure it was assumed to have potential fish presence and that waterbody/watercourse was classified as potentially fish frequented. In this model, and access cofactor of 0.1 was applied to these waterbodies/watercourses (i.e., Unnamed Waterbody 5, Unnamed Watercourse 1A, Unnamed Watercourse 4a and Unnamed Watercourse 6A-01).

In the offsetting/restoration scenario, an access cofactor was applied to Northern Pike (0.25) and White Sucker (0.5), for the diversion channel and pond, noting their species limitations to travel approximately the 3 km from the downstream lake to reach the diversion pond. All other species will be translocated to the diversion pond during fish rescues prior to construction, where appropriate, and an access cofactor of 1 was applied.

1.7 HABITAT CO-FACTOR

The habitat co-factor represents any changes to non-mapped habitat quality (e.g., thermal, hydrological, biological or chemical regimes) that will occur as a result of impacts or offsetting. The use of this factor is suggested by Dr. Ken Minns, and his suggested values as presented in a workshop for DFO in February 2012.

The habitat co-factor could be used to account for changes in habitat quality (e.g., changes in thermal, hydrological, biological, or chemical regimes). This was important to incorporate where the project is expected to result reduced hydrological flow and/or in improved aquatic ecosystem health post-restoration. The habitat co-factor values are determined based on a set of definitions to suit various levels of degradation and anticipated post-restoration outcomes. Habitat co-factors can be applied to the HEP calculations based on the value ranking system below (Table 2).

Table 2: Habitat Co-factor for Various Pre- and Post-compensation Scenarios, according to Minns 2012

Change in Regime	Description	Baseline Conditions Factor	Post-Condition Factor
Degradation	Thermal, hydrologic, chemical and/or biological regime shifts away from preferred state for fish habitat	1	> 0 and < 1
No Change	-	1	1
Enhancement (anticipated or proposed)	Thermal, hydrologic, chemical and/or biological regime expected to shift towards preferred state for fish habitat	> 0 and < 1	1

No habitat cofactor was applied to the baseline condition calculation (i.e., = 1). No habitat cofactors were applied to receiving waterbodies that will receive effluent , as the effluents are anticipated to be controlled and will be within the regulated limits(i.e., = 1). No habitat co-factors were applied to Paragraph 35 potentially impacted waterbodies, as the full value of the impact was recognized (i.e., = 1).

In a similar fashion habitat-condition scalars can be developed to approximate the effect other variables not captured by the habitat data may have impacts on the quality of the area being assessed. For example, for projects where the ecotype includes conversion of habitat patches or multiple ecotypes are to be included than, ecotype scalars can be used. Ecological accounting provides a standardized method to account for the effects of trading habitat parcels that may differ in productivity, approximated through the use of productivity scalars. Below are nominal productivity scalars based on Ecotype (Doka et al. 2022):

- Rivermouth - 1.5
- Wetland - 2
- Embayment - 1
- Open Coast (<=30m) - 0.5
- Offshore (>30m) - 0.25

Habitat cofactors were applied to areas with post-construction offsets are anticipated, and as such were assigned a post condition factor of 0.9. Additionally, for this project spawning shoals and placement of cover debris and substrates to support nursery and refugia habitats were assigned a scalar of 0.9. This lowered post-construction offsets cofactor value considers the uncertainty associated with offset projects.

2 RESULTS OF THE HEP

Documentation of how the proposed offsetting measures balance Project impacts and provide benefits to the fishery was based on the HEP models. The same habitat suitability models were used for the baseline, assessment of loss (construction phase) and post-restoration (gain) scenarios. The models were used to determine habitat supply in aquatic areas based on fish communities and their habitat needs (Minns et al. 2001).

To conservatively assess the negative and positive changes associated with the Project's planned works on fish and fish habitat, the HEP model was used along with the existing habitat attributes (WSP 2025a) to assess the fish habitat potential (habitat units [HU]). Understanding the quality contribution of the habitat to local populations of fish is a key element in the determination of whether the proposed scale of offsetting meets the objectives of DFO's offsetting policy objectives. A conservative approach was taken to analyze the quantity and quality of potential outcomes, whereby gains are expected to at least meet the anticipated conditions (i.e., using mean HSI values i.e., 0 to 1 as calculated) versus using the lowest HSI values as indicated in most models that would have resulted in an underestimation of the habitat potential in baseline, impact and post-restoration scenarios where by most species and habitats HU = 0. A summary of the habitat units and the habitat evaluation values are presented for in Tables 4 below. A full set of HEP results are presented within Attachment A.

Baseline conditions for the project are representative of naturalized boreal forest lake ecosystems, that range in size and complexity from non-permanent small streams with limited habitat features that support species tolerant to a range of environmental conditions, to large rivers and cold water lakes capable of supporting numerous fish species, including those most environmentally sensitive. It should be noted that the model provides an indication of overall suitability per species of the area that would be most used according to their life history preferences.

The assessment of loss scenario represents areas that are anticipated to be impacted by Schedule 2 and/or Paragraph 35 (direct, indirect or flow reduction) impacts as a result of the project. In these conditions it should be noted that the majority of areas where impacts are anticipated were of low quality and in general supported a limited fishery due to lack of permanence and available habitat structure preferred.

The results of the offsetting and compensation measures to offset the Paragraph 35 impacts in usable habitat units for the target fish species are presented below in Table 3. The offset condition represents the restored and improved ecological conditions and are expected to provide a greater area of available, suitable habitat for fish occupation (i.e., Approximately 12 ha). The quantity and quality of these habitats were considered in the development of the offsetting designs to account for some uncertainty in the success of the offset projects, while also considering the various life history requirements of the target fish species present. These offsetting measures meet DFO's Offsetting Policy (DFO 2025) to provide similar to or better habitats than those provided within the baseline conditions.

Table 3: Habitat Evaluation Results

Impact/Condition	Area (m^2)	Area (ha)	Number of Species	Number of Waterbodies	Total HU (m^2)	Total HU (ha)
Baseline	158,236,239	15,823.62	36	31	111,541,279	11,154.13
Schedule 2 Impacts	137,021	13.70	15	13	66,080	6.61
P. 35 Impacts	77,073	7.71	17	20	56,248	5.62
Restoration/Offset Area	243,369	24.34	32	4	124,378	12.44
Accounting Balance Total	158,265,513	15,826.55	-	-	111,543,329	11,154.33

Note: It is anticipated that all Schedule 2 impacts will be able to be mitigated

Kind Regards,

WSP Canada Inc.

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Attachment 1
HSI Data Analysis & Results

Table 1: Blacknose Shiner Riverine Habitat Suitability Model

Blacknose shiner	SI Calculations		Riverine					
	Variable	SI	**Excellent (SI = 1)**	**Above Average (SI = 0.75)**	**Average(SI = 0.5)**	**Below Average (SI = 0.25)**	**None (SI = 0)**	
	V_1	Substrate[a]	G, S, Cl, Si, R/Co			Bo, Bd		
	V_2	Instream cover	veg, rock			wood, rock, other		
	V_3	Dominant channel morphology	flats, pools, backwaters		runs	riffles	rapids, other	
	V_4	% instream cover	>50%	30-50	20-30	0-20	0	
	V_5	Late Winter Dissolved Oxygen (mg/L) [b]	>2			<2		
	V_6	pH	6 to 7.5		5 to 6	7.5 to 9	< 6 or >9	

(a) Bd = bedrock, Bo = boulder (>256 mm), C = cobble (>64 to 256 mm), R = rubble (>64 to 256 mm, angular), G = gravel (>2 to 64 mm), S = sand (>0.06 to 2.0 mm) and CS = clay/silt (<0.06 mm) includes detritus (Bradbury et al., 1999). The distinction between cobble and rubble is that cobble material has a smooth rounded shape while rubble is material in the same size range, but with sharp angular corners.

(b) Late winter dissolved oxygen (DO) criteria are based on the assumptions that if measured late winter DO is greater than the indicated concentration, DO is not limiting at any time of year, and if measured late winter DO is less than the indicated concentration, DO may be limiting in winter but not during the open-water period. In addition, since DO is not measured in all areas within a watercourse or waterbody, there may exist some local areas where late winter DO is greater than the measured concentrations.

Table 2: Bluntnose Minnow Riverine Habitat Suitability Model

Bluntnose Minnow	SI Calculations		Riverine					
	Variable	SI	**Excellent (SI = 1)**	**Above Average (SI = 0.75)**	**Average(SI = 0.5)**	**Below Average (SI = 0.25)**	**None (SI = 0)**	
	V_1	Substrate	G, S, Si, R/Co			cl, Bo, Bd		
	V_2	Instream cover	veg, rock, wood			other		
	V_3	Dominant channel morphology	falts, pools, backwaters		runs	riffles	rapids, other	
	V_4	% instream cover	30-50	>50	20-30	0-20	0	
	V_5	Late Winter Dissolved Oxygen (mg/L)	>2			<2		
	V_6	pH	6 to 7.5		5 to 6	7.5 to 9	< 6 or >9	

(a) Bd = bedrock, Bo = boulder (>256 mm), C = cobble (>64 to 256 mm), R = rubble (>64 to 256 mm, angular), G = gravel (>2 to 64 mm), S = sand (>0.06 to 2.0 mm) and CS = clay/silt (<0.06 mm) includes detritus (Bradbury et al., 1999). The distinction between cobble and rubble is that cobble material has a smooth rounded shape while rubble is material in the same size range, but with sharp angular corners.

(b) Late winter dissolved oxygen (DO) criteria are based on the assumptions that if measured late winter DO is greater than the indicated concentration, DO is not limiting at any time of year, and if measured late winter DO is less than the indicated concentration, DO may be limiting in winter but not during the open-water period. In addition, since DO is not measured in all areas within a watercourse or waterbody, there may exist some local areas where late winter DO is greater than the measured concentrations.

Table 3: Cisco Riverine Habitat Suitability Model

Cisco	SI Calculations		Riverine					
	Variable	SI	**Excellent (SI = 1)**	**Above Average (SI = 0.75)**	**Average(SI = 0.5)**	**Below Average (SI = 0.25)**	**None (SI = 0)**	
	V_1	Substrate	Gr, Co, R		Bo	Bd, Si, Sa, C		
	V_2	Water depth (m)	>10	5 to 10		<5		
	V_3	Cover Features %	no cover	veg, rock		wood, other		
	V_4	Sumer water tempertures	< 10			>10		
	V_5	Late Winter Dissolved Oxygen (mg/L)	>6.5			<6.5		
	V_6	pH	6.5 to 9			<6.5 or >9		

(a) Bd = bedrock, Bo = boulder (>256 mm), C = cobble (>64 to 256 mm), R = rubble (>64 to 256 mm, angular), G = gravel (>2 to 64 mm), S = sand (>0.06 to 2.0 mm) and CS = clay/silt (<0.06 mm) includes detritus (Bradbury et al., 1999). The distinction between cobble and rubble is that cobble material has a smooth rounded shape while rubble is material in the same size range, but with sharp angular corners.

(b) Late winter dissolved oxygen (DO) criteria are based on the assumptions that if measured late winter DO is greater than the indicated concentration, DO is not limiting at any time of year, and if measured late winter DO is less than the indicated concentration, DO may be limiting in winter but not during the open-water period. In addition, since DO is not measured in all areas within a watercourse or waterbody, there may exist some local areas where late winter DO is greater than the measured concentrations.

Table 4: Common Shiner Riverine Habitat Suitability Model

Common Shiner	SI Calculations		Riverine					
	Variable	SI	**Excellent (SI = 1)**	**Above Average (SI = 0.75)**	**Average(SI = 0.5)**	**Below Average (SI = 0.25)**	**None (SI = 0)**	
	V_1	Substrate	G, R/C		S	cl, Bo, Bd	Si, Detritus	
	V_2	Instream cover	veg, rock, wood			other		
	V_3	Dominant channel morphology	falts, pools, backwaters	riffles	runs		rapids, other	
	V_4	% instream cover	30-50	>50	20-30	0-20	0	
	V_5	Average water temperature in spawning habita	15 to 17		12 to 15 and 17 to 19.5		< 12 or >19.5	
	V_6	pH	6.5 to 8.5		5.5 to <6.5 and 8.5 to 9.0	9.0 to <10	<= 5.5 or >=10	

(a) Bd = bedrock, Bo = boulder (>256 mm), C = cobble (>64 to 256 mm), R = rubble (>64 to 256 mm, angular), G = gravel (>2 to 64 mm), S = sand (>0.06 to 2.0 mm) and CS = clay/silt (<0.06 mm) includes detritus (Bradbury et al., 1999). The distinction between cobble and rubble is that cobble material has a smooth rounded shape while rubble is material in the same size range, but with sharp angular corners.

(b) Late winter dissolved oxygen (DO) criteria are based on the assumptions that if measured late winter DO is greater than the indicated concentration, DO is not limiting at any time of year, and if measured late winter DO is less than the indicated concentration, DO may be limiting in winter but not during the open-water period. In addition, since DO is not measured in all areas within a watercourse or waterbody, there may exist some local areas where late winter DO is greater than the measured concentrations.

Table 5: Green Sunfish Riverine Habitat Suitability Model

Green Sunfish	SI Calculations		Riverine					
	Variable	**SI**	**Excellent (SI = 1)**	**Above Average (SI = 0.75)**	**Average(SI = 0.5)**	**Below Average (SI = 0.25)**	**None (SI = 0)**	
	V_1	Channel Morphology	pool	run/glide/flat	riffles	other		
	V_2	Substrate	Sa, Si, Gr			Co, R, Bo	Be	
	V_3	Instream cover	Veg, rock, wood			other		
	V_4	Late Winter Dissolved Oxygen (mg/L)	>5			<5		
	V_5	pH	6.5 to 8.0			<6.5 or<8		

(a) Bd = bedrock, Bo = boulder (>256 mm), C = cobble (>64 to 256 mm), R = rubble (>64 to 256 mm, angular), G = gravel (>2 to 64 mm), S = sand (>0.06 to 2.0 mm) and CS = clay/silt (<0.06 mm) includes detritus (Bradbury et al., 1999). The distinction between cobble and rubble is that cobble material has a smooth rounded shape while rubble is material in the same size range, but with sharp angular corners.

