Volume 2, Section 8 Snake Lake Reservoir Expansion Project
Environmental Impact Assessment
Aquatic Resources

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Executive Summary

The Eastern Irrigation District's (EID's) proposed Snake Lake Reservoir (SLR) Expansion Project requires an Environmental Impact Assessment under the *Environmental Protection and Assessment Act* (Government of Alberta [GOA], 2000d). This document provides a comprehensive description of the aquatic environment to meet requirements provided in the Final Terms of Reference (FTOR) issued by Alberta Environment and Protected Areas (Alberta EPA) and follows the Guide to Preparing Environmental Impact Assessments in Alberta. It includes a description of the aquatic resource baseline in SLR, residual effects of the Project on them after applying mitigation measures, and any cumulative effects on aquatic resources in the surrounding region. Following this, a plan is developed to monitor changes in aquatic resources following reservoir filling and commencement of operations.

The baseline provides details on habitats, and aquatic biota, focusing on fish, in a local and regional study area surrounding the Project. Indicators were selected to ensure requirements are met per provincial and federal legislation. Effects on fish and their habitats may occur during construction, filling, and operation stages, including drawdown of the existing reservoir (before the expanded basin is filled), removal of the SLR dam and potential alteration of water quality during and after reservoir filling. Other effects may occur during the creation of new aquatic habitats in the expanded reservoir, due to changes to reservoir drawdown cycles, related to fish migration through the canal and reservoir system, or due to effects of increased angling.

Fish and reservoir habitat information were quantified and qualified in an Aquatic Local Study Area (ALSA), while information for the Aquatic Regional Study Area (ARSA) was obtained from existing sources for waterbodies, habitats, and aquatic biota with reference to published literature and provincial databases. Local indicators selected for impact assessment included: habitat areas for top predator sportfish, coarse fish, invasive fish, and other aquatic biota, seasonal use of habitats, and variation in water volume and quality through a cycle of reservoir filling and drawdown. Fish species of conservation concern, diversity, and abundance were also discussed. Finally, habitat conditions that could affect fish health and movement were identified including risk of methylmercury bioaccumulation in resident populations.

Baseline information was supported by fieldwork including fish population inventory, determination of lake morphology, description of fish habitats, and sampling for water quality. Biologists sampled fish populations and described fish habitats by species and life-history stages during 3 field trips between spring 2021 to winter 2022. Reservoir bathymetry and water chemistry (further discussed in Volume 2, Section 7) were quantified and discussed as they pertain to fish habitat. Additionally, muscle tissue samples were obtained from mature Northern Pike (*Esox lucius;* the top predator in the SLR) and analyzed for methylmercury accumulation.

Reservoir water chemistry was alkaline with pH ranging from 8.1 to 9.4. Dissolved oxygen concentration (DO) varied between 8 and 14 mg/L across depths during spring and summer field visits. Temperature varied little across depths; the reservoir was not stratified during spring, fall, and winter sampling events. DO was lowest near the bottom in mid-winter, but not anoxic; therefore, SLR provides habitat for fish year-round.

Given its connection to the lower Bow River, any of its resident fish could gain access to SLR via the East Branch Canal at Bassano Dam. Those caught or observed in SLR included Burbot (*Lota*

lota), Lake Whitefish (*Coregonus clupeaformis*), Northern Pike, Prussian Carp (*Carassius gibbelio*), Spottail Shiner (*Notropis hudsonius*), and White Sucker (*Catostomus commersoni*). Juvenile, sub-adult, and adult individuals of Burbot, Northern Pike, White Sucker, and Lake Whitefish were sampled. Analysis of length distribution implied Northern Pike reproduce successfully in the reservoir, while Lake Whitefish likely enter the reservoir from the canal system as juveniles and adults. In spring, Northern Pike were captured in the shallow northwest basin where flooded emergent vegetation (typical of pike spawning habitat) is present, and evidence of recent spawning was recorded. Few White Sucker were caught but based on their length distribution, it is unlikely they spawn in the reservoir. Prussian Carp (Goldfish), an invasive fish, also reside in the reservoir. No species at risk were encountered, nor have any been reported from the Bow River at Bassano Dam.

The SLR benthic invertebrate community is dominated by pelagic species (e.g., midges). Typical drawdown of 1.5 to 2.0 m results in year-round habitat for resident fish. The drawdown in fall 2023 (almost four times the average) did not put fish at risk for winter survival because the EID had refilled the reservoir by November. Several anglers were observed fishing for Northern Pike and Lake Whitefish during spring and fall inventories. Anglers reported that SLR supports “a good fishery” in both summer and winter.

Elemental mercury in water and Methylmercury in sediment and muscle tissue were sampled to establish baseline concentrations in the reservoir and Northern Pike, a top predator. Inorganic mercury was above guideline in sediment and water in winter 2021 and fall 2023, and at a level where consumption may need to be limited for children and pregnant women.

Project effects on aquatic resources included:

- A net increase in aquatic habitat for fish. The same is true for all trophic levels in the reservoir.
- The littoral zone of SLR will need to be drawn down prior to filling the expanded reservoir; this will occur outside the window critical for Northern Pike spawning, incubation and fry emergence. Once filled, both the extant and expanded littoral zones are expected to provide similar ecological function in both reservoir basins once emergent and submergent macrophytes become established.
- The expanded reservoir will contain similar water chemistry and characteristics as the extant SLR.
- Mitigation measures will be employed to prevent or minimize adverse effects on the receiving environment when the dam is breached to fill the new basin. These may include fish salvage and prevention of fish from entry to the expanded reservoir until water is sufficiently deep to provide enough thermal habitat volume for all.

There were no adverse (negative direction, medium to high) residual effects of the Project on aquatic resources. A cumulative effects assessment for aquatic resources was not completed as per the assessment approach (Volume 2, Section 2), which stated cumulative effects will be assessed only on resources with adverse Project effects.

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Abbreviations

Alberta EPA	Alberta Environment and Protected Areas
ALSA	Aquatic Local Study Area
ARSA	Aquatic Regional Study Area
asl	Above Sea Level
CCME	Canadian Council of Ministers of the Environment
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CPUE	Catch-Per-Unit-Effort
DFO	Department of Fisheries and Oceans *(also called Fisheries and Oceans Canada)*
DO	Dissolved oxygen
EIA	Environmental Impact Assessment
EID	Eastern Irrigation District
FRL	Fish Research Licence
FL	Fork length
FSL	Full Supply Level
FTOR	Final Terms of Reference
GOA	Government of Alberta
GOC	Government of Canada
HUC	Hydrologic Unit Code
IO	Instream objective
µgMM/kg	Methylmercury per kg of body mass
MeHg	Methylmercury
µS/cm	Microsiemens per centimetre
PAL	Protection of Aquatic Life
QUAT	Quaternary ammonium compounds
SLR	Snake Lake Reservoir
SSRP	South Saskatchewan Regional Plan
TKN	Total Kjeldahl nitrogen

8.1 INTRODUCTION

8.1.1 Background

In the early 1900s, the Eastern Irrigation District (EID) built a system of canals and reservoirs filled with water diverted from the Bow River. This infrastructure provided water to meet the demands of Alberta's agricultural industry (Government of Alberta [GOA], 2020a). Reservoirs store water during times of high flow and release it via canal infrastructure through summer and early fall to meet agricultural demand. Irrigation reservoirs may be on- or off-stream. On-stream reservoirs are constructed by impounding a watercourse and using the natural valley walls or low terrain to hold-back flowing water onsite; off-stream reservoirs receive water diverted from elsewhere and it is stored in low-lying terrain such as a dammed coulee, lake, or an excavated and/or raised pond.

Snake Lake Reservoir (SLR) is an off-stream reservoir located 23 km northwest of the City of Brooks, Alberta. It was constructed from 1995 to 1997 in a natural coulee with a downstream (east) and upstream (west) dam with natural slopes on the north and south sides. It is owned and operated by the EID, under an existing *Water Act* Licence (No. 00071066-00-00), and is regulated via Alberta's *Irrigation Districts Act* (GOA, 2000a). The EID is licenced to divert 938 million m^3/yr of water from the Bow River and uses an average (over 10 years) of 549 million m^3/yr (varies from 363 million m^3 to 663 million m^3), such that there is an average of 389 million m^3 of water available for offsite storage without requiring additional allocation (Eastern Irrigation District, 2020).

The extant SLR covers 299 ha and stores up to 19.25 million m^3 (15,600 acre-feet) of water at Full Supply Level (FSL) at a geodetic elevation of 781.7 m above sea level (asl). Water diverted from the Bow River at Bassano Dam flows within EID's East Branch Canal and enters the reservoir on the west side via a gated inlet chute. Reservoir volume is controlled by an online check structure. Outflow from the reservoir is through a low-level outlet structure, located near the north end of the East Dam. Water stored supports 50,000 acres (20,000 ha) of downstream irrigated agriculture.

The reservoir expansion will provide additional water security during hot weather and droughts, when direct river withdrawals cannot be maintained (i.e., whenever river waters run low and when most or all river discharge is needed to meet the instream objective [IO] for the protection of aquatic life in the river). The expanded reservoir will inundate an additional 764 ha and increase off-stream storage by 66 million m^3 (see Appendix F1, Figure F1-1). The EID also intends to increase the FSL to 782.0 m in both basins that will store an additional 2.1 million m^3, for a total off-stream water storage capacity of 87.4 million m^3. Portions of the basin will be excavated for aggregate materials to construct the berms, so the new reservoir will hold water both below and above the natural land grade.

The new reservoir requires construction of 8 km of earthen berms on the north, east, and south sides of the new reservoir, up to 20 m high, requiring an estimated 7 million m^3 of material. Most of this material will be excavated within the Project footprint, in areas that will form the reservoir basin. The expanded reservoir will have moderate slopes (3H:1V), and will be up to 17.5 m deep at the lowest elevation (east) side (or possibly deeper in sites where borrow materials are excavated). Following the extant SLR East Dam decommissioning, the SLR will be connected to the expanded reservoir area via a notch to be removed from the East Dam.

8.1.2 Purpose

This Project requires approval per the provincial *Environmental Protection and Assessment Act* before it can be built. It surpasses the threshold for needing an Environmental Impact Assessment (EIA) in support of this approval, due to its height exceeding 15 m and storage exceeding 30 million m^3. The purpose of this section is to describe baseline, Project impacts, mitigation measures, residual impacts, cumulative effects, and monitoring for aquatic resources.

8.1.3 Project Setting

The reservoir expansion is located within the Dry Mixedgrass Natural Subregion which experiences drought every few years. The region is defined by a prolonged reduction in precipitation and/or a sustained water deficit when evaporation exceeds precipitation.

Aquatic systems in Alberta's grasslands are important for the maintenance of biodiversity. Although relatively scarce, saline wetlands, freshwater ponds, and dugouts – common within the EID lands – support open water and riparian habitats, providing protection, breeding and rearing, foraging, and migration corridors for aquatic species, wildlife, and upland plants. Permanent watercourses are typically entrenched, flow gently, and are dominated by depositional habitats (e.g., Red Deer and Bow rivers). Before agricultural development throughout the Grassland Region, aquatic habitats were dominated by small wetlands and seasonal watercourses, with few large rivers and lakes. Following settlement, dugouts, ditches, canals, reservoirs, and other infrastructure were developed to support agriculture, changing the distribution and quantity of aquatic habitat present.

Aquatic species typical for the Grassland Natural Region of Alberta include coarse and forage fish. These are cool or cold-water species. With creation of reservoirs in southern Alberta, cool and cold-water sport fish are present throughout the EID through passive colonization through the canal system and active stocking of certain species. Over time, the Fisheries Management Branch of Alberta Environment and Protected Areas (Alberta EPA) has stocked reservoirs to promote sportfishing within the Irrigation Districts in southern Alberta.