(b) Late winter dissolved oxygen (DO) criteria are based on the assumptions that if measured late winter DO is greater than the indicated concentration, DO is not limiting at any time of year, and if measured late winter DO is less than the indicated concentration, DO may be limiting in winter but not during the open-water period. In addition, since DO is not measured in all areas within a watercourse or waterbody, there may exist some local areas where late winter DO is greater than the measured concentrations.

Table 6: Mooneye Riverine Habitat Suitability Model

Mooneye	SI Calculations		Riverine					
	Variable	**SI**	**Excellent (SI = 1)**	**Above Average (SI = 0.75)**	**Average(SI = 0.5)**	**Below Average (SI = 0.25)**	**None (SI = 0)**	
	V_1	Depth	2 to 5	5 to 10		<2 or >10		
	V_2	Substrate	Sa, Si, Gr			Co, R, Bo	Be	
	V_3	Channel Morphology	pool	run/glide/flat	riffles	other		
	V_4	Instream cover	no cover		veg	rock	other	
	V_5	Spawning temperture ©	10 to 13			<10 or >13		
	V_6	Late Winter Dissolved Oxygen (mg/L)	>6.5			<6.5		
	V_7	pH	6.5 to 9.0			<6.5 or<9		

(a) Bd = bedrock, Bo = boulder (>256 mm), C = cobble (>64 to 256 mm), R = rubble (>64 to 256 mm, angular), G = gravel (>2 to 64 mm), S = sand (>0.06 to 2.0 mm) and CS = clay/silt (<0.06 mm) includes detritus (Bradbury et al., 1999). The distinction between cobble and rubble is that cobble material has a smooth rounded shape while rubble is material in the same size range, but with sharp angular corners.

(b) Late winter dissolved oxygen (DO) criteria are based on the assumptions that if measured late winter DO is greater than the indicated concentration, DO is not limiting at any time of year, and if measured late winter DO is less than the indicated concentration, DO may be limiting in winter but not during the open-water period. In addition, since DO is not measured in all areas within a watercourse or waterbody, there may exist some local areas where late winter DO is greater than the measured concentrations.

Table 7: Rainbow Smelt Riverine Habitat Suitability Model

Rainbow Smelt	SI Calculations		Riverine					
	Variable	SI	**Excellent (SI = 1)**	**Above Average (SI = 0.75)**	**Average(SI = 0.5)**	**Below Average (SI = 0.25)**	**None (SI = 0)**	
	V_1	Depth	>10	5 to 10	2 to 5	<2		
	V_2	Substrate	R/Co	Bo, G	Si, Sa, Cl	Bd		
	V_3	Instream cover	no cover		veg	rock	other	
	V_4	Stream size (m)	<5			>5		
	V_5	spawning water tempertures (fall)	4 to 9			<4 or >9		
	V_6	Late Winter Dissolved Oxygen (mg/L)	>6.5			<6.5		
	V_7	pH	6 to 7		5 to 6	7 to 9	< 5 or >9	

(a) Bd = bedrock, Bo = boulder (>256 mm), C = cobble (>64 to 256 mm), R = rubble (>64 to 256 mm, angular), G = gravel (>2 to 64 mm), S = sand (>0.06 to 2.0 mm) and CS = clay/silt (<0.06 mm) includes detritus (Bradbury et al., 1999). The distinction between cobble and rubble is that cobble material has a smooth rounded shape while rubble is material in the same size range, but with sharp angular corners.

(b) Late winter dissolved oxygen (DO) criteria are based on the assumptions that if measured late winter DO is greater than the indicated concentration, DO is not limiting at any time of year, and if measured late winter DO is less than the indicated concentration, DO may be limiting in winter but not during the open-water period. In addition, since DO is not measured in all areas within a watercourse or waterbody, there may exist some local areas where late winter DO is greater than the measured concentrations.

Appendix B

Fluvial Geomorphological Assessment of the Dixie Creek Mainstem and Unnamed Watercourse 6

Fluvial Geomorphological Assessment of the Dixie Creek Mainstem and Unnamed Watercourse 6

Great Bear Gold Project
East of Red Lake, Ontario

Prepared for:
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Submitted:
April 9, 2025

GEO Morphix Project No. 24109

Ver.	Purpose/Change	Authored by	Approved by	Date
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Disclaimer

This report presents professional opinions and findings of a scientific and technical nature based on the knowledge and information available at the time of preparation. This document is prepared solely for the Client, and the data, interpretations, suggestions, recommendations, and opinions expressed in the report pertain only to the project being completed for the Client.

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Appendix A: Study Reach Mapping

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1 Introduction

Great Bear Resources Ltd. ("Great Bear Resources") is proposing surface water diversion activities as part of the Great Bear Gold Project ("the Project"), located approximately 25 km southeast of Red Lake, Ontario. The proposed activities will affect the drainage areas of select tributary watercourses that discharge into an unnamed waterbody and Dixie Creek. The modifications will therefore also affect the hydrological and sedimentological regime of the watercourses, as well as in-stream habitat.

GEO Morphix Ltd. ("GEO Morphix") was retained by Great Bear Resources, through WSP Canada Inc. ("WSP"), to assess the fluvial geomorphic condition of select watercourses and downstream tributaries affected by the proposed surface water diversion activities. The findings of the fluvial geomorphic assessment were reviewed to inform stream design and habitat restoration requirements to accommodate the proposed modifications.

Specifically, the project scope included a fluvial geomorphic assessment of the following watercourses:

- Unnamed Watercourse 6B, upstream (west) of Unnamed Waterbody 6
- Unnamed Watercourse 6, downstream (east) of Unnamed Waterbody 6
- Dixie Creek, near the confluence with Unnamed Watercourse 6

An overview of the watercourses is provided in Figure 1.

Multiple desktop and field-based activities were completed to support the fluvial geomorphic assessments and development of the channel restoration design concepts, including:

- Review of available existing information and previously completed studies for the subject site, including:
  - Available physiographic and geological mapping of the area
  - Remote sensing data, including Unmanned Aerial Vehicle ("UAV") derived aerials and LiDAR, as provided by others
- Detailed geomorphological field surveys, including reconnaissance level assessments, at reference (i.e., analog) watercourse segments in proximity to impacted sections of watercourse to inform geomorphological parameters and associated design criteria for the channel corridor realignments
- In-channel topographical survey to confirm channel bed and tie-in elevations
- Aerial review and delineation of channel meander belt widths to inform the watercourse erosion hazard and realigned channel corridor width criteria
- Provision of preliminary (conceptual-level) channel corridor realignment design recommendations, including high-level channel and habitat restoration concepts
- Provision of recommendations for design implementation and post-construction monitoring

We provide this technical report which summarizes the findings and/or recommendations associated with the above noted activities, including supporting mapping and conceptual design drawings. The recommendations set out herein are preliminary and subject to further review and refinement at later stages of planning once all supporting investigations (e.g., geotechnical, hydrotechnical, ecological, etc.) have been completed (by others).

Figure 1: Overview of Subject Watercourses within the Study Area

2 Study Area Conditions

Channel morphology and planform are largely governed by the flow regime and the availability and type of sediments (i.e., surficial geology) within the stream corridor. Physiography, riparian vegetation, and land use also physically influence the channel. These factors are explored as they not only offer insight into existing conditions, but also potential changes that could be expected in the future as they relate to a proposed activity. According to available Ontario Geological Survey (OGS) mapping, surficial geology within the study area consists of glaciolacustrine deposits. These deposits are composed of a mix of consolidated silts and clays and are thus resistant to fluvial erosion (if exposed) relative to sandy alluvium. Watercourse 6B traversed intermittent pockets of peat, which is comprised of an accumulation of partially decomposed and loose organic matter derived from plant material. Peat is characterized by a slightly porous, compressible structure and is thus susceptible to fluvial erosion and/or subsurface piping. Peat also does not provide a stable foundation to support constructed elements. Finally, areas of elevated bedrock were present along the middle to upper reaches of Watercourse 6B. Bedrock is resistant to erosion and would thus inhibit stream adjustment.

The subject watercourses flow through naturally forested areas. The presence and availability of organic materials (e.g., coarse and fine woody debris) derived from these woody riparian areas influence channel process patterns. For instance, these organic materials collect within the channels, blocking flow and redistributing erosive forces towards adjacent channel sections, creating anomalous scours. The materials also enhance channel roughness, potentially driving flow into the floodplain. Beavers also use the woody debris to build dams, which disrupt flows and/or inundate upstream areas. Woody debris in the area, therefore, plays an important role in shaping local channel morphology and creating alternative habitat (e.g., refuge) conditions throughout the stream valley corridor.

2.1 Reach Delineation

Reaches are homogeneous segments of stream valley used in geomorphological investigations. They are studied semi-independently as each is expected to function in a manner that is at least slightly different from adjoining Reaches. This allows for a meaningful characterization of a watercourse as the aggregate of Reaches, or an understanding of a particular Reach, for example, as it relates to a proposed activity. Reaches are delineated based on the changes in following:

- Channel planform
- Channel gradient
- Physiography
- Land cover (land use or vegetation)
- Flow, due to tributary inputs
- Soil type and surficial geology
- Certain types of anthropogenic channel modifications

This follows scientifically defensible methodology proposed by Montgomery and Buffington (1997), Richards et al. (1997), as well as others.

Within the study area, five (5) Reaches associated with a minor tributary of Dixie Creek were identified west of Waterbody 6. Reach W6B-1 extends northward, along the flooded margins of the waterbody. Reaches W6B-2 to W6B-5 extend northwest up the adjacent and sloped forested valley. One (1) Reach W6-1 associated with Watercourse 6 was identified east of Waterbody 6 where flows outlet from the pond. Reach W6-1 extended to the channel confluence with Dixie Creek.

Supporting Reach mapping is provided in Appendix A.

3 Field Observations

Field observations for study area were collected from October 17th to October 22nd, 2024 to characterize Reach channel conditions. Field observations generally included the following:

- Mapping and documentation of prominent channel bedform features (e.g., riffle-pool-run sequences, dominant flow paths, etc.), meander bend patterns/sequences and observations of active channel and valley slope erosion.
- Descriptions of riparian conditions including channel-floodplain connectivity and vegetation type.
- Determination of bed and bank material composition and structure.
- Collection of photographs to document the open water areas, riparian areas and/or valley, surrounding land use, and disturbances such as crossing structures.

In addition, reconnaissance-level geomorphic assessment techniques were completed to generally characterize stream stability, health, and channel evolution patterns (See Section 3.1 for details). Finally, detailed channel surveys were completed to fully characterize Reach conditions (see Section 3.2 for details). A description of site conditions from a fluvial geomorphological perspective is included below with a summary of Reach conditions provided in Table 1. To provide context, a photographic record is provided in Appendix B and field note summaries are included in Appendix C.

Reach W6-1 extends southeast from Waterbody 6. The associated watercourse is characterized by a low-gradient meandering channel which traverses an expansive (i.e., unconfined) corridor. The channel corridor was partially inundated due to beaver activity (e.g., dam presence) and due to backwatering effects from Dixie Creek. This also promoted deposition of fine-grained sediments, namely silts and sands, along the channel bed, forming a relatively planar bed morphology. Dominant riparian vegetation included emergent type grasses and reeds, which provided limited cover over the channel. Channel banks were vegetated and stable, although minor undercutting was observed at select locations.

Reach W6B-1 was characterized by a small meandering and low gradient channel which discharged into Waterbody 6. The channel traversed an expansive (i.e., unconfined) valley. Riparian vegetation transitioned from emergent-type grasses and reeds to trees, with increasing distance from the waterbody. Beaver dams were observed throughout the watercourse promoting fine-grained sediment deposition, which in turn formed a relatively planar bed morphology (i.e., limited variability in bed elevation). Water levels were generally at or above the channel bankfull elevation and the floodplain was inundated. Alternate flowpaths were documented within the floodplain. Although, the channel boundary was vegetated and stable.

Reach W6B-2 was characterized by a small meandering watercourse which flowed southeast through an expansive (i.e., unconfined) forested valley towards Waterbody 6. Dominant riparian vegetation included a mix of grasses, shrubs and trees, which provided cover and shade to the channel. Beaver dams were documented throughout the channel. The dams created intermittent backwatering conditions, which promoted upstream deposition of fine-grained sediments and formation of alternate flowpaths within the floodplain. The channel boundary was generally vegetated and stable.

Reach W6B-3 extended southeast towards Waterbody 6 from a culvert crossing associated with an access road. The associated watercourse flowed through a steep (i.e., 1.9%), forested valley. The channel was generally confined by the adjacent valley slopes. Dominant riparian vegetation consisted of mature tree species and intermittent pockets of peat moss. Woody debris and cross-channel roots were observed in-channel, creating vegetated knickpoints which fed into small pools. The channel boundary was vegetated and relatively stable.

Reach W6B-4 extended upstream from the abovenoted access road along a particularly steep section of forested valley. For instance, the assessed system gradient was approximately 8.3%. The associated channel was partially defined with alternating steps and pools. At intermittent locations, flow piping into the underlying bedrock/boulders, beneath the channel bed, was observed. The channel was confined to either side by the valley slope. Dominant riparian vegetation consisted of shrubs and mature tree species, which provided continuous cover and also a source of woody debris to the channel. The channel boundary was generally vegetated and stable with expected low levels of baseflow.

Reach W6B-5 extended through a low gradient, expansive (i.e., unconfined) valley. Valley vegetation consisted mainly of peat moss with few scattered trees. No discernible flowpath was observed as flow was generally conveyed below the ground surface (via subsurface flow or piping) through the relatively porous medium of the peat.

Table 1: Study Reach Characteristics

Reach	Average Bankfull Channel Width (m)	Average Max Bankfull Depth (m)	Dominant Substrate(s)		Valley Type and Gradient (%)	Dominant Riparian Vegetation
			Riffle	Pool		
W6-1	6.09	0.94	Fine sands, silts, clays, organic material		Unconfined (0.1%)	Grasses
W6B-1	1.23	0.19	Fine sands, silts, clays, organic material		Unconfined (backwatering)	Grasses - Shrubs
W6B-2	2.58	0.26	Fine sands, silts, clays, organic material		Unconfined (1.1%)	Grasses – Trees
W6B-3	1.21	0.09	Fine sands, silts, clays		Confined (1.9%)	Trees
W6B-4	3.33	0.26	Fine sands, gravels, cobbles, boulders	Fine sands, clays	Confined (8.3%)	Trees
W6B-5	No channel definition		Peat moss		Unconfined (0.1%)	Peat Moss - Trees

[1] Valley gradient estimated from available LiDAR (as provided by WSP)

3.1 Reconnaissance-Level Geomorphological Assessment

The modified version of the Brierley and Fryirs (2005) River Styles Framework is a set of procedures that are applied to describe channel forms and processes and assess channel response and potential future behaviour. These procedures are integrated into our geomorphic field assessment protocol. The Framework draws on established geomorphic models, such as Thorne (1999), Schumm (1985), and Downs (1995), to identify active fluvial processes, relative stability, dominant sediment transport mechanisms and the energy in a system. It also indicates the type and degree of sinuosity, system gradient, confinement and the number of channels that are present in equilibrium conditions. Collectively, this information provides insight about geomorphic structure, function, systematic adjustments and the evolutionary trajectory of a river system, which, in turn, is used to inform river management applications (Brierley and Fryirs, 2005).

The Downs (1995) model of channel evolution is a method used to evaluate the magnitude and potential for channel instability and is incorporated into our geomorphic field assessment protocol. This model uses physical indicators of systematic adjustment including channel, bank and bar morphology and stability to classify the type of channel evolution. By classifying channels using this model, the nature of fluvial and hillslope processes that are working to change the system can be inferred. Channels are classified as varying degrees of stable, depositional, migrating laterally, enlarging, and experiencing various types of erosion (Downs, 1995; Simon and Downs, 1995).

Information gathered as part of the River Styles Framework is reviewed in tandem with rapid geomorphic assessment techniques to fully characterise a given fluvial system. Applied techniques include the Rapid Geomorphic Assessment (RGA) and Rapid Stream Assessment Tool (RSAT), which are described below.

The Rapid Geomorphic Assessment (RGA) technique evaluates systematic adjustments characterized as degradation, aggradation, widening, and planimetric form adjustment at the Reach scale (MOE, 2003; VANR, 2007). The RGA method relies on the absence or presence of these indicators to evaluate the systematic adjustments in streams associated with natural causes or human activities. Systematic adjustments typically result in changes to the floodplain, channel or valley characteristics. The end result of the RGA is to produce a score, or stability index, which evaluates the degree to which a stream has departed from the equilibrium condition. A stream with a score of less than 0.20 is in regime, indicating minimal changes to its shape or processes over time. A score of 0.21 to 0.40 indicates that a stream is in transition or stress and is experiencing major change to process and form outside the natural range of variability. A score of greater than 0.41 indicates that a stream is in extreme adjustment, likely exhibiting a new stream type and will continue to adjust to the point of returning to equilibrium, or is moving toward a new equilibrium (MOE, 2003; VANR, 2007).

In addition, the Rapid Stream Assessment Tool (RSAT) was applied, which evaluates stream health, based on an inclusion of biological indicators (Galli, 1996). This technique relies on a scale ranging from 'poor' to 'excellent' for observations concerning channel stability, channel scouring/sediment deposition, physical instream habitat, water quality, and riparian habitat conditions, to provide a qualitative assessment of stream health. The evaluation produces values that indicates whether the channel is in poor (score <13), fair (score 13-24), good (score 25-34), or excellent (score >34) condition (Galli, 1996).

Reconnaissance-level geomorphological assessment results are summarized in Table 2. Detailed Reach information is included in Section 3.2 and Appendix D.

Table 2: Reconnaissance-Level Geomorphological Assessment Results

Reach	RGA (MOE, 2003)			RSAT (Galli, 1996)			**Down's** Channel Evolution Model (1995)	Channel Type and Dominant Mode of Transport (Brierly and Fryirs, 2005)
	Score	Condition	Dominant Systematic Adjustment	Score	Condition	Limiting Features		
W6-1	0.11	In Regime	• N/A – relatively stable conditions	26	Good	Riparian habitat	Stable "S"	• Laterally unconfined "meandering fine-grained channel" • Low energy stream • Suspended load dominant
W6B-1	0.17	In Regime	• N/A – relatively stable conditions	27	Good	Instream habitat	Stable "S"	• Laterally unconfined "meandering fine-grained channel" • Low energy stream • Suspended load dominant
W6B-2	0.18	In Regime	• N/A – relatively stable conditions	27	Good	Instream habitat	Stable "S"	• Laterally unconfined "meandering fine-grained channel" • Low to medium energy stream • Mixed load
W6B-3	0.18	In Regime	• N/A – relatively stable conditions	27	Good	Instream habitat	Stable "S"	• Confined • Discontinuous floodplain • Medium energy stream • Mixed load
W6B-4	N/A – Stable step-pool channel with ephemeral/intermittent flow conditions							• Confined

		• Steep, step-pool/cascade type feature
W6B-5	No discernible channel or flowpath	

According to the RGA scores and Down's classification results outlined in Table 2, the assessed Reaches were generally "in regime", owing to relatively stable observed conditions. For instance, the channels exhibited limited evidence of systematic widening, degradation, aggradation or planimetric adjustment. Channel health was evaluated as "good", suggesting favourable aquatic and terrestrial habitat conditions. Disturbances to channel form were generally limited to or associated with beaver activity. For instance, woody debris and/or dams obstructed flow at various locations, causing water to spill onto the floodplain and form alternate flowpaths. Favourable stability and health conditions, as supported by the reconnaissance-level assessments, were supportive of natural and dynamically-stable stream conditions. For instance, the channels have likely adapted forms cognizant of the local hydrological and sedimentological regimes and have attained a quasi-equilibrium of sediment transport and replenishment.

3.2 Detailed Geomorphological Assessment

Detailed channel surveys were undertaken to supplement the reconnaissance-level assessment for a more complete characterization of bankfull channel geometry, flow and sediment characteristics. The survey was completed along channel segments which reflected the watercourse's natural condition.

The detailed geomorphological surveys/assessments involved temporarily setting up multiple representative transects across the channel to determine average bankfull channel dimensions. The channel cross sections were surveyed across each transect, then the average bankfull width and depth were determined as a desktop exercise. The bed profile was also surveyed to determine channel gradient, which was analyzed with the cross-sectional dimensions to compute bankfull channel hydraulics. Additionally, where applicable, a modified Wolman (1954) pebble count was completed at each transect to characterize the bed materials and subsequently analyze sediment transport sensitivity. A summary of measured and computed values for the assessed reach is presented in Table 3.

The "bankfull" channel condition is represented by dimensions that convey what is considered to be the *channel-forming* or *dominant* discharge and is generally linked to flows associated with the 1.25 to 2-year return period flood events (Leopold et al., 1964). In general, the bankfull stage represents the point at which flow begins to spill onto the floodplain in quasi-stable channel systems and/or the "most-effective transporting discharge", which is a product of the rate of sediment transport and frequency of transport event occurrence (Wolman & Miller, 1960).

Table 3: Bankfull Parameters of the Reference Channels

Channel parameter	Reach*				
	W6-1	W6B-1†	W6B-2	W6B-3	W6B-4††
Measured					
Average bankfull channel width (m)	6.09	3.79	2.58	1.36	3.33
Average bankfull channel depth (m)	0.94	0.17	0.26	0.11	0.26
Channel gradient (%)	0.06	0.32	0.42	2.51	7.39
D_{50} (mm)	2	2	2	2	2
D_{84} (mm)	2	2	2	2	8
Manning's *n* roughness coefficient	0.040	0.045	0.045	0.045	0.046
Computed					
Bankfull discharge (m^3/s) [a]	3.77	0.25	0.40	0.12	2.72
Average bankfull velocity (m/s)	0.66	0.17	0.59	0.82	3.16
Unit-width stream power at bankfull discharge (W/m^2)	4	2	6	22	1500
Stream power at bankfull discharge (W/m)	21	8	16	30	450
Shear stress at bankfull discharge (N/m^2)	5	5	11	27	188
Critical shear stress (N/m^2) [b]	1.46	1.46	1.46	1.46	1.46
Flow competency for D_{50} (m/s) [c]	0.27	0.27	0.27	0.27	0.27
Flow competency for D_{84} (m/s) [c]	0.27	0.27	0.27	0.27	0.50

* Reach W6B-5 channel was not characterized by a defined flowpath and is excluded from the Table
[a] Based on Manning's equation
[b] Based on Shields diagram from Miller et al. (1997)
[c] Based on Komar (1987)
† Discharge potentially underestimated due to inundated corridor conditions and presence of alternate flowpaths
†† Relatively oversized cascade type feature, channel parameters not reflective of typical meandering channel "bankfull" or dynamically stable conditions

In review of Table 3, bankfull widths generally decrease moving upstream (Reach W6-1 to W6B-3) due to the associated reductions in contributing drainage area. In general, the findings support that in-channel materials are susceptible to mobilization during bankfull flow events. However, the assessed watercourses exhibited limited evidence of erosion, which could suggest a combination of the following factors:

- There is a steady influx of sediment to the system from upstream sources to replenish sediments that were mobilized downstream
- In-channel flow energy is dissipated due to the presence of woody debris, beaver dams, and/or alternate flow pathways located in the floodplain, which promote sediment deposition
- Established vegetation observed along the channel margins is helping to hold the channel boundary intact
- Select reaches are characterized by slightly enlarged channels due to high system gradients, and are not fully representative of meandering channel bankfull conditions (i.e., the dynamic discharge flow level contains only a portion of the channel feature)

4 Hydrotechnical and Geotechnical Investigations

At the time of the fluvial geomorphological assessment, supporting hydrotechnical and geotechnical investigations of the study area were still being carried out by other qualified professionals. The findings of these supporting investigations will influence the proposed fluvial geomorphological assessment and associated conceptual designs. As such, the recommendations set out in this report are preliminary and subject to refinement at later stages of planning, once all supporting project information is available.

5 Erosion Assessment

At this time, it is understood that proposed surface water diversion activities include construction of a dam and diversion pond within the W6B-5 footprint. The pond will intercept and drain additional flow from an adjacent tributary, resulting in a 1.3 km^2 increase of the Watercourse 6B drainage area. The additional contributing drainage can be expected to result in an increase to bankfull discharge throughout the receiving watercourse.

Stream systems typically respond to disturbances in hydrological regime through morphological adjustment. For instance, channel width and/or depth may change to accommodate the new flow contributions such that the stream is achieving a new dynamic equilibrium. The degree and type of adjustment depend on multiple factors including the extent of flow being contributed, relative to the channel's capacity to assimilate the flow without significant erosion of the channel boundary materials. These factors are discussed below.

Preliminary projected changes to the Watercourse 6B and Watercourse 6 catchment areas, as provided by WSP, are summarized in Table 4. The table also summarizes a high-level comparative analysis of corresponding changes to bankfull discharge, based on Annable (1996) Ontario stream relations (Equation 1), to facilitate project planning. Note, the values in Table 4 were derived from an empirical relationship and will therefore differ from site-specific measurement (e.g., Table 3). Actual drainage area and watercourse bankfull discharge may vary from what is shown below and will be confirmed at later stages of the project with the completion of detailed hydrological modelling.

$$Q_{bf} = 0.52 * {A_d}^{0.74}$$ Equation (1)

Where, Q_{bf} is bankfull channel discharge (m^3/s) and A_d is drainage area (km^2).

Table 4: Comparison of Pre- and Post-Condition Site Drainage

Hydrogeomorphic parameters	Reach					
	W6-1	W6B-1	W6B-2	W6B-3	W6B-4	W6B-5
Drainage Area (A_d) †						
Existing drainage area in km^2	15.7	5.2	2.1	1.7	0.8	-
Proposed drainage area in km^2	17.0	6.5	3.4	3.0	2.1	1.3
Percentage increase in proposed drainage area (compared to existing conditions)	+8%	+25%	+62%	+76%	+262%	-
Discharge (Q_{bf}) ††						
Estimated existing bankfull discharge in m^3/s	3.98	1.76	0.90	0.77	0.44	-
Estimated proposed bankfull discharge in m^3/s	4.23	2.08	1.29	1.17	0.90	0.63
Percentage increase in proposed bankfull discharge (compared to existing conditions)	+6%	+18%	+43%	+52%	+204%	-

† Information provided by WSP, based on Ontario Watershed Information Tool (MNR tool; data retrieved December 2024)
†† Bankfull discharge computed based on Equation 1 (Annable, 1996)

In review, the most notable (relative) differences between existing and proposed conditions occur along the upstream-most Reaches, where changes will have a more substantive impact on the existing, relatively smaller contributing area. Based on this high-level analysis, possible channel responses to the noted differences in hydrological regime were interpreted and discussed below.