A more detailed description of the Project setting is found in the Project Description (Volume 1, Section 2: Overview).

8.1.4 Regulatory Context

Baseline and effects assessment are guided by provincial and federal legislative requirements for the management and protection of fish and aquatic habitat resources. Alberta legislation and guidelines include the *Water Act* (GOA, 2000b), which regulates all activities that could affect waterbodies and water resources in the province and uses approval tools such as Water Licences, Water Approvals, and Codes of Practice to ensure fish and their habitat are protected during in-water activities. These guide several aspects of projects including water crossings, disturbances to the bed and shore of waterbodies, water diversion, development of reservoirs, dugouts or other anthropogenic water features, and the protection of springs and aquifers as well as lakes, wetlands, watercourses, and ephemeral draws.

Rules for irrigation works and canals are governed by the *Irrigation Districts Act* (GOA, 2000a). An important rule applied to canals is that they provide fish habitat only while they are flowing. Once the water stops flowing each fall, these features cease to be aquatic habitat. Another is that once irrigation works are approved under a Water Licence, new *Water Act* approvals are not required for activities on the same lands.

Water quality is protected under the *Water Act*, ensuring water that is suitable for aquatic life does not become unsuitable because of anthropogenic activities (i.e., exceed acute or chronic toxicity concentrations or stop meeting the quality needed for protection of aquatic life). Water quality concentration limits for the protection of aquatic life are established by the Canadian Council of Ministers of the Environment (CCME, 2007). Additional guidelines and planning tools that interact with the protection of fish and aquatic habitat include:

- *Wildlife Act* (GOA, 2000c), which governs the protection and management of wildlife resources, including fish and other aquatic species. This Act and its Regulations include listings of species that are *Threatened* or *Endangered* in Alberta, and if so, may result in the development of Action Plans that provide management tools to ensure aquatic species are protected. Regulations also address rules and closures for sport fishing and commercial harvesting and address the management of exotic aquatic species.
- Alberta Wildlife Species Status Reports (GOA, 2022) which use information on population trends and known risks to list species that are *At Risk*, *May Be at Risk*, or *Sensitive*, in the province.
- The South Saskatchewan Regional Plan (SSRP) (GOA, 2017), and the Bow River Basin Plan (Bow River Basin Council, 2012) provide strategies and actions to encourage the protection of aquatic resources and maintenance of watershed integrity throughout the South Saskatchewan Regional Plan Area and within the Bow River. They establish management priorities to protect or enhance fish and aquatic habitats. Under the SSRP there is an objective to manage terrestrial and aquatic biodiversity for the benefit of Albertans. A biodiversity management framework has been planned but has not yet been implemented.
- The federal *Fisheries Act* (Government of Canada [GOC], 1985) has tools and approval mechanisms to ensure fish resources are protected in natural waterways, including protection of aquatic habitats. The tools and mechanisms include Approvals, Letters of Advice, and Codes of Practice to protect species and habitats, and may require development of compensation habitats to replace any aquatic habitats lost through Project activities.
- The *Species at Risk Act* (GOC, 2002) protects critical habitats for species that are listed as *Endangered*, *Threatened*, or *Special Concern*, and directs the development of federal recovery plans. Protective measures for aquatic species listed under Schedule 1 of the *Species at Risk Act* are enforced through Fisheries and Oceans Canada (DFO).

8.2 STUDY AREAS

Baseline conditions and potential Project effects were qualified at both a local (Project-specific) scale and a regional (cumulative effects) scale by examining resources or indicators in a Local and Regional Study Area. Study areas for waterbodies and aquatic habitats were defined as:

- Aquatic Local Study Area (ALSA) – Project boundary + appropriate buffer (see Appendix F1, Figure F1-2).

- Aquatic Regional Study Area (ARSA) – the Hydrological Unit Code Level 8 (HUC8) watershed boundary where the ALSA occurs, as modified (see Appendix F1, Figure F1-3).

The ALSA (see Appendix F1, Figure F1-2) incorporated all waterbodies and watercourses within the Project footprint or next to it. This included the existing SLR, its inlet canal from EID's East Branch Canal, and the reservoir expansion area (i.e., all areas east of the East Branch Canal and SLR within Sections 29, 30, 31, and 32-21-16 W4M).

The ARSA was selected to include all terrain from the water source for the East Branch Canal at Bassano Dam on the Bow River, northwest of the SLR, and all stored and flowing water within a relevant watershed unit (of the Red Deer River Basin) to its confluence with the Red Deer River northeast of SLR (see Appendix F1, Figure F1-3). The watershed selected is the HUC 8 watershed (GOA, 2018a) named the Onetree Creek Subbasin, which is a subset of the larger HUC 6 Matzhiwin Creek Basin (Red Deer Watershed Alliance, 2009).

The Hydrologic Unit Code Watersheds of Alberta defines hydrologic units that form a standardized baseline throughout the province. Successively smaller hydrologic units are nested within larger hydrologic units to create hierarchal watershed boundaries based on flow direction determined through detailed surface elevation mapping. Because the Onetree Creek Watershed did not include the area near Bassano Dam, and because its northern boundary was within 1 km of the Project boundary, additional lands were added to the ARSA north of the Project to the Trans-Canada Highway (Highway 1) and west to the edge of the Matzhiwin Watershed. From there, the boundary followed elevation contours to the Bow River.

8.3 ISSUE SCOPING

At the onset of the EIA, resources and indicators for the aquatic ecology discipline were identified that could be affected by the Project. Included in the effects assessment were potential challenges posed by construction and operation phases on fish and their habitats. As well, the likelihood of these being realized, screening out those effects that are likely to be neutral or negligible and focussed on SLR as since other waterbodies in the local area are not fish bearing. This met the requirements in the Final Terms of Reference (FTOR) Clause 3.5.1.1 (see Appendix A, FTOR 3.5.1.1). Issues scoping related to the Bow River were excluded, as the Project occurs downstream of the Bow River below Bassano Dam, using the existing allocated water under EID's Water Licence, such that there will be no new effects on Bow River flow. The canals were also not assessed; while they do support fish seasonally, they do not provide year-round habitat. Scoping for this discipline (Table 8-1) included:

- Project activities that may affect fish, their habitat, or other aquatic resources;
- Potential issues, risks, or concerns regarding Project effects;
- Indicators or measures used to qualify potential impacts on aquatic resources;
- Screening on whether effects are likely; and
- The spatial scale that a potential issue is applicable for (local and/or regional).

Table 8-1: Issue scoping for fish and aquatic habitat resources

Project Activities and Risks	Resources	Potential Issues	Indicators or Measures	Screening[1]	Applicability
• SLR drawdown before joining of the existing and new reservoirs • Decommissioning and partial removal of existing east SLR dam structure • Removal of surface waterbodies in expansion area • Altered water quality during reservoir filling • Creation of new aquatic habitats • SLR drawdown and reduced habitat area/volume • Altered fish migration between natural watercourses, canals, and reservoirs • Increased fish harvest	Aquatic Habitat	• Loss of Natural Aquatic Habitat Area from within the new reservoir footprint • Increased Aquatic Habitat Area in the new reservoir • Altered timing and availability of specific habitats due to changes in filling and drawdown cycles • Fragmentation of fish-bearing aquatic habitats	Littoral zone area for fish	• Clearing of the new reservoir footprint will remove existing wetlands, ponds, dugouts and draws and their associated aquatic habitats. These areas will be included within new deepwater habitats • Local data is available from baseline assessment of SLR (waterbody mapping, water depth, habitat assessments, and water quality sampling) • Regional data is available from existing mapped waterbodies and from databases and reports on aquatic habitats • Aquatic habitat connectivity will not be altered by the Project	Local, Regional
			Pelagic zone area for fish		Local, Regional
			Description and availability of seasonal habitat areas (e.g., habitats for spawning, rearing, growth, feeding, and protection.)		Local, Regional Qualitative
					Local Only
			Aquatic habitat connectivity		N/A
	Aquatic Species Diversity and Population Parameters	• Loss of Species of Conservation Concern • Increase in Exotic Fish Abundance • Altered Fish Spawning and Rearing Potential • Change in Aquatic Species Richness and Abundance	Fish Species of Conservation Concern (presence and abundance)	• No species of conservation concern present	N/A
			Exotic Fish Species (presence and abundance)	• Effects may occur as exotic species populations expand in the new habitat area • Data from SLR surveys	Local, Regional Qualitative
			Fish Species Richness (Count of observations)	• Changes in aquatic habitat availability / characteristics may allow new species to establish while others disappear	Local, Regional Qualitative
			Distribution and Abundance of Macrophytes, Phytoplankton, Zooplankton, and Benthic Invertebrates (Qualitative Data)	• Changes in water quality and quantity may affect occurrence, seasonality, and distribution of these biota	Local and Regional Data Sources
			Fish Abundance (species densities, catch per unit effort)	• Change in habitat area likely to alter fish abundance	Local Only
	Harvested and Consumed Fish	• Increase in fishing activity and harvest • Health effects of mercury accumulation in fish	Number of anglers and reported catches (qualitative evidence)	• Larger reservoir and publicity will likely attract more anglers • Anecdotal evidence is available on fishing websites • Quantitative data may be available from sportfishing surveys or reported catches	Addressed in the Land and Resource Use section
			Methylmercury bioaccumulation	• Top fish predators may accumulate methylmercury via the food chain • Local fish sampling • Regional harvest recommendations	Local Only

[1] Determine if the issue is unlikely to occur, or if relevant data is not sufficient for assessment.

Based on the scoping exercise, only those waterbodies affected directly by construction and operation of the Project were included. Volume 2, Appendix A, FTOR 3.5.1.4 states "Describe and map fish habitat and aquatic resources in waterbodies and watercourses." This assessment does not address Red Deer River and Bow River, as there are no planned activities that will affect these rivers as there will be no new withdrawals and no new return flows. To meet the requirements in the FTOR and the Alberta Impact Assessment Guidelines, the following indicators were selected for the assessment of fish and aquatic resources:

- loss of habitat area for sportfish (and others) species (in hectares [ha]);
- loss of fish during breaching of east dam to fill new basin;
- increase in turbidity downstream during construction;
- change in habitat area and volume for aquatic fauna (ha, m^3);
- description and availability of seasonal habitat (ha);
- exotic fish species abundance (density);
- change in fish species richness and relative abundance (count);
- change in distribution and abundance of phytoplankton, zooplankton, and benthic invertebrates (qualitative data);
- change in survival of fish and benthos;
- change in recreational use (angling);
- methylmercury (MeHg) bioaccumulation in top predator sportfish;
- change in water quality seasonally; and
- altered interaction between ground and surface water.

8.4 BASELINE

8.4.1 Methods

Little information exists about aquatic resources within SLR. Environmental consequences of the proposed expansion can only be determined once a baseline of aquatic resources in SLR is known. To establish this baseline, biologists sampled fish populations and water chemistry, measured bathymetry, and described habitat within the reservoir in spring and fall of 2021 and winter of 2022. Reservoir bathymetry was mapped at the current FSL of 781.7 m above sea level.

Habitat was described in terms of type and its potential to support individual species and life-history stages nearshore and offshore. Additional sampling during reservoir drawdown occurred in late September 2023 to sample water, sediment, and Northern Pike (*Esox lucius*) muscle tissue to quantify background concentration of inorganic mercury in the reservoir and methylmercury in sediments and in a top predator resident in SLR.

8.4.1.1 Reservoir Habitat

Limnetic habitat was described at several sites within the reservoir and related to its potential for use by different species and life-history stages of resident fish. At each site, the presence of aquatic vegetation, habitat parameters (i.e., depth, structure, boulders, etc.), substrate type, and extent of littoral habitat was described and mapped. Photographs were taken representative of each habitat area (see Appendix F2, Plate F2-1 to F2-14). The habitat type and amount of littoral versus pelagic habitat were quantified at FSL, during typical drawdown, and at extensive drawdown in a "drought year" (2023). Additionally, sampled water chemistry and bathymetry data, discussed further in the Surface Waterbodies section (Volume 2, Section 7), were used to describe habitat within the SLR.