In Reach W6-1, the increase to the proposed drainage area is relatively minor (less than 10%) compared with the other channel locations. The existing channel is characterized by a low gradient (0.06%), stable conditions and a computed bankfull channel discharge (3.77 m^3/s; Table 3) that is approximately in line with the estimated proposed condition discharge of 3.98 m^3/s. The channel also has good connectivity to an expansive floodplain (floodplain width is >20x bankfull width). The relatively large channel and associated floodplain are therefore expected to accommodate the relatively small changes in discharge.

In Reach W6B-1, the increase to drainage area is greater than 10%. However, the existing channel extends into and is therefore approximately level with Waterbody 6. Backwatering effects from the lake intercept channel flow and promote sediment deposition along the channel bed. Moreover, the existing channel has good connectivity to an expansive, well vegetated, and partially inundated floodplain (accessible floodplain width is generally >20x bankfull channel width). Therefore, erosion potential throughout the Reach is considered low after accounting for the projected increases in drainage area and flow.

In Reach W6B-2, the relative increase to drainage area and flow is more substantive. The relative difference is skewed by the fact that the existing drainage area is small (i.e., less than 2.1 km^2) and flow within the watercourse is intermittent. Existing channel substrates consist of fine sediments (sands, silts, and clays), which, based on the supporting flow competency analysis in Table 3, are susceptible to entrainment during below-bankfull flow events in both the existing and proposed condition. Although, deposition of fine materials is promoted by beaver activity (i.e., damming), vegetation encroachment, and woody debris buildup. In addition, flows are dispersed into alternative, vegetated flowpaths which exist in the relatively low-lying floodplain during runoff events. These factors help distribute flow energy and control erosion throughout the corridor, as evidenced by the well-vegetated and generally stable condition of the watercourse. Addition of flow due to the proposed catchment changes will increase the erosion potential and lead to more frequent "flushing flows"; mobilization of accumulations of relatively fine in-channel sediments which can be beneficial for instream habitat. Channel banks, which were well vegetated, should generally resist erosion. For instance, permissible shear ranges associated with long native grasses (60 – 80 N/m^2) and/or vegetated surfaces (i.e., shrubs; 100 – 150 N/m^2) exceed the computed bankfull channel shear rates (Fischenich, 2001).

Flow impacts to Reaches W6B-3 and W6B-4 may be more substantive, compared to the downstream locations. These Reaches are characterized by moderate to high gradients channels. For instance, the overall gradient of W6B-3 and W6B-4 was assessed at 1.9% and 8.3%, respectively. Both channels were partly entrenched and bounded closely by the adjacent valley slope(s). This means that streampower is generally confined to the watercourse with limited opportunity to dissipate flow energy to the adjacent floodplain, which raises the erosion potential. Channel boundary materials consisted of a range of soft to firm vegetated soils, as well as intermittent pockets of peat. Available research on peat erodibility suggest low erosion resistance (critical shear range of 0.01 N/m^2 to 0.06 N/m^2, with more severe erosion of peat samples occurring at flow velocities up to 0.15 m/s; Marttila & Klove [2008]). Finally, there is a large difference in bankfull widths between the existing and proposed conditions (e.g., see Table 3). The combination of these factors suggest that modification of the hydrological regime to the noted extents is more likely to result in channel adjustments (i.e., erosion) and sediment transfer downstream.

Reach W6B-5 was not characterized by a discernible flowpath and runoff within the area is likely transported mainly via subsurface flow. Field investigations support that bed materials along lower-lying sections of valley consisted of peat, which, as noted above, is susceptible to fluvial erosion.

6 Preliminary Fluvial Geomorphological Design Considerations

Preliminary fluvial geomorphological requirements and associated recommendations were developed based on current available project information, collected field observations, and with comparison to geomorphic relations documented in supporting literature. With respect to the proposed work at the Project site, it is understood that water diversion activities will likely require modification of the W6B-3, W6B-4, and W6B-5 channels and/or corridor widths in order to assimilate the updated flow conditions.

In review of the supporting erosion assessment in Section 5, and based on supporting discussion with WSP regarding geotechnical/hydrogeological requirements, projected changes to existing channel corridors are limited to Reaches W6B-3, W6B-4, and W6B-5. A summary of preliminary considerations, provided from a fluvial geomorphological perspective, is included in Table 5.

Table 5: Summary of Preliminary Fluvial Geomorphological Design Recommendations

Reach	Notes	Preliminary Recommendations
W6-1	Existing watercourse is stable with low erosion potential and likely able to accommodate the proposed changes to catchment hydrology with no perceived impacts to channel morphology.	None
W6B-1	Existing watercourse is stable with low erosion potential and likely able to accommodate the proposed changes to catchment hydrology with limited impacts to channel morphology.	Implementation of a low-effort monitoring program to assess natural channel development and identify potential erosion issues/remedial activities
W6B-2	Existing watercourse is moderately stable with low erosion potential and likely able to accommodate the proposed changes to catchment hydrology with minor perceived impacts to channel morphology (i.e., flushing of fine sediments).	Implementation of a detailed monitoring program to assess natural channel development and identify potential erosion issues/remedial activities
W6B-3	Existing watercourse(s) are moderately stable with moderate to high erosion/morphological adjustment potential.	Watercourse modifications or realignment within an updated (e.g., widened) corridor
W6B-4		
W6B-5	Reach characterized by subsurface flow conditions (i.e., peat) with no discernible flowpath	Watercourse realignment within an updated corridor with stable connection to the proposed pond (pond design by WSP)

Detailed description of possible updated watercourse and corridor configurations to help address fluvial geomorphological requirements is provided in Sections 6.1 and 6.2. Watercourse restoration concepts and associated benefits to geomorphic function and ecology are discussed in Section 7.

6.1 Bankfull Channel Requirements

The "bankfull" channel condition is represented by dimensions that convey what is considered to be the *channel-forming* or *dominant* discharge. Bankfull width is linked to and used to inform channel meander patterns and valley corridor requirements. Refer to Section 3.2 for additional information on "bankfull".

New hydraulically-sized channels would be constructed where updated corridors are proposed (i.e., Reaches W6B-3, W6B-4, and W6B-5). Bankfull channel widths required to accommodate the proposed flow conditions were computed through application of a simple Manning's approach. The approach included back-calculation of channel geometry from Manning's (1890) equation (Equation 2).

$$V = \frac{R^{2/3}\,S^{1/2}}{n} \qquad \text{Equation (2)}$$

where, *V* is the average velocity of flow, *R* is the hydraulic radius, *S* is the channel gradient, and n is the Manning's roughness coefficient. The back-calculated channel widths, as well as anticipated bankfull flow conditions are provided in Table 6 below. As noted, bankfull channel parameters will be confirmed at later stages of the project once the hydrological conditions are better understood.

Table 6: Back-calculated Proposed Condition Channel Parameters

Back-calculated channel parameters	Reach		
	W6B-3	W6B-4	W6B-5
Average bankfull width (m)	2.6	1.8	3.4
Overall system gradient (%)	1.9	8.3	0.1
Bankfull velocity (m/s)*	1.4	2.3	0.4
Bankfull discharge (m^3/s)*	1.2	0.9	0.6
Discharge to accommodate (m^3/s)**	1.2	0.9	0.6

*Based on Manning's equation (Equation 2)
**Based on Table 4 (values to confirmed with hydrological modelling at later project stages)

6.2 Channel Corridor Requirements

Most watercourses in Ontario have a natural tendency to develop and maintain a meandering planform, provided there are no spatial constraints. A meander belt width assessment estimates the lateral extent that a meandering channel has historically occupied and can therefore potentially re-occupy in the future. The assessment is therefore useful for informing suitable channel corridor widths for newly realigned channels.

With respect to the proposed work at the Project site, water diversion activities will potentially require the realignment of W6B-3, W6B-4, and W6B-5 within updated corridors that are able to assimilate the updated flow conditions. Therefore, a preliminary meander belt width assessment was completed for these Reaches. Channel corridor alignments, grading, widths, and tie-in inverts will be refined at later stages of the planning process once additional supporting information is available.

Meander Belt Width Assessment

In unconfined systems, the meander belt is broadly defined as the lateral extents within a floodplain in which the channel has historically occupied, plus an erosion setback (if applicable) to account for future channel migration and shifts in the meander belt axis. Typically, aerial imagery is used to trace past channel positions and the channel's central tendency (or meander axis). Parallel or near parallel guide lines are then drawn tangentially to the outside bends of the most laterally extreme meanders within the corresponding channel reach to form the preliminary meander belt.

With respect to the subject site, Reach W6B-3 and W6B-4 channels were situated in a confined valley. The adjacent slopes act as a barrier and inhibit lateral channel adjustment. Cascade or step-pool type channels, characterized by moderate-high gradients and relatively low sinuosity, tend to form in such environments. For instance, the surveyed section of W6B-3 had a sinuosity of 1.11 m/m and a maximum meander amplitude of approximately 3.0 m. The W6B-4 channel had a sinuosity 1.12 m/m and a maximum meander amplitude of 5.3 m.

The Reach W6B-5 channel is set within a relatively unconfined section of valley where a meander belt would apply. As there is no existing discernible flowpath upon which to visually delineate a meander belt, the belt width was instead informed based on available documented relations between channel hydrogeomorphic variables and meander limits from Williams (1986), Annable (1996), and Ward (2002).

$$B_w = 4.3 * {W_b}^{1.12} \quad \text{Equation (3)}$$

$$B_w = 18 * {A_{bf}}^{0.65} \quad \text{Equation (4)}$$

$$B_w = 16.3 * Q_{bf}^{0.88}$$ Equation (5)

$$B_w = 120 * A_d^{0.43}$$ Equation (6)

Where B_w is the belt width (m), W_b is the design bankfull channel width (m; based on Table 6), A_{bf} is the design cross-sectional channel area (m^2), and A_d is the catchment drainage area (mi^2; B_w output in feet and converted to m).

A summary of the meander belt width assessment results is included below in Table 7 and an overview of the belt limits is provided in Appendix B. A suite of equations was applied to consider a range of possible belt limits, as they relate to various hydrogeomorphic variables.

Table 7: Preliminary Belt Width Estimation for Reach W6B-5 Channel

Equation	Source	Preliminary Belt Width (m) †	Notes
Equation 3	Williams (1986)	17	Based on back-calculated bankfull width
Equation 4	Williams (1986)	23	Based on back-calculated channel area
Equation 4	Annable (1996)	11	Based on back-calculated bankfull discharge (E-type channel classification)
Equation 5	Ward (2002)	27	Equation is in imperial units. Based on hypothetical drainage area
Preliminary Design Belt Width (m)		20	Represents average of computed preliminary belt widths

† Belt widths do not include additional erosion setback

The computed belt widths were not equipped with an additional erosion setback or safety factor as larger corridors would require further encroachment into natural forested areas, which is not a desired impact at the subject site where there is limited risk to infrastructure, development, and/or human safety.

Channel Corridor Design Recommendations

For Reaches W6B-3 and W6B-4, restoration of the channel corridor with an expansive valley floor/floodplain is not practical with respect to channel morphology and would require greater disturbance to natural forested areas. As an alternative, we suggest provision of a valley floor equivalent to at least two to three times the bankfull channel width to accommodate a cascade-type channel and incorporation of a subtle channel sinuosity (e.g., 1.0 - 1.2 m/m), effectively mimicking existing channel morphology and valley conditions. For Reach W6B-5, a corridor width of 20 m is suggested to accommodate a meandering-type channel.

7 Conceptual Channel Restoration Design

Various design objectives and constraints were identified for the study reaches based on the assessment of the existing channel condition. These include:

- Restore the physical, natural and dynamically stable form of the channel
- Enhance aquatic habitat through the provision of a morphologically diverse channel with spatially varied flows and a greater diversity of substrates
- Enhance aquatic wildlife passage opportunity by incorporating pool features with relatively quiescent flow conditions
- Reduce the potential for corridor inundation, and, in turn, reduce in-channel vegetation encroachment and sediment deposition

- Promote transfer of fine sediments (e.g., silts and sands) through provision of a concentrated low-flow path, preventing cover of underlying granular materials, to benefit aquatic wildlife and benthic communities
- Improve riparian habitat by installing woody plantings and floodplain features such as offline wetlands and beaver dam analogues

7.1 Channel Design Concepts

With consideration to the above-noted objectives and equipped with a comprehensive understanding of the existing watercourse conditions, channel realignment following a cascade-type morphology is suggested for Reaches W6B-3 and W6B-4. Cascades consist of a series of rock weirs (e.g., steps) which feed into intermittent pools. Cascades tend to form naturally in relatively steep valleys and offer numerous structural and ecological benefits, including:

- Invert control and in-channel energy dissipation
- Erosion mitigation through prescription of hydraulically-sized materials
- Channel bed relief with flow and substrate variability
- Relatively quiescent flows in pool sections, due to backwatering generated between the weir crests, which provide a low-velocity refuge for fish and increased opportunity for upstream fish passage through the culverts
- Increased water aeration at rock weir "steps"
- Promote transfer of fine sediments (e.g., silts and sands) through provision of a concentrated low-flow path, preventing cover of underlying granular materials, which benefits aquatic wildlife and the benthic community
- Improve riparian habitat by installing native woody plantings

Alternating low points in the vortex rock weirs can increase flowpath sinuosity to help manage fluvial erosion in particularly steep channel sections. Bioengineering consisting of stone and live woody materials is proposed along the cascade banks to mitigate the lateral erosion potential.