To quantify the amount of habitat in the extant reservoir, depth was measured along 7 transects to determine Bathymetry at FSL; depth was measured every 100 m for the longitudinal transect and every 10 m along each of the 6 lateral transects (see Appendix F1, Figure F1-4), using a Hummingbird™ side-scan sonar unit mounted on an inflatable boat powered by an outboard engine. The sonar measured depth along a transect and each point recorded by the sounder was geo-referenced simultaneously. These data were downloaded into a spreadsheet and imported into ArcMap™ ArcGIS® software by Esri, and plotted to generate a bathymetric and habitat map of the reservoir (see Appendix F1, Figure F1-5) showing habitat. The 3 m depth contour was then determined, allowing the pelagic (>3 m depth) and littoral (0-3 m depth) zones to be mapped and quantified. Maps were used to compare changes in littoral habitat availability, primarily in the shallow northwest basin, during normal drawdown which varied in depth between 0 and 2 m below FSL. These zones were also compared during a typical fall drawdown (1.5 m in 2021/22), and drought year (8.3 m drawdown in 2023; see Appendix F1, Figure F1-6).

Biologists sampled the reservoir perimeter to determine fish presence and use of littoral (<3.0 m deep) habitat by individual species and life-history stages. This information was incorporated into the habitat and bathymetry map discussed above.

8.4.1.2 Fish Population Inventories

Fish species composition, relative abundance, and distribution were determined in spring and summer using multiple approaches. These inventories were completed under Fish Research Licence (FRL) 21-2407. All equipment that would encounter water was sanitized using quaternary ammonium (QUAT) solution before and after it was deployed to prevent the spread of aquatic invasive species and pathogens per Alberta EPA protocol (GOA, 2020b).

A Smith-Root™ (Vancouver, Washington), Type 15-VVB portable float electrofisher mounted in a 4.1 m inflatable boat powered by a 25 HP outboard engine was used to capture fish. The electrofisher was held parallel to the shore with boom anodes spaced 2.5 m apart and was moved parallel to the shore, slowly through the littoral zone of the reservoir. Generator output was released in bursts of 4 to 14 seconds and varied as the crew electrofished. Sampling effort was concentrated within littoral habitat to improve the probability of fish capture. Electrofishing was completed when the perimeter of the reservoir was sampled. Fish immobilized by the electrofisher were retrieved with a dipnet and placed in an aerated live car.

Besides the float electrofisher, gillnets were set in the spring and fall visits for 1 to 2 hours. Nets were run every 30 minutes to minimize fish mortality. In both seasons, 2 fyke nets (a type of fish trap with a long lead attached to the entrance) were set in areas at least 1.5 m deep for 20 to 24 hours each. Baited, Gee-type minnow traps were set overnight at each of 10 locations in the spring (see Appendix F1, Figure F1-4). Minnow traps in deeper water were suspended 2 m into the water column between a float and anchor. All other minnow traps were placed on the bottom of the reservoir within the littoral zone. During the fall inventory, four northwesternmost trap locations were moved into deeper water given the low water level at the time. Traps were set in the isolated ponds which formed within the reservoir's northwest basin as water was drawn down.

Each trap and either end of the gillnet was identified by a flag and float for ease of retrieval as required by the licence.

All fish caught were placed in aerated live cars until biometric data were recorded. Individuals were identified to species and life-history stage (young-of-the-year, juvenile, adult, adult spawning and condition), fork lengths were measured, and fish were weighed. Sex and state of maturity were assigned if discernible externally. Voucher photographs of each species were taken. Once processed, individuals of native species were returned immediately to the reservoir. Any exotic Prussian Carp (*Carassius gibbelio*) caught were killed and disposed of per the FRL.

8.4.1.3 Water and Sediment Chemistry

Water and sediment chemistry parameters were sampled to understand the water and sediment quality as it pertains to maintenance of aquatic life. Water samples were obtained in spring, fall, and winter at two designated locations from the deepest basin of the reservoir: Sample 1 near the east end and Sample 2 at the west end of the SLR (see Appendix F1: Figure F1-4). Water samples were collected by lowering a Van Dorn sampler between 0.5 and 1 m above bottom. Personnel wore nitrile gloves to avoid contamination during sample collection and transfer.

Water collected was transferred to bottles provided by the ALS Environmental laboratory in Calgary. Field staff ensured bottles were filled to avoid oxygen bubbles and all preservatives were added per laboratory protocol. A duplicate sample was also collected at the Sample 2 site. This sample was needed to confirm sample analysis precision. All samples were stored in coolers at 5°C until they were dropped off the laboratory for analysis. Parameters analyzed included:

- routine water parameters: alkalinity, pH, conductivity, hardness, total dissolved solids (TDS), and total suspended solids (TSS);
- anions: bicarbonate, carbonate, chloride, fluoride, sulfate, hydroxide;
- other: coliform bacteria, biochemical oxygen demand;
- nutrients: nitrogen (ammonia, nitrate, nitrite, total Kjeldahl nitrogen [TKN]), phosphorus;
- total metals: aluminum, antimony, arsenic, barium, beryllium, bismuth, boron, cadmium, calcium, cesium, chromium, cobalt, copper, iron, lead, lithium, magnesium, manganese, mercury, molybdenum, nickel, phosphorus, potassium, rubidium, selenium, silicon, silver, sodium, strontium, sulfur, tellurium, thallium, thorium, tin, titanium, tungsten, uranium, vanadium, zinc, and zirconium;
- organochlorine pesticides;
- polycyclic aromatic hydrocarbons; and
- polychlorinated biphenyls.

In-situ water quality parameters were also measured in SLR at 0.5 m depth intervals at the same 2 vertical stations described earlier. A calibrated, YSI Professional Plus Quatro™ multiparameter meter was lowered and allowed to stabilize at each depth interval. Parameters measured include temperature, dissolved oxygen (DO) concentration, pH, and specific conductivity.

In spring and fall, Secchi depth was recorded at both water quality locations. Secchi depth is a measure of how transparent the water column is and indicative of the trophic state of a water body (i.e., the amount of phytoplankton present). It was recorded by lowering the disk into the water column, avoiding shadow cast by the boat. Transparency was recorded when the disk was just out of sight. Turbidity was also measured at the surface in the fall and winter field trips using a LaMotte® 2020we Turbidity Meter.

Once analyzed, data were transcribed to an electronic spreadsheet and individual parameters were compared to Water Quality Guidelines. These are set by the CCME for the protection of aquatic life (CCME, 2007) and the Alberta Surface Water Quality Guidelines for the Protection of Aquatic Life (GOA, 2018a).

A 15 cm x 15 cm Eckman dredge was used to collect sediment samples from both locations in the reservoir and select waterbodies within the regional study area. Reservoir sediment samples collected in 2023 were analyzed for:

- water saturation;
- resistivity;
- sodium;
- potassium;
- calcium;
- magnesium;
- sulfur (as sulfate);
- chloride;
- total metals; and
- methylmercury.

8.4.2 Results

Fieldwork was complete June 5 to 10, 2021 (spring), October 6 to 9, 2021 (fall) and January 19, 2022 (winter). Fish inventories were completed in spring and fall; only water parameters were sampled in winter. Fish habitat was sampled at 4 sites and fish were sampled at 7 locations with gill nets, 10 for minnow trap sets, and 2 where fyke nets were set (see Appendix F1, Figure F1-4). Water chemistry was sampled from the shallow west and deep east basin locations each field trip. Bathymetry was mapped during the June 2021 visit (see also Volume 2, Section 7: Surface Waterbodies).

8.4.2.1 Aquatic Resources by Study Area

The littoral zone is the most productive zone in lacustrine habitats (Wetzel, 1983; Mitchell & Prepas, 1990). It is that portion of a waterbody that is <3 m deep. In reservoirs, its stability depends on operations relative to demand downstream. In reservoirs used for hydroelectric power generation, its area can fluctuate more than once daily to meet peak power demand of users. In reservoirs used to store water for irrigation, the littoral zone shrinks as irrigation (typically during summer and fall) demand for water downstream exceeds input, resulting in lowering of the water level and total volume of a reservoir. This is known as drawdown.

With climate change, forecasters predict that Canadian prairie provinces will experience wetter springs and falls but drier summers (Volume 2, Section 12: Climate Change) and overall, more drought (WaterSMART Solutions, 2020); hence the importance of reservoirs for the maintenance of agricultural production into the future. Without the Project, the EID predicts more frequent and intense drawdown events. In the extant (smaller) reservoir associated with increased irrigation demand during droughts (see Volume 2, Appendix A, FTOR 3.4.2.8).

This would trigger potentially greater adverse effects on fish within the reservoir during a prolonged drought.

Aquatic Local Study Area (ALSA)

The ALSA (see Appendix F1, Figure F1-2) includes SLR and its inlet canal from EID's East Branch Canal, and the reservoir expansion area. These lands and irrigation infrastructures are fully owned and operated by EID. The ALSA covers 1,309.2 ha (Table 8-2).

Aquatic Regional Study Area (ARSA)

The ARSA boundary follows the Bow River south and east to where it is intersected by the Onetree Creek Watershed. As most of the area is within a natural watershed, most flowing water in the ARSA eventually exits into the Red Deer River about 10 km northeast of the town of Patricia. The ARSA covers all or part of 22 townships in southeast Alberta surrounding the town of Bassano and City of Brooks, and near Duchess and Patricia to the east. Notable aquatic features within this study area include Bassano Dam on the Bow River in the northwest, San Francisco Lake southeast of SLR, most of the Rock Lake Reservoir (near Duchess), and numerous smaller reservoirs, dugouts, and canals. Natural, shallow, saline lakes and wetlands are also common throughout the ARSA, as are several ephemeral draws and intermittent watercourses fed by the canal system, local runoff, and possibly by groundwater. The ARSA covers 115,712.5 ha (Table 8-3).

8.4.2.2 Water Quantity for Aquatic Habitat

Bathymetry at FSL in SLR is shown on habitat maps at FSL and September 2023 drawdown levels in Appendix F1, Figures F1-5 and F1-6. At FSL, reservoir depths are >10 m on the east side of the reservoir near the dam and in the central basin; depth becomes progressively shallower nearshore and to the west. The deepest basin (>12 m depth) occurs near the northeast end of the reservoir.

At FSL, shallow water up to 2 m deep is found in the northwest. This basin is formed by a former inlet to the coulee and an extensive flat with several depressions that may have been borrow pits, dugouts, or wetlands prior to filling of SLR in the 1990s. These depressions vary in size from 0.02 ha to 3.8 ha. Additionally, a chain of raised mounds occurs from the western dam leading to the southeast. At high water levels, a raised peninsula and 3 to 4 islands are present; however, during drawdown, these features form a single connected peninsula. Water depth from the inner (south side) of the peninsula and from all other shores and both dams increases quickly within a 100 m to 200 m distance from the shoreline to a depth of >8 m. During drawdown, mudflats develop with up to 6 ponds of varied areas and depths, which maintain habitat for fish. Deeper drawdown results in mudflats around the perimeter of the reservoir as experienced in September 2023 (see Appendix F2, Plates F2-15 to F2-17).

The maximum water depth in the SLR was 14.3 m in spring 2021 at FSL (Table 8-4). This dropped to 12.8 m in the fall of 2021, representing 1.5 m of drawdown. Data collected from the water gauge at the SLR dam indicated drawdown began in late September (see Surface Waterbodies, Volume 2, Section 7, Appendix E1, Figure E1-6). During winter 2022, water was slowly released from the reservoir to an elevation 2 m below FSL. Drawdown in 2023 (8.3 m) resulted in appreciably lower surface water depths (maximum depth of 6 m in late September). However, the water level recovered by several metres as the reservoir was refilled partially in Fall 2023 before input from the inlet canal was shut off for the season.