An updated corridor equipped with a meandering-type channel is proposed at Reach W6B-5 to capture flow from the proposed dam/pond and direct it downstream towards the W6B-4 cascade. Discussion of potentially appropriate corridor widths is outlined in Section 6.2. It is anticipated that the low gradient and minor flow input to W6B-5 will encourage in-channel vegetation growth, enhancing boundary roughness. An over-deepened channel characterized by a low width-to-depth ratio (i.e., less than 8:1) would therefore help control vegetation and prevent significant encroachment. This configuration essentially mimics an "E" type meandering stream, which form naturally in similar conditions (Rosgen, 1996). Depending on the extent of peat cover (i.e., depth and lateral extents), as determined by the geotechnical assessment, alternate low-energy channel configurations will also be considered. For instance, a multi-threaded channel typology, which tend to form naturally in organic-heavy or bog-like landscapes characterized by hydraulically inefficient conditions (i.e., gradients less than 0.10%), may be appropriate. To promote bank stability during major flooding events, woody debris disturbed as part of the site access and channel excavation work is proposed to be salvaged and redistributed in the floodplain along the margins of the creek.

Figure 2: Example Photograph of a Constructed Low-Gradient Valley Transition to Steeper Cascade-type Channel

7.2 Natural Erosion Control

Newly constructed channel restoration treatments can be vulnerable to erosion. This is particularly true before vegetation has established along the channel banks. Low-flow events should not intensify erosion. The concern for erosion occurs when there are high flows or precipitation events during construction. The following recommendations are provided to manage and reduce the potential for erosion:

- For immediate erosion protection, mechanical stabilization in the form of biodegradable erosion control mats (e.g., coir cloth, jute mat, etc.) should be used. As the mats will biodegrade over time, this serves as a short-term stabilization measure.
- For long-term stability, implementation of a planting plan, is recommended. This includes deep rooting native grasses and other herbaceous species seeded along and within channel sections, prescription of flood tolerant native shrub and tree species, and use of seed banks within the local soil. Deep rooting grasses close to the channel provide habitat for small-bodied fish. The planting plan should include live stakes and shrubs in nodes, with grass bank areas in between.
- Live staking and shrub stock should be used adjacent to the channel bank to provide immediate benefit as well as long-term infilling. If appropriate live staking methods are followed, this method should provide greater stability than simple potted or bare root shrub plantings because of the potential for higher densities with live staking.

8 Channel Monitoring and Maintenance Plan

Most adjustments to stream form will occur during the first years of construction, and subsequently during large flood events. As such, in the event of that channel restoration works are undertaken, development of a comprehensive post-construction monitoring and maintenance plan is recommended help ensure the continued stability and functionality of the newly constructed channel or restoration elements. Early identification and timely maintenance of potential issues will preserve the integrity of the stream corridor geomorphology, vegetation, and overall stability, and mitigate possible downstream effects. The monitoring and maintenance plan would be developed at later stages of the project once the proposed works are better understood.

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We trust this letter meets your current requirements. Should you have any questions, please contact the undersigned.

Respectfully submitted,

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Director, Principal Geomorphologist

Bryce Molder, M.Sc., P.Geo., CAN-CISEC
Geomorphologist, Project Manager

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Appendix A: Study Reach Mapping

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Study Area

Red Lake, Ontario

Legend

Reach Break and ID

Detailed Geomorphological Assessment Location

Watercourse

Scoped Geomorphological Assessment Location

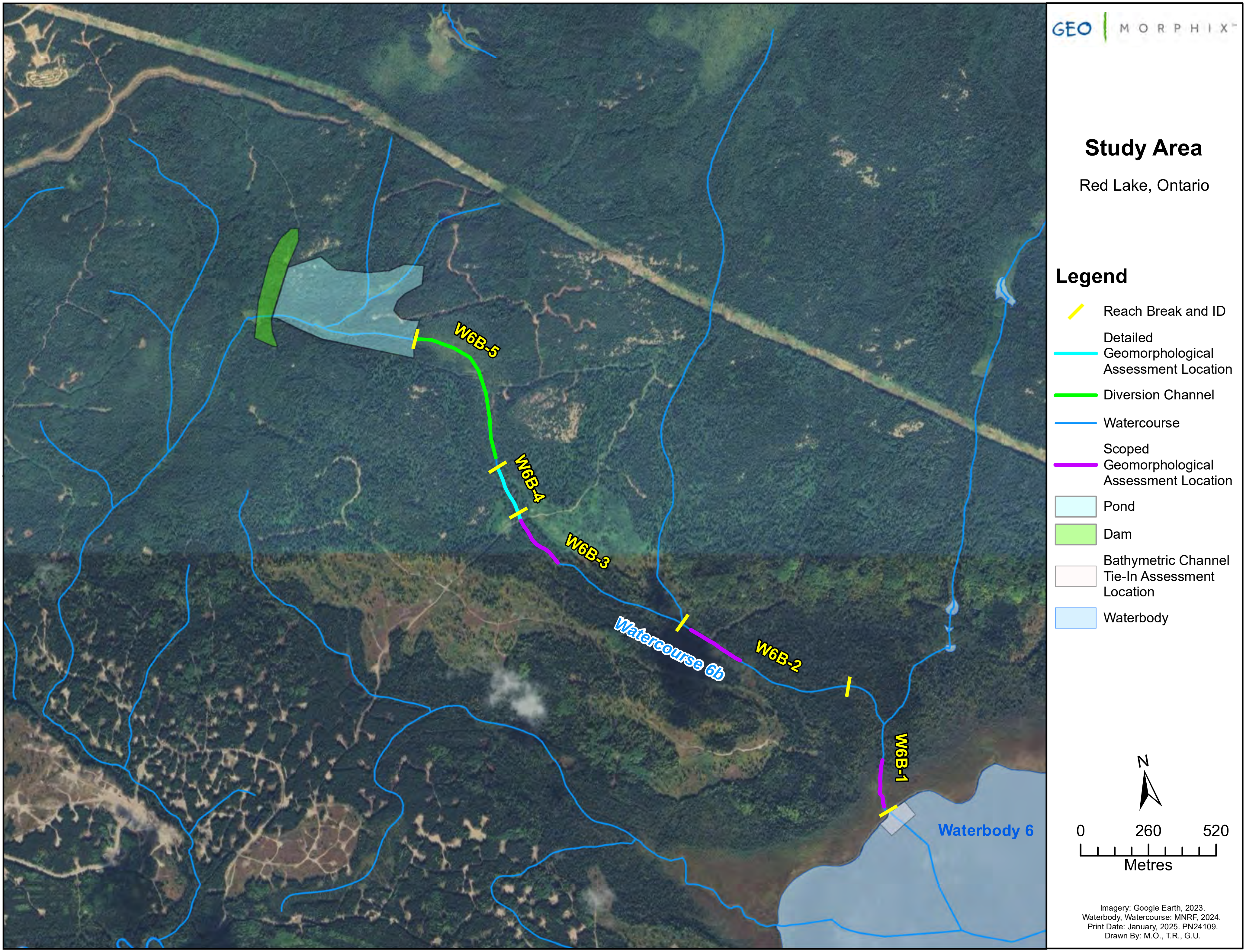
Waterbody

N

0 125 250

Metres

Imagery: Google Earth, 2023.
Waterbody, Watercourse: MNRF, 2024.
Print Date: January, 2025. PN24109.
Drawn By: M.O., T.R., G.U.



GEO MORPHIX
Study Area
Red Lake, Ontario
Legend
Reach Break and ID
Detailed Geomorphological Assessment Location
Diversion Channel
Watercourse
Scoped Geomorphological Assessment Location
Pond
Dam
Bathymetric Channel Tie-In Assessment Location
Waterbody
W6B-5
W6B-4
W6B-3
W6B-2
W6B-1
Watercourse 6b
Waterbody 6
N
0
260
520
Metres
Imagery: Google Earth, 2023.
Waterbody, Watercourse: MNRF, 2024.
Print Date: January, 2025. PN24109.
Drawn By: M.O., T.R., G.U.

Appendix B: Photographic Record

Photo 1 – Reach W6-1	
	Reach W6-1 consisted of a meandering, low gradient, low energy channel that traversed an expansive (unconfined) valley. The channel corridor was partially inundated due to backwatering from Dixie Creek and due to beaver dams.
Photo 2 – Reach W6-1	
	View of the Reach W6-1 channel confluence with Waterbody 6. The channel and waterbody outlet exhibited stable conditions.

Photo 3 – Reach W6B-1	
	Reach W6B-1 consisted of a meandering, low gradient, low energy channel which traversed an expansive valley.
Photo 4 - Reach W6B-1	
	The channel exhibited a high variability in width, high water level conditions (due to backwatering from Waterbody 6) with alternate flowpaths found in the floodplain.

Photo 5 – Reach W6B-2	 Reach W6B-2 consisted of a meandering, low – moderate gradient channel which traversed an expansive, forested valley. Riparian vegetation included a mix of shrubs, grasses, and trees.
Photo 6 – Reach W6B-2	 The channel was characterized by slightly inundated conditions, due to beaver activity and woody debris buildups, which promoted formation of small alternate flow paths in the floodplain.

Photo 7 – Reach W6B-3	 Reach W6B-3 consisted of a relatively linear, high gradient channel which traversed a forested valley. Riparian vegetation included a mix of shrubs, grasses, and trees.
Photo 8 – Reach W6B-3	 Roots and woody debris formed alternating steps and pools in the channel.

Photo 9 – Reach W6B-4	 Reach W6B-4 consisted of a relatively linear, high gradient channel which traversed a forested valley. Riparian vegetation included a mix of shrubs, grasses, and trees.
Photo 10 – Reach W6B-4	 Channel flows were intermittently carried via subsurface flow (e.g., piping) between supporting boulders/bedrock.

Photo 11 – Reach W6B-5	
	There was no discernible flowpath at Reach W6B-5. Flow was conveyed via subsurface processes/through the surrounding peat moss.

Appendix C: Field Observations

Detailed Geomorphological Assessment Summary

Reach W6-1

Project Number:	PN24109	Date:	2024-10-20
Client:	WSP	Length Surveyed (m):	1582.7
Location:	East of Red Lake, Ontario	# of Cross-Sections:	8

Reach Characteristics

Drainage Area:	16 km^2	Dominant Riparian Vegetation Type:	Grasses/Emergent Type
Geology/Soils:	Glaciolacustrine	Extent of Riparian Cover:	Continuous
Surrounding Land Use:	Forest	Width of Riparian Cover:	> 10 Channel Widths
Valley Type:	Unconfined	Age Class of Riparian Vegetation:	Established
Dominant Instream Vegetation Type:	Grasses/Reeds	Extent of Encroachment into Channel:	Moderate
Portion of Reach with Vegetation:	50%(along banks)	Density of Woody Debris:	Moderate

Hydrology

Estimated Discharge (m^3/s):	0.34	Estimated Bankfull Discharge (m^3/s):	3.77
Modelled 2-year Discharge (m^3/s):	Review HEC-RAS	Estimated Bankfull Velocity (m/s):	0.66
Modelled 2-year Velocity (m/s):	Review HEC-RAS		

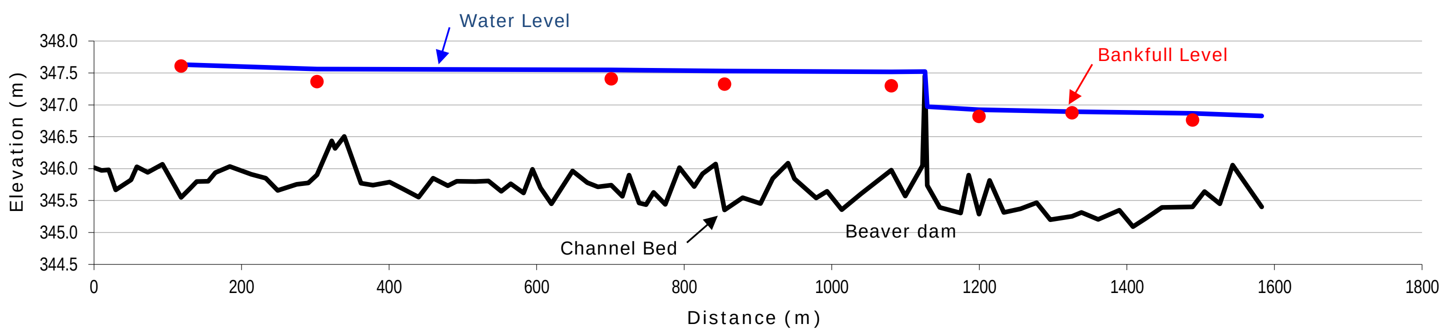
Profile Characteristics

Bankfull Gradient (%):	0.06
Channel Bed Gradient (%):	0.03

Planform Characteristics

Sinuosity:	1.47
Meander Belt Width (m):	See Report
Radius of Curvature (m):	9.8
Meander Amplitude (m):	30.0
Meander Wavelength (m):	21.8

Longitudinal Profile



Bank Characteristics

	Minimum	Maximum	Average
Bank Height (m):	1.44	1.86	1.68
Bank Angle (deg):	50	90	69
Root Depth (m):	0.40	0.40	0.40
Root Density (%):	80	80	80

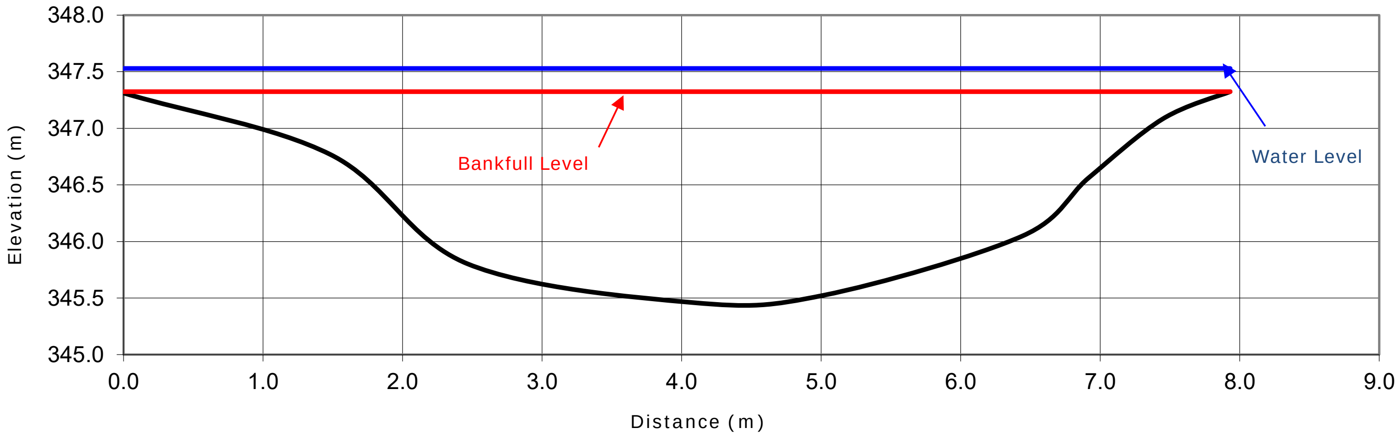
	Minimum	Maximum	Average
Bank Material (range):		Fine Sand - Clay	

Cross-Sectional Characteristics

	Minimum	Maximum	Average
Bankfull Width (m):	4.17	12.19	6.09
Average Bankfull Depth (m):	0.83	1.07	0.94
Bankfull Width/Depth (m/m):	4	11	6
Wetted Width (m):	4.17	12.19	6.56
Average Water Depth (m):	0.82	1.29	0.99
Wetted Width/Depth (m/m):	4	9	7
Entrenchment Ratio (m/m):	>2.2 (Slight/Low Entrenchment)		
Maximum Water Depth (m):	1.54	2.07	1.80
Manning's *n*:		0.040	

Photograph at cross section 4 (looking upstream)

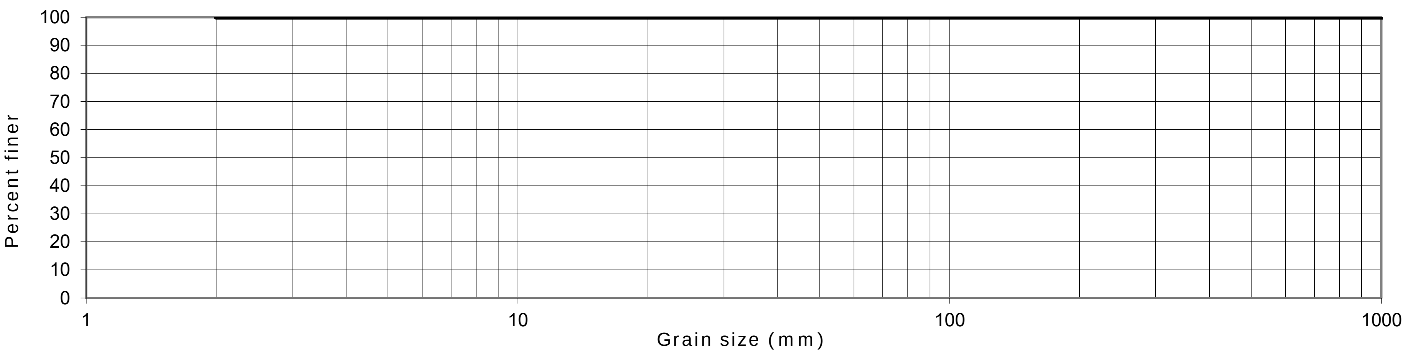
Representative Cross-Section #4



Substrate Characteristics

Particle Size (mm)		Subpavement:	Sand - Clay
D_{10} :	2.0	Embeddedness (%):	100
D_{50} :	2.0		
D_{84} :	2.0		

Cumulative Particle Size Distribution



Channel Thresholds

Flow Competency (m/s):		Tractive Force at Bankfull (N/m^2):	5.32
for D_{50}:	0.27	Tractive Force at 2-year flow (N/m^2):	Not available
for D_{84}:	0.27	Critical Shear Stress (D_{50}) (N/m^2):	1.46
Unit Stream Power at Bankfull (W/m^2):	4		

General Field Observations

Channel Description

1) Reach W6-1 extended southeast from Waterbody 6
2) Low gradient, meandering channel, unconfined valley setting
3) Riparian vegetation = emergent type vegetation (grasses, reeds) surrounded by forest
4) Beaver activity (dams present)
5) Inundated conditions due to dams and low system gradient
6) Limited variability in bed morphology due to sediment accumulation
7) Low erosion potential/limited evidence of erosion

Facing Downstream

Detailed Geomorphological Assessment Summary

Reach W6B-1 (Scoped Assessment)

Project Number:	PN24109	Date:	2024-10-19
Client:	WSP	Length Surveyed (m):	124.0
Location:	East of Red Lake, Ontario	# of Cross-Sections:	3

Reach Characteristics

Drainage Area:	5.2 km^2	Dominant Riparian Vegetation Type:	Mature Forest - Grasses
Geology/Soils:	Glaciolacustrine deposits	Extent of Riparian Cover:	Fragmented
Surrounding Land Use:	Wetland / Forest	Width of Riparian Cover:	> 10 Channel Widths
Valley Type:	Unconfined	Age Class of Riparian Vegetation:	Established
Dominant Instream Vegetation Type:	Grasses/Reeds	Extent of Encroachment into Channel:	Moderate (banks)
Portion of Reach with Vegetation:	40%	Density of Woody Debris:	Moderate

Hydrology

Estimated Discharge (m^3/s):	0.02	Estimated Bankfull Discharge (m^3/s)*:	0.25
Modelled 2-year Discharge (m^3/s):	Not available	Estimated Bankfull Velocity (m/s):	0.38
Modelled 2-year Velocity (m/s):	Not available	* Bankfull discharge mispresented due to backwatering conditions/multiple flowpaths	

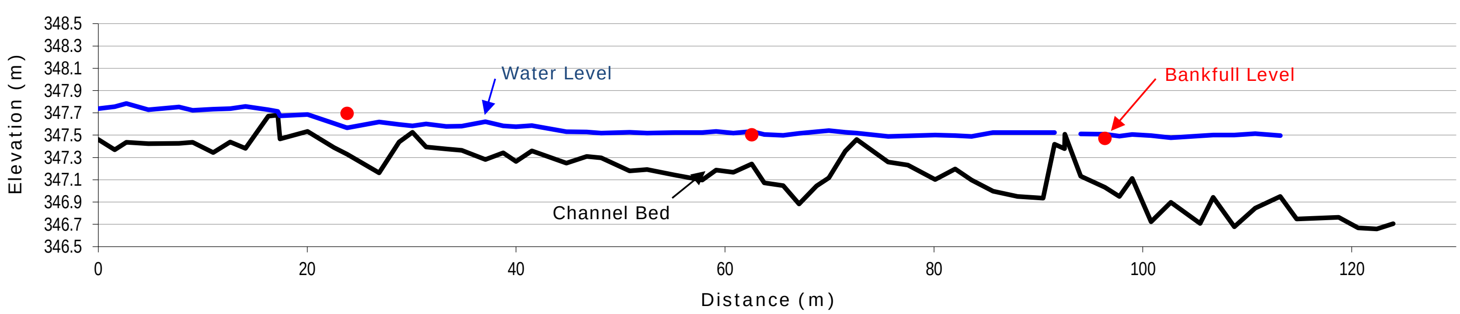
Profile Characteristics

Bankfull Gradient (%):	0.32
Channel Bed Gradient (%):	0.57

Planform Characteristics

Sinuosity:	1.14
Meander Belt Width (m):	See Report
Radius of curvature (m):	3.0
Meander Amplitude (m):	8.8

Longitudinal Profile



Bank Characteristics

	Minimum	Maximum	Average
Bank Height (m):	0.40	0.60	0.50
Bank Angle (deg):	50	60	53
Root Depth (m):	0.40	0.60	0.50
Root Density (%):	40	70	57

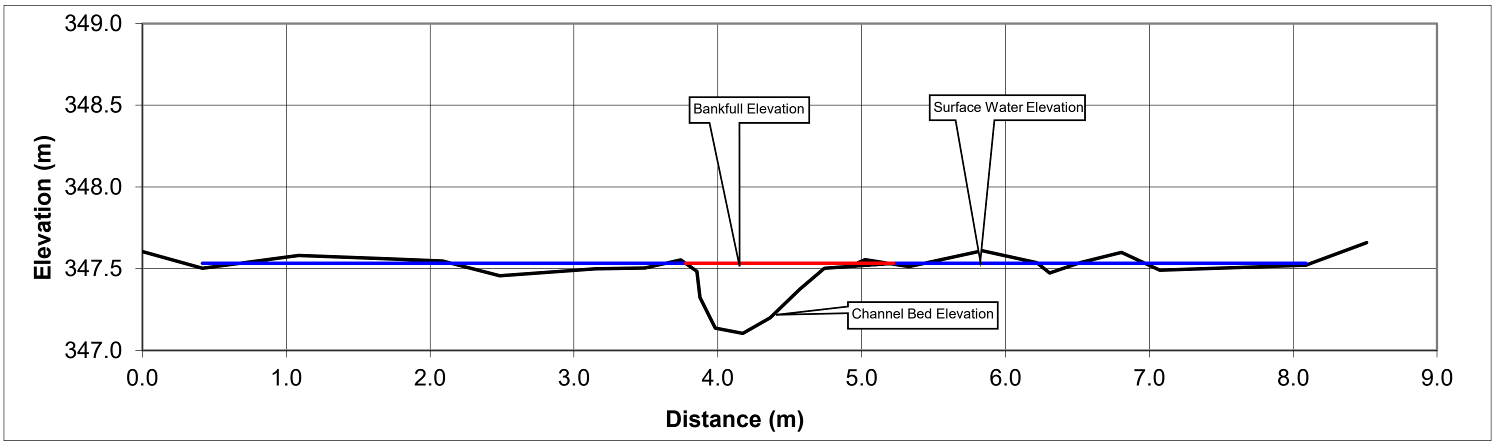
	Minimum	Maximum	Average
Penetrometer Value (kg/cm3):	0	0	0
Bank Material (range):		Fine Sand - Clay	

Cross-Sectional Characteristics

	Minimum	Maximum	Average
Bankfull Width (m):	1.44	5.99	3.79
Average Bankfull Depth (m):	0.15	0.19	0.17
Bankfull Width/Depth (m/m):	9	39	23
Wetted Width (m):	3.90	7.67	6.09
Average Water Depth (m):	0.11	0.15	0.13
Wetted Width/Depth (m/m):	30	68	47
Entrenchment Ratio (m/m):	>2.2 (Slight/Low Entrenchment)		
Maximum Water Depth (m):	0.23	0.66	0.44
Manning's *n*:		0.045	

Photograph at cross section 1 (looking Upstream)

Representative Cross-Section #2

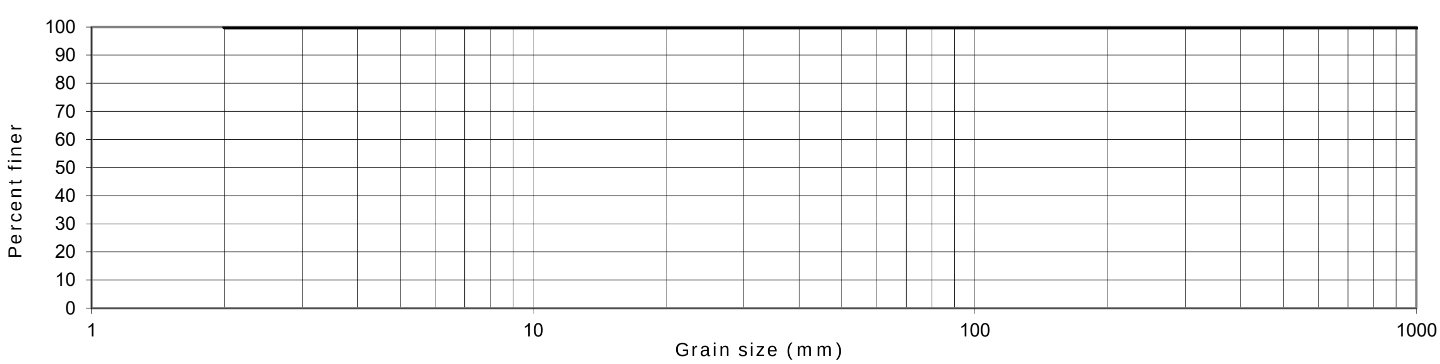


Substrate Characteristics

Particle Size (mm)

D_{10} :	2.0	Subpavement:	Clay / Sands
D_{50} :	2.0	Embeddedness (%):	100
D_{84} :	2.0		

Cumulative Particle Size Distribution



Channel Thresholds

Flow Competency (m/s):		Tractive Force at Bankfull (N/m^2):	5.26
for D_{50}:	0.27	Tractive Force at 2-year flow (N/m^2):	Not available
for D_{84}:	0.27	Critical Shear Stress (D_{50}) (N/m^2):	1.46
Unit Stream Power at Bankfull (W/m^2):	2		

General Field Observations

Channel Description

1) Reach W6B-1discharges into Waterbody 6 from the west
2) Low gradient, meandering channel, unconfined valley setting
3) Riparian vegetation = emergent type vegetation (grasses, reeds), shrubs, surrounded by forest
4) Beaver activity and/or woody debris buildup (dams present)
5) Inundated conditions due to dams, woody debris and backwatering from Waterbody 6
6) Fine sediment accumulation along bed
7) Low erosion potential/limited evidence of erosion, vegetated banks
8) Low-lying floodplain with alternate flowpaths present in floodplain