Table 8-2: Baseline components of the Aquatic Local Study Area

ALSA Components	Area (ha)	% of Study Area
Extant Snake Lake Reservoir and Surrounding Lands		
SLR Open Water at FSL (781.7 m above sea level)	298.8	22.8
Littoral Zone at FSL (to 3 m depth)	*105.1*	*8.0*
Pelagic Zone at FSL (below 3 m depth)	*193.7*	*14.8*
Canals and Ditches	27.8	2.1
Other Waterbodies	12.8	1.0
Vegetated Areas	86.0	6.6
Disturbances	4.7	0.4
Subtotal SLR Area	**430.1**	**32.8**
Reservoir Expansion Area		
Canals and Ditches	12.4	0.9
Waterbodies	66.2	5.1
Vegetated Lands	788.1	60.2
Disturbances	12.5	1.0
Subtotal Expansion Area	**879.2**	**67.2**
Combined ALSA		
Reservoir (Water Surface)	298.8	22.8
Canals and Ditches	40.2	3.1
Waterbodies	79.0	6.0
Vegetated Lands	874.1	66.8
Disturbances	17.2	1.3
Total Study Area	**1,309.2**	**100.0**

Note: Numbers may not add up exactly due to rounding

Table 8-3: Baseline components of the Aquatic Regional Study Area

Baseline Components	Area (ha)	% of Study Area
Reservoir (Water Surface)	671.1	0.6
Watercourses	78.1	0.1
Canals and Ditches	928.4	0.8
Other Waterbodies (Wetlands, Dugouts)	9,731.5	8.4
Total Waterbodies	**11,409.1**	**9.9**
Vegetated Lands	95,148.0	82.2
Disturbances	9,155.5	7.9
Total Study Area	**115,712.5**	**100.0**

Table 8-4: SLR water depth and volume in a typical year and drought year

Scenario	Surface Area (ha)	Littoral Zone (0-3 m) (ha)	Pelagic Zone (>3 m) (ha)	Maximum Depth (m)	Mean Depth (m)	Water Volume (million m^3)
Typical Year (FSL)	298.8	105.1	193.7	14.3	5.6	16.6
Typical Fall Drawdown (1.5 m)	297.1	105.1	192.0	12.8	4.1	12.0
Drought Year Drawdown (8.3 m)	97.0	85.2	11.8	6.0	1.5	1.7

8.4.2.3 Water Quality Pertaining to Aquatic Habitat

A more complete analysis of water chemistry and quality is provided in the Surface Waterbodies section (see Volume 2, Section 7). What follows is a summary as it pertains to fish and their habitat in the SLR.

Water quality is a primary attribute of aquatic habitat. It is described through the measurement of physical, chemical, and biological parameters. Routine parameters measured to describe water quality include temperature, DO, pH, conductivity, salinity, and total suspended materials or turbidity. Metals are also measured as total or dissolved concentrations. Note that dissolved plus suspended materials are “total” concentrations (Wetzel, 1983; Mitchell & Prepas, 1990).

This review was primarily based on information presented in the Atlas of Alberta Lakes (Mitchell & Prepas, 1990). Water temperature affects the rate of chemical reactions, decomposition, and growth, and strongly influences DO. Most Alberta lakes range from 0°C to 26°C throughout the year (Mitchell & Prepas, 1990). Because cold water is denser than warm water, deeper lakes typically become stratified over summer as the warm upper layer settles over the colder layer at depth. In winter, ice that is less dense than water forms on the surface, protecting the water from extreme weather but also reducing oxygenation through air contact. Below 4°C, water again becomes less dense, which can result in reverse stratification. Maximum ice thickness in mid-winter typically ranges from 0.4 to >1.0 m. In Alberta, ice cover lasts for 4 to 6 months but can be longer in northern areas and mountains and shorter in the prairies.

The littoral or euphotic zone (that portion of the lake through which light penetrates) is where DO is generated through photosynthesis, supporting respiration and decomposition by aquatic species in lacustrine habitats. It typically varies between 0 and 10-15 mg/L in lakes, with more oxygen near the surface and less to none at the bottom. DO affects use of the lake by aquatic organisms, and is a function of water temperature, oxygen content of incoming water, input of oxygen at the water/air interface, and presence of algae and aquatic plants which respire oxygen during photosynthesis, and all biota, including algae and plants, which use oxygen for respiration. As photosynthesis only occurs during daylight, DO can cycle daily: lower at night and higher by day. The cycling is also influenced by water temperature. The colder the water, the greater the DO within it. Additionally, the ability of lake water to support fish eggs and fry is dependent on relatively high DO (8-10 mg/L).

Lake water contains minute amounts of salts. When dissolved in water, salts separate into positively charged cations and negatively charged anions. Common cations include calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^{+}) and potassium (K^{+}); common anions include bicarbonate (HCO_3^{-}), carbonate (CO_3^{2-}), sulphate (SO_4^{2-}) and chloride (Cl^{-}). These major ions are vital to the health of plants and animals in lakes. Specific conductivity measures the ability of an electric current to flow in water, which increases with ionization; water can range from fresh (conductivity less than 500 µS/cm) to highly saline (greater than 32,000 µS/cm). Reservoir water derived from Alberta mountain rivers tends to have low conductivity, while groundwater measured at spring outlets or low-lying wetlands tends to have high conductivity. Salinity affects the types of plant species that can grow in lake water. When saline lakes and wetlands dry, a white crust is evident along the water's edge.

pH indicates whether water is acidic or basic. The term pH refers to the concentration of hydrogen ions (H^+) on a negative logarithmic scale extending from 1 (highly acidic) to 14 (highly basic). Basic solutions have a high concentration of hydroxide ions (OH^-). A decrease of one unit in pH corresponds to a 10-fold increase in the concentration of hydrogen ions (or a 10-fold decrease of hydroxide ions). When the pH is less than 7 the solution is acidic, at pH 7 it is neutral, and above this it is basic. While most rainwater is slightly acidic (pH 5.5 to 6.5), in most Alberta lakes, pH is between 7 and 10 and is thus basic, resulting from water that has dissolved alkaline hydroxides that can neutralize hydrogen ions. High (>9.0) or low (<4.5) pH is detrimental to many organisms. When a basic solution contains dissolved hydroxides of alkali or alkaline earth metals, such as potassium (KOH), sodium (NaOH), calcium ($Ca(OH)_2$), or magnesium ($Mg(OH)_2$), the solution is termed alkaline. These differ from saline solutions as the negative ion is a non-basic ion such as chloride (Cl^-) or carbonate (CO_3^{2-}), instead of hydroxide (OH^-), and does not directly affect pH.

A nutrient is a chemical that plants need for growth. Phosphorus and nitrogen are the two main nutrients, as well as potassium, carbon, sulphate, and micronutrients (chemicals needed in much smaller amounts). A small amount of phosphorus is continuously being transferred into lakes through precipitation and runoff, but most phosphorus is recycled from bottom sediments. In summer, a small amount of the phosphorus will dissolve near the lake bottom. Once this mixes into the euphotic zone, it will lead to rapid growth of algae. More phosphorus is mobilized in warm shallow lakes than in deep stratified lakes. Nitrogen is also an essential nutrient for primary producers. Nitrogen is usually present in much higher concentrations than phosphorus and exceeds the needs of aquatic plants. Nitrogen is expressed as a concentration (mg/L) and as the ratio of inorganic carbon to total nitrogen (C:N Ratio). Nitrogen needs to be in ionic form for uptake, including nitrite (NO_2^-), nitrate (NO_3^-) or ammonium (NH_4^+).

***In-situ* water quality**

In-situ water quality in SLR was basic with a pH range from 8.1 to 9.4 units (see Appendix F1, Figure F1-7). The guidelines for aquatic health suggest a pH between 6.5 and 9 (GOA, 2018a). Even though the reservoir is slightly more basic than suggested for aquatic health at times, it still supports fish species and some reproduction and recruitment of juveniles.

The water column was not stratified during spring, fall, and winter during 2021 to 2022 sampling. Water temperature was almost identical across vertical stations and depth intervals in all three sample periods. DO varied between 8 and 14 mg/L across depths during spring and summer field visits. Ice was 0.8 m thick at the time of winter sampling. DO data from Winter 2022 showed values between 14 and 16 mg/L in one sample and between 21 and 23 mg/L in the other sample, these latter data are clearly erroneous and are likely attributed to a faulty sensor. DO should not typically exceed concentrations over 13 mg/L in cold water, however, if water is supersaturated, due to high winds, as experienced in SLR, values up to 14 are plausible (CCME, 2007). While the lower depths were in an oxygen deficit (see Appendix F1, Figure F1-7), most of the reservoir DO was sufficient to support fish (Barton & Taylor, 1996).

Uniform DO and temperature with depth imply that sampling took place soon after spring and fall turnover (Mitchell & Prepas, 1990). Given the reservoir is narrow, up to 15 m deep and its fetch (length of exposed water) is oriented parallel to the prevailing wind, it is likely that water in the reservoir turns over frequently. Lack of stratification may result from frequent (wind-related) turnover or from a short water residency time (time between input and outflow), such that the reservoir does not have time to stratify. Most likely, lack of thermal stratification is a function of both short residency time and fetch of the main basin (Mitchell & Prepas, 1990).

Lab sampled water quality

Water sampling and laboratory testing occurred in spring and fall 2021, winter 2022 and fall 2023. Over this period, only two parameters exceeded water quality Protection of Aquatic Life (PAL) guidelines: fluoride and mercury (Table 8-5, Table 8-6). Fluoride was found above the guideline in all samples and (total) mercury was above the guideline in 2 of 4 samples. However, as fish, benthic invertebrates, phytoplankton and zooplankton and other life forms thrive in this reservoir these parameter exceedances do not mean the water is unhealthy. Instead, these measured values set a baseline for comparison to future reservoir conditions to determine if Project-related changes are occurring.

Table 8-5: Laboratory sampled water quality parameters from SLR (2021 to 2023) compared to environmental quality guidelines for Alberta surface waters