Cross Section 3 - Facing Downstream

Detailed Geomorphological Assessment Summary

Reach W6B-2

Project Number:	PN24109	Date:	2024-10-19
Client:	WSP	Length Surveyed (m):	59.3
Location:	East of Red Lake, Ontario	# of Cross-Sections:	4

Reach Characteristics

Drainage Area:	2.1 km^2	Dominant Riparian Vegetation Type:	Trees - Mature Forest
Geology/Soils:	Glaciolacustrine deposits	Extent of Riparian Cover:	Fragmented
Surrounding Land Use:	Forest	Width of Riparian Cover:	> 10 Channel Widths
Valley Type:	Unconfined	Age Class of Riparian Vegetation:	Established
Dominant Instream Vegetation Type:	Grasses/Reeds	Extent of Encroachment into Channel:	Moderate
Portion of Reach with Vegetation:	50% along banks	Density of Woody Debris:	High

Hydrology

Estimated Discharge (m^3/s):	0.03	Estimated Bankfull Discharge (m^3/s):	0.40
Modelled 2-year Discharge (m^3/s):	Not available	Estimated Bankfull Velocity (m/s):	0.59
Modelled 2-year Velocity (m/s):	Not available		

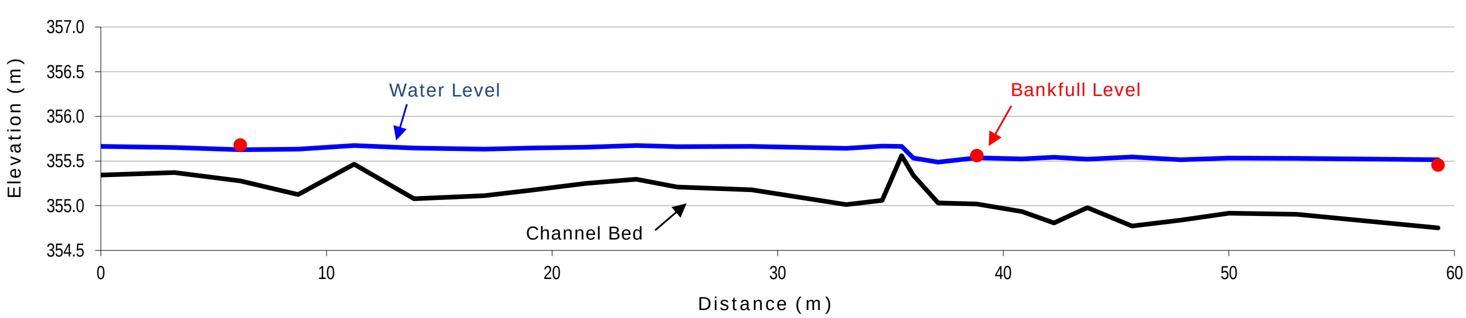
Profile Characteristics

Bankfull Gradient (%):	0.42
Channel Bed Gradient (%):	0.93

Planform Characteristics

Sinuosity:	1.11
Meander Belt Width (m):	See Report
Radius of curvature (m):	3.2
Meander amplitude (m):	3.1

Longitudinal Profile



Bank Characteristics

	Minimum	Maximum	Average
Bank Height (m):	0.60	0.80	0.70
Bank Angle (deg):	55	70	65
Root Depth (m):	0.60	0.80	0.70
Root Density (%):	40	60	50
Bank Undercut (m):	0.00	0.00	0.00

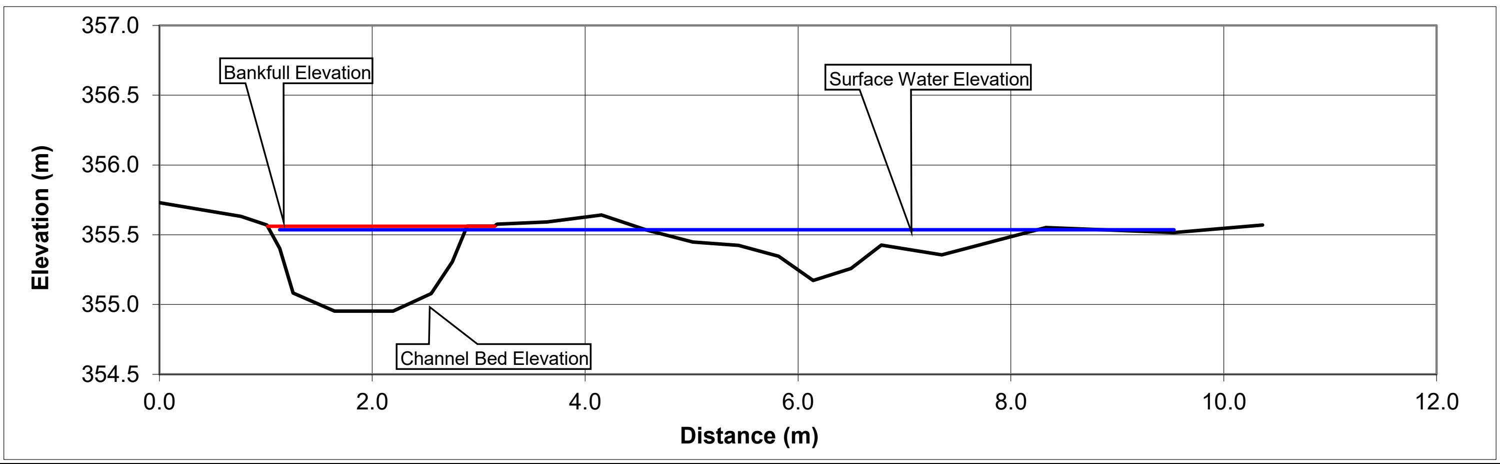
	Minimum	Maximum	Average
Penetrometer Value (kg/cm3):	0	0	0
Bank Material (range):		Clay - Sand	

Cross-Sectional Characteristics

	Minimum	Maximum	Average
Bankfull Width (m):	2.13	3.12	2.58
Average Bankfull Depth (m):	0.15	0.35	0.26
Bankfull Width/Depth (m/m):	7	17	11
Wetted Width (m):	2.47	17.63	9.51
Average Water Depth (m):	0.16	0.38	0.27
Wetted Width/Depth (m/m):	16	46	32
Entrenchment Ratio (m/m):	>2.2 (Slight/Low Entrenchment)		
Maximum Water Depth (m):	0.43	0.81	0.66
Manning's *n*:		0.045	

Photograph at cross section 3 (facing downstream)

Representative Cross-Section #3

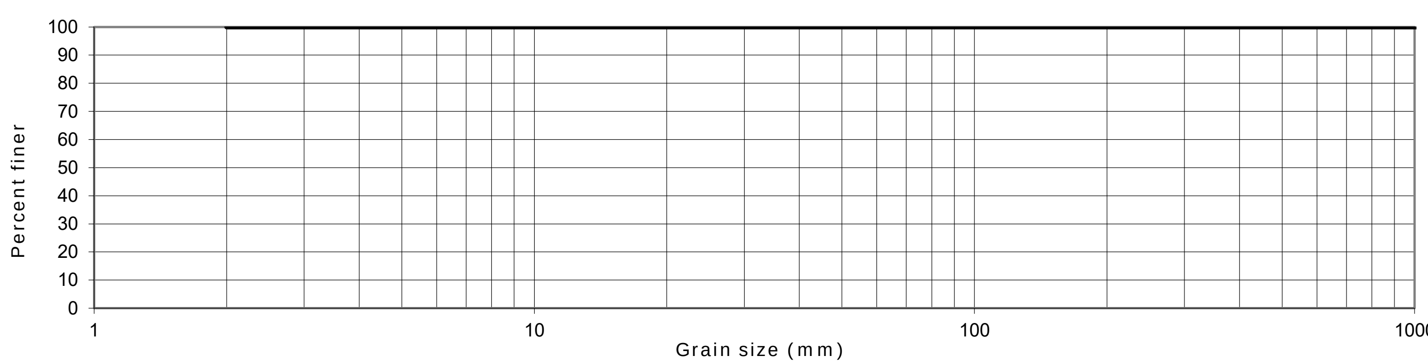


Substrate Characteristics

Particle Size (mm)

D_{10} :	2.0	Subpavement:	Clay / Sands
D_{50} :	2.0	Embeddedness (%):	100
D_{84} :	2.0		

Cumulative Particle Size Distribution



Channel Thresholds

Flow Competency (m/s):		Tractive Force at Bankfull (N/m^2):	10.81
for D_{50}:	0.27	Tractive Force at 2-year flow (N/m^2):	Not available
for D_{84}:	0.27	Critical Shear Stress (D_{50}) (N/m^2):	1.46
Unit Stream Power at Bankfull (W/m^2):	6		

General Field Observations

Channel Description

1) Reach W6B-2 flows southeast through a forested area towards Waterbody 6
2) Low-moderate gradient, sinuous channel, unconfined valley setting
3) Riparian vegetation = Grasses, shrubs, and trees
4) Beaver activity and/or woody debris buildup (dams present)
5) Partially inundated conditions due to dams and woody debris obstructions
6) Fine sediment accumulation along bed
7) Low erosion potential/limited evidence of erosion, vegetated banks
8) Low-lying floodplain with alternate flowpaths present in floodplain

Facing Upstream

Detailed Geomorphological Assessment Summary

Reach W6B-3

Project Number:	PN24109	Date:	2024-10-19
Client:	WSP	Length Surveyed (m):	58.9
Location:	East of Red Lake, Ontario	# of Cross-Sections:	2

Reach Characteristics

Drainage Area:	1.7 km^2	Dominant Riparian Vegetation Type:	Trees
Geology/Soils:	Glaciolacustrine deposits	Extent of Riparian Cover:	100%
Surrounding Land Use:	Forest	Width of Riparian Cover:	> 10 Channel Widths
Valley Type:	Confined	Age Class of Riparian Vegetation:	Established - Mature
Dominant Instream Vegetation Type:	None	Extent of Encroachment into Channel:	Moderate
Portion of Reach with Vegetation:	None	Density of Woody Debris:	Moderate

Hydrology

Estimated Discharge (m^3/s):	0.01	Estimated Bankfull Discharge (m^3/s):	0.12
Modelled 2-year Discharge (m^3/s):	Not available	Estimated Bankfull Velocity (m/s):	0.82
Modelled 2-year Velocity (m/s):	Not available	* Steep cascade, bankfull discharge potentially underestimated	

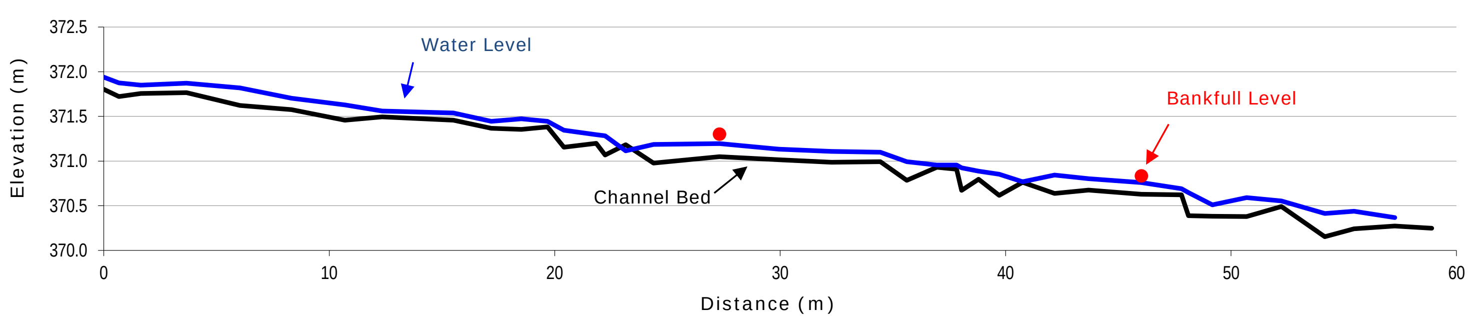
Profile Characteristics

Bankfull Gradient (%):	2.51
Channel Bed Gradient (%):	2.71
Riffle Gradient (%):	N/A (Step pool)
Riffle Length (m):	N/A (Step pool)
Riffle-Pool Spacing (m):	N/A (Step pool)

Planform Characteristics

Sinuosity:	1.12
Meander Belt Width (m):	See Report
Radius of curvature (m)	2.8
Meander amplitude (m):	3.0

Longitudinal Profile



Bank Characteristics

	Minimum	Maximum	Average
Bank Height (m):	0.25	0.30	0.28
Bank Angle (deg):	30	45	38
Root Depth (m):	0.25	0.30	0.28
Root Density (%):	30	40	35
Bank Undercut (m):	0.00	0.00	0.00

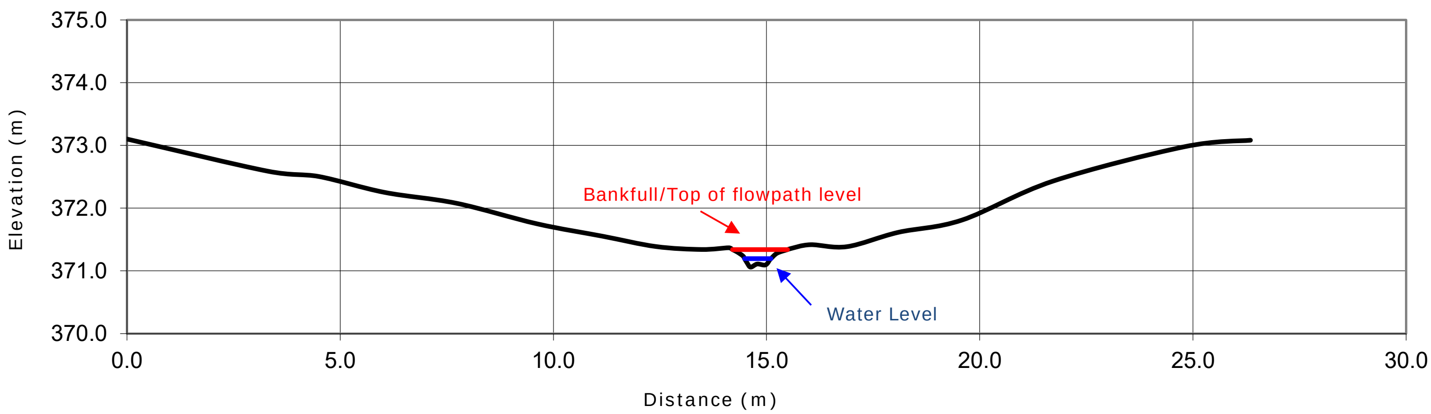
	Minimum	Maximum	Average
Penetrometer Value (kg/cm3):	N/A	N/A	N/A
Bank Material (range):	Clay - Coarse Sand		