Parameter	Unit	ASWQG PAL	CCME Aq Life	Spring 2021[1]	Fall 2021[1]	Winter 2022[1]	Fall 2023[1]	Fall 2023 (Dugouts)[1]
TSS	mg/L	narrative[2]	-	<3.0	-	<3.0	-	-
Turbidity	NTU	narrative[2]	-	0.80	-	2.23	-	-
TDS (Calculated)	mg/L	-	-	341	-	329.5	240.0	307.5
Alkalinity, Total (as $CaCO_3$)	mg/L	20 (min)	-	162	-	163	118	84
Bicarbonate (HCO_3)	mg/L	-	-	197	-	193.5	148	104.5
Carbonate (CO_3)	mg/L	-	-	<5.0[4]	-	1.3	<5	<5
Chloride (Cl) (Soluble)	mg/L	120	120	16.9	-	17.1	15	17.1
Conductivity (EC)	µS/cm	-	-	544	-	536	422	517
Fluoride (F)	mg/L	-	0.15	0.160	-	0.157	0.12	0.25
Hardness (as $CaCO_3$)	mg/L	-	-	213	-	159.5	179	170.5
Hydroxide (OH^-)	mg/L	-	-	<5.0	-	<1.0	<5	<5
Nitrate (as N)	mg/L	3	3	<0.020	<0.020	<0.020	<0.02	<0.02
Nitrite (as N)	mg/L	equation[3]	-	<0.010	<0.010	<0.010	<0.01	<0.01
TKN	mg/L	-	-	0.35	0.37	0.330	-	1.95
Total Nitrogen	mg/L	-	-	0.35	0.37	0.330	-	3.6
pH ($CaCl_2$ Extraction)	pH	6.5-9	-	7.79	-	8.32	7.92	8.08
Phosphorus (P)-Total	mg/L	narrative[2]	-	0.0126	0.0170	2	-	-
Sulfate (SO_4; Soluble)	mg/L	equation[3]	-	120	-	107	15	17.1
Coliform Bacteria	CFU/100mL	-	-	<1	<1	<1	-	-
MPN - Total Coliforms	MPN/100mL	-	-	7	-	<1	-	-
BOD	mg/L	-	-	<2.0	<2.0	<2.0	-	-
Aluminum (Al)-Total	mg/L	-	-	0.0256	0.0256	0.0091	0.031	0.029
Antimony (Sb)-Total	mg/L	-	-	<0.00010	<0.00010	0.00011	<0.001	<0.001
Arsenic (As)-Total	mg/L	0.005	0.005	0.00054	0.00097	0.00068	0.005	0.005
Barium (Ba)-Total	mg/L	-	-	0.0608	0.0571	0.0709	0.06	0.10
Beryllium (Be)-Total	mg/L	-	-	<0.00010[2]	<0.00010	<0.000020	<0.0005	<0.0005
Bismuth (Bi)-Total	mg/L	-	-	<0.000050	<0.000050	<0.000050	-	-
Boron (B)-Total	mg/L	1.5	1.5	0.028	0.023	0.030	0.03	0.06
Cadmium (Cd)-Total	mg/L	equation[3]	0.00009	<0.0000050	<0.0000050	<0.0000050	<0.000016	<0.000016
Calcium (Ca)-Total	mg/L	-	-	55.7	45.3	54.35	-	-
Cesium (Cs)-Total	mg/L	-	-	<0.000010	<0.000010	<0.000010	-	-
Chromium (Cr)-Total	mg/L	0.0089	0.0089	<0.00010	<0.00010	<0.00050	<0.0005	<0.0005
Cobalt (Co)-Total	mg/L	equation[3]	-	0.00016	0.00015	0.00014	0.00022	0.00061
Copper (Cu)-Total	mg/L	0.007[4] & equation[3]	0.0357	0.00075	0.00052	0.00071	0.0012	0.0013
Iron (Fe)-Total	mg/L	-	-	0.024	0.052	0.014	1.1	1.1
Lead (Pb)-Total	mg/L	equation[3]	35	<0.000050	<0.000050	0.000121	0.0002	0.0007
Lithium (Li)-Total	mg/L	-	-	0.0144	0.0106	0.0141	-	-
Magnesium (Mg)-Total	mg/L	-	-	20.9	18.6	22.5	-	-
Manganese (Mn)-Total	mg/L	-	0.43	0.00630	0.00929	0.00530	0.023	0.084
Mercury (Hg)-Total	µg/L	0.005	0.026	0.00033	0.00024	0.360	0.3375	<0.025

Parameter	Unit	ASWQG PAL	CCME Aq Life	Spring 2021[1]	Fall 2021[1]	Winter 2022[1]	Fall 2023[1]	Fall 2023 (Dugouts)[1]
Molybdenum (Mo)-Total	mg/L	0.073	0.073	0.00162	0.00145	0.00642	0.001	0.002
Nickel (Ni)-Total	mg/L	equation[3]	-	0.00122	0.00114	0.00135	0.003	0.003
Phosphorus (P)-Total	mg/L	-	-	<0.050	0.017	<0.050	-	-
Potassium (K)-Total	mg/L	-	-	3.33	2.51	3.09	2.4	5.8
Rubidium (Rb)-Total	mg/L	-	-	0.00082	0.00081	0.00076	-	-
Selenium (Se)-Total	mg/L	0.002	-	0.000228	0.000237	0.000227	<0.0005	<0.0005
Silicon (Si)-Total	mg/L	-	-	0.772	0.672	0.20	-	-
Silver (Ag)-Total	mg/L	0.00025	0.00025	<0.000010	<0.000010	<0.000010	<0.00005	<0.00005
Sodium (Na)-Total	mg/L	-	-	30.6	24.2	28.6	19	43.3
Strontium (Sr)-Total	mg/L	-	-	0.315	0.277	0.331	-	-
Sulfur (S)-Total	mg/L	-	-	40.45	29.7	41.7	-	-
Tellurium (Te)-Total	mg/L	-	-	<0.00020	<0.00020	<0.00020	-	-
Thallium (Tl)-Total	mg/L	0.0008	0.0008	<0.000010	<0.000010	<0.000010	<0.0001	<0.0001
Thorium (Th)-Total	mg/L	-	-	<0.00010	<0.00010	<0.00010	-	-
Tin (Sn)-Total	mg/L	-	-	<0.00010	<0.00010	<0.00010	-	-
Titanium (Ti)-Total	mg/L	-	-	<0.00030	0.0004	<0.00030	0.002	<0.001
Tungsten (W)-Total	mg/L	-	-	<0.00010	<0.00010	<0.00010	-	-
Uranium (U)-Total	mg/L	0.015	0.015	0.00121	0.000734	0.00105	<0.001	<0.001
Vanadium (V)-Total	mg/L	-	-	<0.00050	0.00062	0.00052	-	-
Zinc (Zn)-Total	mg/L	0.03	0.007	<0.0030	<0.0030	<0.0030	0.006	<0.004
Zirconium (Zr)-Total	mg/L	-	-	<0.00020	<0.00020	<0.00020	-	-
Acenaphthene	mg/L	0.0058	0.0058	<0.00001	<0.00001	<0.00001	-	<0.00001
Acridine	mg/L	0.0044	0.0044	<0.00001	<0.00001	<0.00001	-	<0.00005
Anthracene	mg/L	0.000012	0.000012	<0.00001	<0.00001	<0.00001	-	<0.00001
Benzo(a)anthracene	mg/L	0.000018	0.000018	<0.00001	<0.00001	<0.00001	-	<0.00001
Benzo(a)pyrene	mg/L	0.000015	0.000015	<0.000005	<0.000005	<0.000005	-	<0.000007
Fluoranthene	mg/L	-	0.00004	<0.00001	<0.00001	<0.00001	-	<0.00001
Fluorene	mg/L	0.003	0.003	<0.00001	<0.00001	<0.00001	-	<0.00001
Naphthalene	mg/L	0.001	0.0011	<0.00002	<0.00002	<0.00005	-	<0.00001
Phenanthrene	mg/L	0.0004	0.004	<0.00002	<0.00002	<0.00002	-	<0.00001
Pyrene	mg/L	0.000025	0.000025	<0.00001	<0.00001	<0.00001	-	<0.00001
Quinoline	mg/L	0.0034	0.0034	<0.00005	<0.00005	<0.00005	-	<0.00004
Total PCBs	µg/L	-	-	<0.030	<0.030	<0.060	-	<0.050

[1] Mean of East and West Sites for the SLR, or of two dugout sites in the expansion area

[2] Narrative: the guideline is based on maintaining the value within a certain range of the baseline concentration

[3] For Hardness ($CaCO_3$) or Chloride values in this table, the equations provide the following guideline concentrations (see Table 8-6)

[4] Chronic effects guideline

Note: Irrigation guidelines are crop specific; red shading: exceeds guideline levels for environmental quality guidelines for Alberta surface waters; (-) = no guideline value available or detection limit listed

Table 8-6: Calculated guideline values for water quality parameters from SLR (2021 to 2023) based on environmental quality guidelines for Alberta surface waters

Parameter	Unit	Method	Spring 2021	Winter 2022	Fall 2023	Fall 2023 (Dugouts)
Cadmium Chronic Guideline	µg/L	Varies with hardness[1]	0.000030	0.00023	0.00026	0.00025
Cadmium Acute Guideline	µg/L	Varies with hardness[1]	0.0046	0.0034	0.0038	0.0036
Cobalt Chronic Guideline	µg/L	Varies with hardness[1]	0.0014	0.0012	0.0013	0.0013
Copper Acute Guideline	µg/L	Varies with hardness[1]	0.034	0.025	0.028	0.027
Lead Chronic Guideline	µg/L	Varies with hardness[1]	0.007	0.0058	0.0067	0.0063
Nickel Chronic Guideline	µg/L	Varies with hardness[1]	0.10	0.078	0.078	0.082
Nickel Acute Guideline	µg/L	Varies with hardness[1]	0.900	0.700	0.700	0.740
Nitrite-N 30 Day Average Guideline	mg/L	Varies with chloride[2]	0.429	0.309	0.309	0.309
Nitrite-N Maximum Guideline	mg/L	Varies with chloride[2]	0.0002	0.0002	0.0002	0.0002
Sulfate (SO_4^{2}) (Soluble)	mg/L	Varies with hardness[1]	429	309	309	309

[1] Refer to measured Hardness (as $CaCO_3$) values for each specified timeframe, presented in Table 8-5.

[2] Refer to measured Chloride (Cl) (Soluble) values for each specified timeframe, presented in Table 8-5.

Note: Fall 2021 values were not collected. Values presented in this table are calculated based on Table 1.3 and Table 1.4 in Environmental Quality Guidelines for Alberta Surface Waters (GOA, 2018a)

8.4.2.4 Aquatic Biota

A review of aquatic life and habitats typical of north temperate lakes and reservoirs was completed to better understand conditions present in SLR. This review was primarily based on information presented in the Atlas of Alberta Lakes (Mitchell & Prepas, 1990).

Aquatic habitats support diverse ecosystems of bacteria, fungi, algae, protozoans, zooplankton, aquatic plants, invertebrates, amphibians, and fish. The lake surface and surrounding riparian habitat are also home to waterfowl, shorebirds, and semi-aquatic mammals like muskrats. In addition, many other insects and invertebrates live and breed on or above waterbodies and many other species use lakes to obtain water, minerals, or food. Aquatic biota includes primary producers (plants, algae, and cyanobacteria) that use photosynthesis to convert carbon, oxygen, and trace elements into organic matter. Primary consumers (herbivores or planktivores) feed on primary producers, while secondary consumers feed on the primary consumers. There are also decomposers (fungi and bacteria) that break down organic matter, including matter produced in the waterbody like algae and macrophytes, and matter transported into the waterbody like tree leaves. Finally, detritivores consume dead and partially decomposed organic matter. These classifications are generalizations as many species feed on more than one type of food.

Primary producers include aquatic vascular and nonvascular plants, algae (e.g., green algae and diatoms) and cyanobacteria (blue-green algae). Cyanobacteria are simple life forms related to bacteria (prokaryotic organisms) that have chlorophyll dispersed through their cells and gain energy through photosynthesis. Some cyanobacteria have specialized cells where nitrogen fixation occurs; other cyanobacteria are responsible for toxic algal blooms and/or grow into undesirable floating mats. Algae include a diverse group of complex-celled (eukaryotic) species with specialized chlorophyll-containing chloroplasts in their cells. They include colonial (filamentous or mat forming) and single-celled forms, including green algae (*Chlorophyta*), golden brown algae (*Chrysophyta*), diatoms (*Bacillariophyta*), cryptophytes (*Cryptophyta*), dinoflagellates (*Pyrrhophyta*), and euglenoid flagellates (*Euglenophyta*). Unicellular algae species include both free floating (buoyant) and motile organisms, the latter of which can move throughout the water column in response to light, temperature, or chemical factors. Algae and cyanobacteria, which float freely in the euphotic zone, are known as phytoplankton.

In north-temperate lakes, phytoplankton biomass is generally lowest from December through February given low temperatures and limited light penetration through ice and snow. Typically, algal biomass peaks in the spring when temperature, light intensity and duration, plus nutrient concentrations increase. Algal growth declines in late spring when the water stratifies, cutting off the nutrients from deep water, and following the increase in secondary consumers that graze on phytoplankton. Shallow, nutrient-rich lakes often experience algal blooms throughout summer, while lower nutrient lakes and reservoirs only experience blooms if higher water temperatures and nutrient concentrations occur. Algal blooms are often composed of cyanobacteria, which are not as desirable for consumption and may release toxins; when these blooms are over, the decomposing algae result in depleted oxygen concentrations. An additional algal peak may occur if the lake water mixes in the fall. Reservoirs with low nutrients and rapid flushing rates tend to have low algal biomass all year.

Macrophytes are almost all vascular plants, except for a few algae and bryophytes. Macrophytic algae include colonial species such as Muskgrass (*Chara spp.*), which form large colonies attached to rocks or substrates. In some lakes, aquatic bryophytes (mosses and liverworts) also occur. Macrophytic vascular plants include emergents (rooted plants with stems above water surface, such as Common Cattail (*Typha latifolia*), Bulrushes (*Scirpus/Bolboschoenus/ Schoenoplectus sp*.), rooted, floating leaved varieties (e.g., pond-lilies), free floating species (duckweeds [*Lemna sp.*]), and submergents (fully emersed species such as Northern Watermilfoil [*Myriophyllum sibiricu*]). Macrophytes form highly productive plant communities and provide important nesting, cover, and feeding habitats for fish, amphibians, waterfowl, songbirds, and semi-aquatic mammals.

Emergent macrophytes, such as Common Cattail, Bulrushes, Tall Reed Grass (*Phragmites australis*), Tall Manna Grass (*Glyceria grandis*) and several sedges like Water Sedge (*Carex aquatilis*) are rooted in flooded or saturated soils but the shoots emerge above the water surface. Emergents occur over a depth range from about 0.5 m above the flooded zone to a depth of about 1.5 m. Some emergent species are only found near the lake perimeter, including several sedges, Water Parsnip (*Sium suave*), Water Hemlock (*Cicuta maculata*), Swamp Horsetail (*Equisetum fluviatile*), Broad-leaved Water-plantain (*Alisma triviale*), Arum-leaved Arrowhead (*Sagittaria cuneata*), and Common Mare's Tail (*Hippuris vulgaris*). Floating-leaved macrophytes, such as Yellow Pond Lily (*Nuphar variegatum*) and Floating Leaf Pondweed (*Potamogeton natans*) are generally rooted in lake sediments from about 0.5 m to 3 m deep. These plants are usually restricted to calm waters where their leaves are protected from strong waves or currents. Free-floating macrophytes like Common Duckweed (*Lemna turionifera*) float freely on the water surface. They provide important food for waterfowl. An aquatic invasive macrophyte (prohibited noxious weed), Flowering Rush (*Butomus umbellatus*), is found in canals throughout Alberta and needs to be controlled where identified.

Submergent macrophytes are found in deeper water. Some of the taller submergent plants that flower and disperse seeds above surface, include Richardson's Pondweed (*Potamogeton richardsonii*), Water Smartweed (*Polygonum coccineum*), Northern Watermilfoil, and Coontail (*Ceratophyllum demersum*). Shallow waters often have species such as White Water-crowfoot (*Ranunculus aquatilis*) and Common Bladderwort (*Utricularia vulgaris*), the latter being a carnivorous plant that captures and digests zooplankton species for nitrogen. In brackish to saline waters, there are several different emergent and submergent plant species that have adapted to high ion concentrations. Species such as Seaside Arrow Grass (*Triglochin maritima*), Widgeon Grass (*Ruppia cirrhosa*), Sago Pondweed (*Potamogeton pectinatus*), Three-square Bulrush (*Schoenoplectus pungens*), and River Grass (*Scolochloa festucacea*) are common in brackish to saline waters.

Decomposers include bacteria and fungi. These two groups are important as they break down dead organic matter in lakes. They are consumed by zooplankton and in some aquatic systems, imported and "recycled" organic materials form a large proportion of the total energy within a food web. Zooplankton are tiny animals suspended in open water; they include primary or secondary consumers and comprise three main groups in Alberta lakes: Rotifers, Copepods, and Cladocerans. Dominant species change through the seasons, in response to light conditions, water temperature, DO, food supply, predation, differential growth rates, and behavioural factors. Zooplankton migrate around a lake through the year to locate suitable habitat for feeding and to escape predation. Some species prefer the littoral zone in and among submergent macrophytes which provide oxygen and food, as algae may grow attached to these plants. Copepods and cladocerans also migrate vertically in response to diurnal light intensity.

In spring, when zooplankton populations begin to multiply, grazers like copepods and some cladocerans that feed on small, single-celled algae are most common. As the algae are consumed, the food supply becomes limited, and the water may become very clear again. Sometimes the larger cladoceran species will be dominant then, feeding on organic debris. Other times the less palatable algae and cyanobacteria become dominant and only the few species that can feed on these algae will be dominant. In this case the food chain will switch to bacteria which decompose dead algae and which are then consumed by rotifers and cladocerans.

Benthic invertebrates live in or on the bottom mud, on aquatic plants, on or under rocks, and among the debris on the bottoms of lakes. They include insect larvae, worms, and mollusks. Molluscs include species of snails and clams. Fingernail clams and unionid clams are the most common molluscs in Alberta. Insects include water beetles, water boatmen (*Corixidae*), dragonflies (*Aeshnidae*), damselflies (*Libellulidae*) and mayfly nymphs (*Ephemeroptera*). Leeches (*Hirudinae*) are also common. Amphipods (freshwater shrimp) typically dominate invertebrate community in productive littoral zones). All benthos are a major food source for fish, waterfowl, and shorebirds. Their abundance and diversity depend on water depth, nutrient (trophic) status, DO, and the presence of fish (Mitchell & Prepas, 1990).

Because of their diversity, relative ease of identification and high densities, benthic invertebrates are often used to qualify the ecological health of lakes. The SLR benthic invertebrate community is dominated by chironomids (midges) given substrate is predominantly silt and fines. Limnephilid mayflies, diving beetles (*Dytiscidae*), water boatmen, leeches, damselfly and dragonfly larvae are present in shallower littoral habitat in the northeast basin (see Appendix F1, Figure F1-5 and Figure F1-6). These species are common within littoral habitat of ponds, lakes, and reservoirs. Their abundance fluctuates seasonally in ponded habitats and with reduced water level associated with drawdown in reservoirs over the open water season.

Like benthos, fish distribution within lakes depends on the type and availability of habitats, water depth, oxygen concentration, water quality, temperature and stratification, and presence of food resources and protective cover. Cold-water fish are generally found in deep, cold waters (pelagic zone, >3 m depth), whereas warm-water fish are generally restricted to shallow waters or lake margins that warm up rapidly in spring and remain warm through summer. Limiting factors affecting the distribution of species among habitats in reservoirs and lakes include water quality, abundance of forage, competition with other fish, and presence of predators. In particular, the presence of Northern Pike, a piscivore, can result in smaller fish restricted to small safe areas such as habitats with dense aquatic vegetation or cover provided by boulders or logs. Fish are important predators of zooplankton and benthic invertebrates. Small crustaceans (zooplankton) are the main foods of most types of young fish while adult fish feed mainly on benthic invertebrates or other fish. Different habitats are used during life cycles stages, such as egg-laying, rearing, juvenile development, and mature adult predators.

Reservoirs are typically low in productivity, especially those with unstable littoral habitats associated with drawdown (for irrigation) or appreciable fluctuation associated with hydro-electric power generation. Benthic invertebrates were not sampled specifically in SLR as part of the inventory program. They were reported incidentally as larvae or winged adults; are present as part of the community. Their colonization of SLR is both passive and active – via the canal from the Bow River and through hatching and adults laying eggs in the reservoir, respectively. Regional data from the Alberta Biodiversity Monitoring Institute was obtained on benthic invertebrate distribution within the ARSA. These data show healthy populations of benthic invertebrates are present in ponds and lakes throughout the region (see Appendix F3). Benthos production will increase and are not limiting fish production as is now within SLR. Fish sampled were all in good condition; especially Lake Whitefish (*Coregonus clupeaformis*) that would have Condition Factor at or above 1 and frankly "fat" (Mackay et al., 1990).

8.4.2.5 Traditional Use of Fish Species

A review of literature was completed to identify if there were fish of traditional importance to First Nations or other Indigenous groups in the grassland region of Alberta [see Volume 2, Appendix A, FTOR 3.5.1.1 a) vi]. The review focussed on information regarding the Siksika (Blackfoot) Nation and the Blackfoot Confederacy in general. One source "The significance of Fish and Water to the Blackfoot People" included interviews with Blackfoot Elders in Alberta (Miistakis Institute, 2021). Common themes that emerged include the cultural importance of fish, the use of fish as indicators of ecosystem change, and understanding that fish presence can be used to indicate water quality.

Fish were identified as an important survival food when big game were scarce, but individual species of fish were not identified (City of Lethbridge, 2017). However, the Blackfeet Nation in Montana, part of the Blackfoot Confederacy, have identified Bull Trout (*Salvelinus confluentus)* as a species of cultural significance (Dickson, 2018). This species no longer uses the Bow River above Bassano Dam, nor is it found in SLR. However, it is known to occur in Lake Newell and the Red Deer River (Table 8-7). Additionally, sources state that some Indigenous Peoples are fishermen and catch fish for food while others may work as fishing guides. Without references to identify species of importance, it is not possible nor advisable to speculate on which species are of greatest importance to the Blackfoot Peoples in general and Siksika Nation in particular. Further discussion on Traditional Use can be found in Volume 2, Section 15 (Traditional Ecological Knowledge and Traditional Land Use).

8.4.2.6 Fish Populations

Upstream of the Bassano Dam, the Bow River (source of fish for SLR) supports 22 species of fish, while recent inventories in SLR caught only 6 (Table 8-7). Other reservoirs with data available in southern Alberta support 9 or 10 species (Lake Newell and Crawling Valley Reservoir). In comparison, the Red Deer River is known to have 27 species (Table 8-7).

Given SLR is connected to the lower Bow River, any of its resident population could gain access to the reservoir when water is diverted. Fish caught in SLR during spring and fall inventories included Burbot (*Lota lota*)*,* Lake Whitefish, Northern Pike, Prussian Carp, Spottail Shiner (*Notropis hudsonius*), and White Sucker (*Catostomus commersoni*; Tables 8-7 and 8-8). Given relatively high abundance, large size of adults, importance as sport-fish species and wide range of age and size classes in SLR, two species, Northern Pike and Lake Whitefish are selected as key indicator fish species.

Northern Pike caught were represented by juvenile, sub-adult, and adult individuals. Of these, 12 were juveniles represented by three length classes (see Appendix F1, Figure F1-8). Lake

Whitefish were all adults and dominated the spring and fall catch (76% of fish caught; Table 8-8; see Appendix F1, Figure F1-8). Northern Pike varied from 20 to 60 cm fork length (FL), Lake Whitefish from 30 to 65 cm FL and the two Burbot caught were 25 and 50 cm FL.

All life-history stages of Northern Pike were caught in SLR. Northern Pike spawn after ice-out over flooded emergent vegetation (Joynt & Sullivan, 2003; Nelson & Paetz, 1992). They were caught within the shallow northeast basin where flooded emergent vegetation was present; this area represents typical spawning habitat for this species. Most pike collected in the spring had spawned recently as per evidence of milt, lesions, cuts, and abrasions (not associated with being captured by gillnet). Most were >40 cm long (see Appendix F1, Figure F1-8). Presence of spent males in the shallow northeast basin supports Northern Pike spawning in SLR. Northern pike spawning may fail when pH is 9 or greater. Breeding activity suggests the pH is lower in the littoral zone in the northeast basin of SLR, permitting eggs to be viable and fry to hatch.

Few White Sucker were caught (n=2; Table 8-8); however, their lengths were appreciably different. It is unlikely they spawn in the reservoir given absence of suitable substrate and moving water. It is probable these individuals were entrained in water diverted from the river to the Reservoir via the canal.