Cross-Sectional Characteristics

	Minimum	Maximum	Average
Bankfull Width (m):	1.29	1.43	1.36
Average Bankfull Depth (m):	0.09	0.13	0.11
Bankfull Width/Depth (m/m):	10	16	13
Wetted Width (m):	0.62	1.27	0.94
Average Water Depth (m):	0.06	0.06	0.06
Wetted Width/Depth (m/m):	11	22	17
Entrenchment Ratio (m/m):	1.4 - 2.2 (Moderately Entrenched)		
Maximum Water Depth (m):	0.11	0.14	0.12
Manning's *n*:		0.045	

Photograph at cross section 1 (looking downstream)

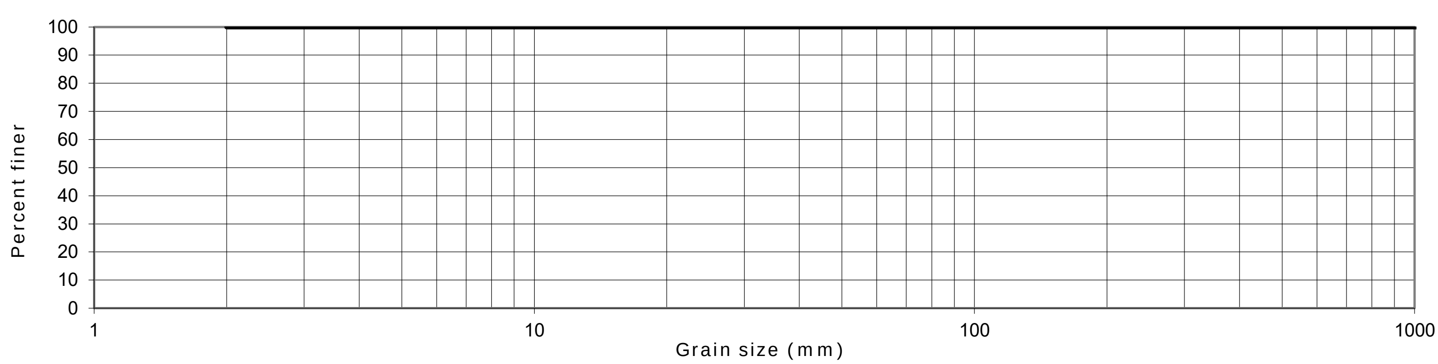
Representative Cross-Section 1



Substrate Characteristics

Particle Size (mm)		Subpavement:	Cobbles
D_{10} :	2.0	Particle Shape:	Fine-grain particles
D_{50} :	2.0	Embeddedness (%):	100
D_{84} :	2.0		

Cumulative Particle Size Distribution



Channel Thresholds

Flow Competency (m/s):		Tractive Force at Bankfull (N/m^2):	27.49
for D_{50}:	0.27	Tractive Force at 2-year flow (N/m^2):	Not available
for D_{84}:	0.27	Critical Shear Stress (D_{50}) (N/m^2):	1.46
Unit Stream Power at Bankfull (W/m^2):	22		

General Field Observations

Channel Description

1) Reach W6B-3 flows southeast through a forested area towards Waterbody 6
2) Moderate-high gradient, slightly sinuous channel, confined valley setting
3) Cascade-type morphology (i.e., steps and pools)
3) Riparian vegetation = Trees dominant
4) Intermittent woody debris buildup in channel
5) Limited evidence of erosion, (i.e., vegetated banks, stable steps)

Cross Section 2 - Facing Downstream

Detailed Geomorphological Assessment Summary

Reach W6B-4

Project Number:	PN24109	Date:	2024-10-19
Client:	WSP	Length Surveyed (m):	230.8
Location:	East of Red Lake, Ontario	# of Cross-Sections:	7

Reach Characteristics

Drainage Area:	0.80 km^2	Dominant Riparian Vegetation Type:	Trees (mature forest)
Geology/Soils:	Bedrock	Extent of Riparian Cover:	100%
Surrounding Land Use:	Forest	Width of Riparian Cover:	> 10 Channel Widths
Valley Type:	Confined	Age Class of Riparian Vegetation:	Established
Dominant Instream Vegetation Type:	None	Extent of Encroachment into Channel:	Moderate
Portion of Reach with Vegetation:	None	Density of Woody Debris:	Moderate

Hydrology

Estimated Discharge (m^3/s):	0.01	Estimated Flowpath Discharge (m^3/s):	2.07 *
Modelled 2-year Discharge (m^3/s):	Not Available	Estimated Flowpath Velocity (m/s):	2.40
Modelled 2-year Velocity (m/s):	Not Available	*Enlarged feature, likely not representative of "bankfull" conditions	

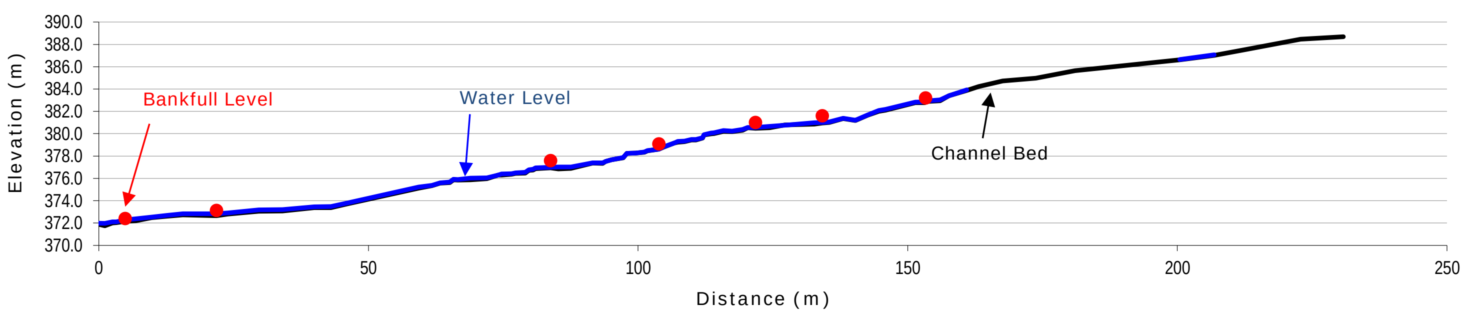
Profile Characteristics

Bankfull Gradient (%):	7.39
Channel Bed Gradient (%):	7.74
Riffle Gradient (%):	N/A (step pool)
Riffle Length (m):	N/A
Riffle-Pool Spacing (m):	N/A

Planform Characteristics

Sinuosity:	1.12
Meander Belt Width (m):	See Report
Radius of curvature (m):	2.5
Meander amplitude (m):	5.3

Longitudinal Profile



Bank Characteristics

	Minimum	Maximum	Average
Bank Height (m):	0.25	1.25	0.54
Bank Angle (deg):	10	75	33
Root Depth (m):	0.25	1.25	0.54
Root Density (%):	30	40	33
Bank Undercut (m):	0.00	0.00	0.00

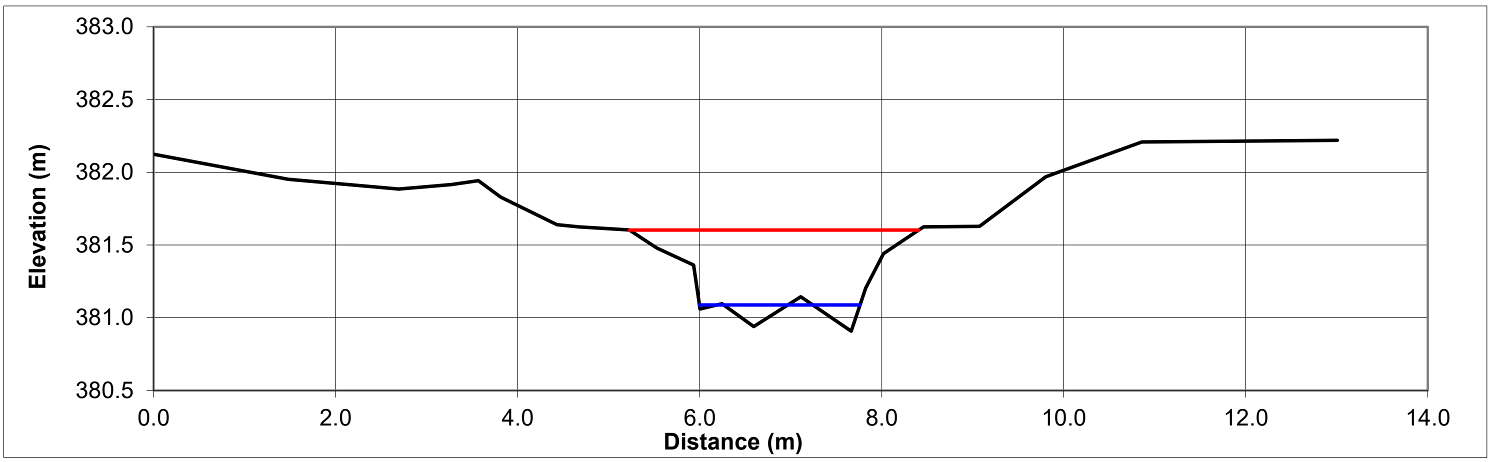
	Minimum	Maximum	Average
Penetrometer Value (kg/cm3):	0	0.15	0.2
Bank Material (range):	Clay / Sand / Small Cobble / Boulder		

Cross-Sectional Characteristics

	Minimum	Maximum	Average
Bankfull Width (m):	1.41	4.28	3.33
Average Bankfull Depth (m):	0.10	0.41	0.26
Bankfull Width/Depth (m/m):	9	30	15
Wetted Width (m):	0.58	3.41	1.74
Average Water Depth (m):	0.03	0.08	0.06
Wetted Width/Depth (m/m):	13	116	38
Entrenchment Ratio (m/m):		<1.4 (Entrenched)	
Maximum Water Depth (m):	0.04	0.20	0.13
Manning's *n*:		0.046	

Photograph at cross section 3 (facing upstream)

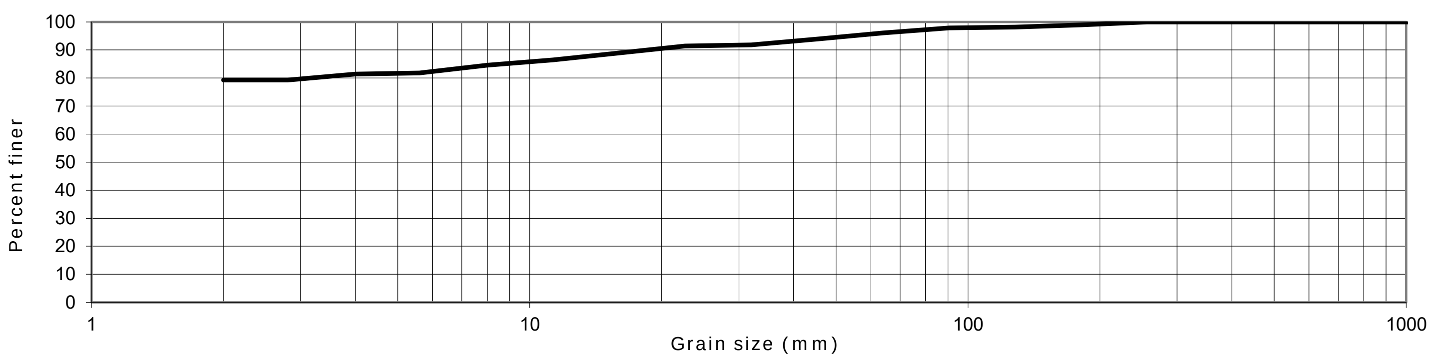
Representative Cross-Section #3



Substrate Characteristics

Particle Size (mm)			
D_{10} :	2.0	Subpavement:	Cobble
D_{50} :	2.0	Particle Shape:	Sub-Rounded - Angular
D_{84} :	7.5	Embeddedness (%):	10% - 20%
		Particle Range (riffle):	Fine Sand - Large Boulders
		Particle Range (pool):	Clay - Fine Sand

Cumulative Particle Size Distribution



Channel Thresholds

Flow Competency (m/s):		Tractive Force at Bankfull (N/m^2):	187.55
for D_{50}:	0.27	Tractive Force at 2-year flow (N/m^2):	Not available
for D_{84}:	0.50	Critical Shear Stress (D_{50}) (N/m^2):	1.46
Unit Stream Power at Bankfull (W/m^2):	451		

General Field Observations

Channel Description

1) Reach W6B-4 flows southeast through a forested area towards Waterbody 6
2) High gradient, slightly sinuous channel, confined valley setting
3) Cascade-type morphology (i.e., steps and pools)
3) Riparian vegetation = Trees dominant
4) Intermittent woody debris buildup in channel
5) Limited evidence of erosion, (i.e., vegetated banks, stable steps)
6) Intermittent peat presence along channel boundary with characteristic subsurface flow

Cross Section 5 - Facing Upstream