Gill nets set in water greater than 2 m deep caught Lake Whitefish exclusively and a few adult Northern Pike. Minnow traps did not capture any fish. In the spring, a single Prussian Carp was caught using fyke nets, and in fall a juvenile Northern Pike.

Total float electrofishing effort in spring was 30,700 seconds and in fall, 28,760 seconds. Both electrofishing efforts surveyed about 1,600 m and followed the same track. Catch-per-unit-effort (CPUE) which refers to the number of fish caught per 100 seconds of effort, was low. This is likely a sampling artifact since electrofishing efficiency is reduced appreciably in water >2 m deep and the reservoir littoral zone was steep walled: greater than 2 m deep within 1 m of shoreline (lots of room for fish to avoid the electrofisher attraction field and become immobilized).

Angling CPUE was relatively high in late October 2023 (~6 Northern Pike/angler hour). This result is also a sampling artifact. Fish were concentrated in the deep basin making them easier to catch with the reservoir being drawn down. Overall abundance data needs to be interpreted cautiously. What is clear is that SLR supports sport, coarse and forage fish; they reside there year-round. There is sufficient forage for sportfish to retain good condition factors.

Lake Whitefish, Northern Pike, and Burbot were sportfish present in the reservoir in descending relative abundance (Table 8-8). Abundance should be interpreted cautiously as most fish were caught in nets set offshore in deeper water which is less attractive to Northern Pike who prefer littoral habitats (<3 m deep). Float electrofishing captured fish in the northeast basin, around the peninsula (see Appendix F1, Figure F1-4). Few individuals were encountered electrofishing along steep walled habitat in the balance of the reservoir. Northern Pike were represented in the electrofishing catch as was a juvenile Burbot and two Spottail Shiner (Table 8-8).

Prussian Carp (colloquially referred to as Goldfish), an invasive fish, have been introduced in most watersheds across Alberta. They are present in SLR but not abundant based on the inventory (Table 8-8). They have proliferated throughout major population centers when released into stormwater ponds or waterways. Prussian Carp are now a threat to many aquatic ecosystems in Alberta.

Table 8-7: Fish species reported from SLR, the Aquatic Regional Study Area, and surrounding waterbodies

Species	Alberta Status[1,7]	Bow River[2]	SLR	ARSA (FWMIS[3] Reports)	Crawling Valley Reservoir[4]	Lake Newell[5]	Red Deer River[6]
Brook Stickleback (*Culea inconstans*)	N	X		C[7]	X		X
Brook Trout (*Salvelinus fontinalis*)	E	X			X[4]	X[4]	X
Brown Trout *(Salmo trutta)*	E	X			X[4]		X
Bull Trout (*Salvelinus confluentus*)	N					X	X
Burbot *(Lota lota)*	N	X	X	L	X	X	X
Emerald Shiner *(Notropis atherinoides)*	N	X					X
Fathead Minnow *(Pimephales promelas)*	N			C	X		
Finescale Dace (*Chrosomus neogaeus*)	N						X
Goldeye *(Hiodon alosoides)*	N						X
Lake Chub *(Couesius plumbeus)*	N	X					X
Lake Sturgeon *(Acipenser fulvescens)*	N	X					X
Lake Whitefish *(Coregonus clupeaformis)*[8]	N	X	X	L		X[4]	X
Longnose Dace *(Rhynichthys cataractae)*	N	X		C			X
Longnose Sucker *(Catostomus catostomus)*	N	X		L	X		X
Mooneye (*Hiodon tergisus*)	N						X
Mountain Sucker *(Catostomus platyrhynchus)*	N						X
Mountain Whitefish *(Prosopium williamsoni)*	N	X					X
Northern Pike *(Esox lucius)*[8]	N	X	X	L[6]	X	X	X
Prussian Carp *(Carassius gibbelio)*	E	X	X				
Quillback (*Carpiodes cyprinus)*	N	X					X
Rainbow Trout *(Oncorhynchus mykiss)*	N/E	X		L	X[4]	X	X
River Shiner (*Notropis blennius*)	N						X
Sauger *(Sander canadense)*	N	X					X
Shorthead Redhorse *(Moxostoma macrolepidotum)*	N	X			X		X
Silver Redhorse *(Moxostoma anisurum)*	N	X					
Spoonhead Sculpin (*Cottus ricei*)	N						X
Spottail Shiner *(Notropis hudsonius)*	N	X	X	L, C		X	X
Trout-Perch *(Percopsis omiscomaycus)*	N	X					X
Walleye *(Sander vitreus)*	N	X		L		X	X
White Sucker *(Catostomus commersoni)*	N	X	X	L	X	X	X

[1] List of Native and Naturalized Fish of Alberta (GOA, 2013).
[2] Bow River Basin Watershed (Bow River Basin Council, 2012)
[3] Fish and Wildlife Internet Mapping Tool (GOA, 2024a)
[4] Atlas of Alberta Lakes (Mitchell & Prepas, 1990)
[5] Stocked
[6] State of the Watershed Report (Red Deer Watershed Alliance, 2009)
[7] N=Native; E=Exotic; L = Lakes and reservoirs; C = Creeks
[8] Key indicator species for SLR

Table 8-8: Fish capture results from SLR spring and fall 2021 fish population inventory

Fish Species	Spring			Fall			Total
	Fish Capture Method			Fish Capture Method			
	Float Electrofisher	Fyke Net	Gill Net	Float Electrofisher	Fyke Net	Gill Net	
Burbot (*Lota lota*)	0	0	0	1	0	0	**1**
Lake Whitefish (*Coregonus clupeaformis*)	0	0	21	0	0	50	**71**
Northern Pike (*Esox lucius*)	0	0	6	5	1	4	**16**
Prussian Carp (*Carassius gibbelio*)	0	1	0	1	0	0	**2**
Spottail Shiner (*Notropis hudsonius*)	0	0	0	0	0	1	**1**
White Sucker (*Catostomus commersoni*)	2	0	0	0	0	0	**2**
Total	**30**			**63**			**93**

Within the ARSA, no Species at Risk have been reported from the Bow River (to point of diversion) or other natural waterbodies. Only one species in the South Saskatchewan River Drainage is listed under the *Species at Risk Act* (GOC, 2002). This species, Bull Trout, is listed as *Threatened* (GOC, 2023). Bull Trout naturally occur well upstream of the Bassano Dam in the Bow River in Foothills and Mountain regions, are not known from the river southeast of Calgary, AB, and are not likely to be found anywhere near the Bassano Dam or within any waters in the ARSA, although it is known from Lake Newell (Table 8-7).

An additional species, Lake Sturgeon (*Acipenser fulvescens*) is not listed under *Species at Risk Act*; however, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) has recommended some populations of this species to be listed as *Endangered*. This species occurs in lower reaches of the South Saskatchewan drainage; it was reported historically in the Red Deer River downstream from the Town of Innisfail and from the South Saskatchewan River downstream from its confluence with the Oldman and Bow rivers. This species is functionally extirpated from habitats within the upper and lower ranges of the ARSA (GOA, 2002).

The littoral zone is narrow for the balance of the reservoir (<1 m from edge; see Appendix F1, Figure F1-5). Walls are steep and depth increases quickly which reduced catch-per-unit effort of the float electrofisher for most of the reservoir. Nooks, crevices, and other interstitial places are preferred habitat of juvenile Burbot which rear in cover at waters' edge until late fall at age 2+, when they move offshore (Boag, 1989; Joynt & Sullivan, 2003).

The field crew met several anglers who were fishing for Northern Pike and Lake Whitefish during both spring and fall inventories. Anglers reported that SLR supports "a good fishery" in both summer and winter (ice fishing). CPUE for an angling survey on September 29, 2023, was high: 23 were caught and released in 3.5 hours (~6 Northen Pike/per angler-hour) during efforts to catch fish for MeHg body burden analysis. Of those caught, 2 were >65 cm fork length and sampled. The remainder were between 300 and 500 mm long.

8.4.2.7 Reservoir Habitats

Water depth, lake area, and trophic (productive) status of a lake influence habitat suitability for resident biota. Lake waters can be divided into three depth zones: upper littoral (zone of emergent macrophytes to about 1.5 m depth), lower littoral zone (zone where submerged macrophytes occur), and the pelagic zone. The littoral zone comprises 35% of SLR at baseline. These zones and other habitat zones discussed below have been measured for SLR (Table 8-9).

Within the pelagic zone the waters can be further divided into euphotic (light present-phytoplankton productivity) and profundal (deep water with <1% of surface light, no phytoplankton productivity). Reservoir habitat is characterized by instability of the littoral zone since it fluctuates seasonally. Based on Secchi depth measurements in SLR, the average observed depth of light penetration is 2.0 m. The Euphotic zone is typically 2 to 2.5 times deeper than the Secchi depth; in SLR this zone was estimated to be 4 m deep. Within SLR is 105 ha of littoral zone, divided into 68 ha of emergent zone and 37 ha of submergent zone at FSL. Areas with boulders (riprap, and habitat suitable for rearing) have also been identified (see Appendix F1, Figure F1-5). Habitat based sampling has allowed an understanding of baseline habitat use by resident fish. This information was used for broad-level predictions for the expanded reservoir as part of the EIA.

SLR provides habitat for sport and forage fish (see Appendix F2, Plates F2-1 to F2-14). At the far east and west ends of the reservoir, interstitial spaces within the rock armour provide rearing habitat for juvenile burbot and small cyprinids (Boag, 1989). In the northwest bay, depth is shallower and emergent and submergent macrophytes are well established (see Appendix F1, Figure F1-5). When inundated in the spring from mid-May through mid-June, this bay provides suitable spawning and rearing habitat for Northern Pike (Casselman & Lewis, 1996; Inskip, 1979). This was confirmed in 2021 when spent adults were caught there while float electrofishing.

In 2021 and 2022, the reservoir was drawn down about 1.5 m (+/-) over summer and fall. In 2023, SLR was drawn down >8 m. The littoral zone was dry and what water remained, was concentrated in the deepest basin (maximum depth 6 m; see Appendix F2, Plate F2-15 to F2-17).

Based on mapped habitat and depths, habitat areas for fish and other aquatic organisms were calculated (Table 8-10). Lake Whitefish, White Sucker and Prussian Carp can use the entire SLR, whereas Northern Pike have different habitat areas available for hiding, spawning and rearing, and foraging. Total habitat for Burbot was limited to boulder (riprap) areas on the dam walls.

Lake Whitefish are pelagic during much of the open water season. With a typical drawdown of 1.5-2.0 m over summer through fall, sufficient depth remains in the basin to support them year-round, and the reservoir produces sufficient forage given the large size of individuals captured. Of those netted 12/63 (13%) were “jumbo” (>2.5 kg; see Appendix F1, Figure F1-8). These large individuals would be prized by anglers. Spawning habitat suitable for Lake Whitefish (“firm”, coarse, or hard packed substrate) is absent in SLR. No juveniles were caught during the inventories (see Appendix F1, Figure F1-8). Despite severe drawdown, Lake Whitefish were able to survive in the 6 m deep basin that remained during fall 2023 (i.e., no fish were found dead from hypoxia, nor were any stranded because of the drawdown). It is like fish also survived in the deep (excavated) basins on the northwest side of SLR.

Table 8-9: SLR habitats based on depth zones at FSL

Habitat Zones	Surface Area (ha)	% of Reservoir
Littoral Zone (0-3 m depth)	105.1	35.1
Upper Littoral (Emergent) Zone (0-1.5 m)	68.0	22.7
Lower Littoral (Submergent) Zone (1.5-3 m)	37.1	13.8
Mapped Habitat Areas	83.5	27.9
Riprap / Boulders	12.1	4.0
Temporary Rearing Habitat	28.4	9.5
Permanent Rearing Habitat	43.0	14.4
Pelagic Zone (>3 m)	193.7	64.8
Euphotic Zone (0-4 m)	130.7	43.7
Profundal Zone (>4 m)	168.1	56.3
Total[1]	**298.8**	**100.0**

[1] Sum of Littoral and Pelagic Zones, or of Euphotic and Profundal Zones

Habitat is suitable for White Sucker feeding and rearing throughout SLR. The reservoir does not contain spawning habitat for this species (unembedded coarse substrate and flow). Hence, the absence of young-of-the-year White Sucker during the inventory is not surprising. White Sucker present in SLR have arrived there passively through the canal system. Forage fish are common and typical of those found in southern Alberta reservoirs that are fed by water from the Bow River (Applied Aquatic Research, 2022).

Table 8-10: Estimated SLR habitat areas for various biota

Biota	Habitat Zone of Interest	Surface Area (ha)
Sport Fish		
Burbot	Juvenile Rearing Habitat (Boulder)	12.1
Northern Pike	Hiding Cover (Permanent Rearing Habitat + Boulder Area)	55.1
	Spawning & Rearing Habitat (Permanent + Temporary Rearing Habitat)	71.4
	Foraging Habitat (Littoral Zone)	105.1
Lake Whitefish	Foraging (Full reservoir seasonally)	298.8
Coarse Fish		
White Sucker	Full Reservoir	298.8
Aquatic Invasive Species		
Prussian Carp	Full Reservoir	298.8
Macrophyte		
Emergent	Upper Littoral Zone	68.0
Submergent	Lower Littoral Zone	37.1
Other		
Phytoplankton	Euphotic Zone	130.7
Zooplankton	Euphotic Zone	130.7
Benthic Invertebrate	Full Reservoir	298.8

8.4.2.8 Mercury in Reservoirs

A common challenge associated with reservoir development is metabolism of mercury at the soil and water interface and its accumulation through the food web during the years immediately post-inundation (reviewed in Appendix F4). Methylmercury cannot be metabolized and accumulates over time within animal tissue. Consequently, top predators (piscivores) such as Northern Pike, Walleye (*Sander vitreus*), or Rainbow Trout (*Oncorhynchus mykiss*) can accumulate an appreciable body burden of methylmercury as they grow. Baseline methylmercury concentration in fish in reservoirs compared with those in nearby watercourses can often exceed recommended human consumption limits (Environmental Management Associates, 1993; Applied Aquatic Research, 2022).

Biologists collected adult Northern Pike from SLR by angling to determine methylmercury body burden in fall 2023. CPUE was high (8.3 fish/angler-hour) since the reservoir had drawn down appreciably. Only two individuals >50 cm were caught, and these were sampled. Sediment samples was also collected to determine their methylmercury concentration. Water samples were collected with a VanDorn bottle from just above substrate at each of the east and west basin locations. Inorganic mercury was measured in the water column (Table 8-11).

Table 8-11: Inorganic and methylmercury in SLR water, sediment, and fish, fall 2023

Parameter and Medium	West Sample Site	East Sample Site	Average
Total Inorganic Mercury in Water (µg/L)	0.105	0.160	0.133
Methylmercury in Sediment (ng/g)	<0.4	<0.4	<0.4
Methylmercury in Fish Tissue (ng/g)	217	218	218

Consuming fish (Northern Pike) from SLR could affect human health at the measured concentration of methylmercury in their tissue. For example, if a 60 kg person consumes an average of 100 g of Northern Pike from SLR per day, they would accumulate 0.363 µg methylmercury per kg body mass (µgMM/kg) per day. This rate is higher than the recommended maximum (0.2 µgMM/kg) for women of childbearing age and children; however, it is lower than the 0.47 µgMM/kg for the remainder of the population.

Based on a review of information for southern Alberta reservoirs (see Appendix F4), the expansion of SLR is expected to increase fish habitat and productivity (catch). Sample size of Northern Pike adults (>65 cm long) was small so results need to be interpreted cautiously. Regardless, the harvest and consumption of fish from the expanded reservoir may need to be monitored to avoid methylmercury bioaccumulation in individuals.

8.5 IMPACT ASSESSMENT

Refer to the Project Description for water management and use analysis as it pertains to surface water in the ALSA and ARSA. This section describes the predicted impacts and mitigation measures to be applied for the expansion of SLR. Its surface area will increase more than three times once filled. This change is permanent, and aquatic resources will be affected positively by increased habitat.

8.5.1 Methods

For a full description of the EIA approach including the assessment methods and EIA criteria see Volume 2, Section 2. The effects of construction on Aquatic Resources were described and qualified by a senior fish biologist based on an understanding of aquatic ecology, reservoir operations and experience. Experience with other southern Alberta reservoirs (e.g., Twin Valley, Little Bow, Pine Coulee) was reviewed to qualify consequences to fish and their habitat for the expansion of SLR.

8.5.2 Measures to Mitigate Adverse Effects

The design, construction and operational factors of the expanded reservoir including diversion incorporated into the expansion do not consider fish specifically (see Volume 2, Appendix A, FTOR 3.5.2.2). Fish have colonized the SLR passively since there is no mechanism to prevent fish from being diverted into the canal system at the headworks in the river. None of the design specifications have been developed specifically for the benefit of fish. The reservoir is being built to store water; having a fishery present is a net benefit.

Mitigation measures that follow and consistency of operation will avoid adverse effects to fish and their habitat. Fish entrained to the reservoir will benefit as a byproduct of the design. The expanded reservoir will store appreciably more water off-stream. A net gain in fish habitat is anticipated once the expanded reservoir is filled. Consequently, there is no need to offset the short-term habitat loss extant SLR will experience during the initial period of filling the expanded reservoir. In 2023, during a drought year, the reservoir lowered 8.3 m with 5 m of water left in the basin and it refilled to within 1 m of FSL within 3 weeks during late fall, the EID taking advantage of higher water in the river associated with rainfall at the time.

The greatest risk to fish and their habitat will arise when the dam is breached to begin infilling the new basin. The EID intends to employ several standard mitigation measures to ensure best construction practice will be employed during the period of breaching of the east dam and infilling of the new basin. As there is not a specific guideline for breaching a reservoir, EID will follow whatever approval conditions are placed as part of the EPEA approval. A detailed explanation of mitigation measures to protect aquatic habitat and fish is presented in Volume 1, Section 11. The following are mitigation measures to minimize adverse effects to aquatic resources during construction. These meet provincial and federal fish management policies to maintain productive capacity of the reservoir's habitat (see Appendix A, FTOR 3.5.2.3). The EID will:

- Ensure filling of the new basin occurs during freshet and/or during high discharge event(s) in the Bow River at Bassano.
- Where possible, when the existing reservoir is full, flow through the outlet canal will be used to support filling of the expansion. Once the water level in the extant reservoir is sufficiently reduced, equipment can be deployed on drained ground to excavate a notch in the East Dam. By continuing to drain the extant reservoir during this process fish should not become stranded in the shallower west basin and scour of the new reservoir surface can be minimized. The intent of filling the new basin slowly at the start is to prevent the clay surface from eroding.
- Isolate SLR from active workspace if construction requires excavation or placement of material within the wetted perimeter (i.e., within water) of the reservoir. Placement of a silt curtain will be weighed with a chain to help contain sediment mobilized within the

workspace, especially during breaching of the east dam and removal then replacement of rock armour on its face.

- If isolation is required, retain biologists to rescue any fish from within the isolated workspace and return them to the reservoir.
    - During initial filling, biologists will prevent fish from entering the new reservoir until water level is sufficiently high in the new basin to maintain water temperature, clarity and DO suitable for the protection of aquatic life.
    - Block nets will be strung upstream from the breach to prevent fishes from leaving the reservoir once it begins filling. These nets have large floats and weighted lead line that suspends them in the water column once deployed and anchored to shore.
- Ensure equipment working within the reservoir's wetted perimeter (in the water) will operate with vegetable based hydraulic fluid to prevent deleterious effects of a spill on water quality.
- Ensure equipment is not refuelled within 100 m of the reservoir. All motorized equipment must be placed in a spill tray or have ready access to a spill kit. All spills need to be reported to Alberta EPA.
- Filling of the reservoir will be timed to minimize water level change in littoral habitat in SLR to avoid its use as potential spawning and rearing habitat for Northern Pike.
    - Schedule infilling when water is abundant in the river, or post-storm event to minimize drawdown of shallow water habitat as the new basin is filled from the old and input from the canal.

8.5.3 Impact Assessment Results (Application Case)

This section describes the predicted effects of SLR expansion for the Application Case, which includes the Project plus mitigation and the baseline and compares it to the Baseline Case (baseline only). These are described in the sections that follow and summarized in tables below.

8.5.3.1 Net Increase in Fish Habitat

Clearing of the Project footprint for reservoir expansion will remove several existing shallow ponds, wetlands, dugouts, and draws which provide seasonal habitat for aquatic, semi-aquatic, and terrestrial species (for water or mineral needs). Clearing will remove habitat that some species rely on, while increasing the aquatic area for others to disperse and exploit. These habitats will be replaced by an additional 760.8 ha of lentic habitat suitable for fish, other aquatic species, and semi-aquatic wildlife in the expansion (see Appendix F1, Figure F1-9).

At Baseline, the extant SLR contains 105.1 ha of littoral habitat (<3 m deep) and 193.7 ha of pelagic habitat (>3 m deep) habitat (Table 8-12). However, when the FSL is increased by 0.3 m as part of the Project, this area will be changed as more areas become pelagic zone (220.0 ha; a 13.6% increase) at the expense of littoral zone (85.3 ha or an 18.8% decrease). However, once the expanded reservoir is filled, the total littoral (166.9 ha; 58.8% increase) and pelagic zones (906.0 ha; 367.8% increase) will increase compared to baseline (see Appendix F1, Figure F1-10).

Table 8-12: Reservoir parameters at FSL for baseline, increased FSL height, and following expansion

Parameters	Extant Reservoir (Baseline FSL)	Extant Reservoir (New FSL)	% Change	Expanded Reservoir (New FSL)	% Change
Surface Area (ha)	298.8	305.3	2.2	1,072.9	259.1
Littoral Zone[1] (0-3 m) (ha)	105.1	85.3	-18.8	166.9	58.8
Pelagic Zone (>3 m) (ha)	193.7	220.0	13.6	906.0	367.8
Maximum Depth (m)	14.3	14.3	0.0	17.5	22.4
Mean Depth (m)	5.6	5.7	1.8	9.0	60.7
Water Volume (million m^3)[2]	16.5	17.4	5.5	96.5	484.8

[1] Littoral zone includes emergent zones on islands within the reservoir as these provide shaded habitat for fish

[2] Calculated from depth contours for new FSL of 782.0 m asl at current surface elevation.

In most north temperate waterbodies, the maximum depth for rooted macrophytes (submerged and emergent aquatic vegetation) is 3 m and that equates to the littoral zone (Mitchell & Prepas, 1990). Since light can penetrate through the water column to bottom, this zone is most productive in terms of benthos and macrophyte growth and spawning and forage habitat for fish. In the SLR, the littoral zone provides spawning habitat for forage fish and Northern Pike and is nursery for other species of fish entrained by the canal system. In reservoirs, it is typically unstable and fluctuates appreciably from full supply level in early spring through drawdown by late summer because of irrigation demand.

Based on anecdotal evidence, species that exploit littoral habitat are relatively abundant in SLR. These include Northern Pike. The new reservoir will greatly increase the area of littoral habitat for at least one third of the irrigation season: spring through early summer (Table 8-12). Additionally, littoral zone stability should improve into early summer since water volume is substantially greater and drawdown will be attenuated across more than two-thirds of the additional surface area of the reservoir.

8.5.3.2 Altered Timing of Habitat Availability

The nature of reservoir operations whether for water storage results in an unstable water level within the littoral zone. Extreme fluctuations can occur when water use exceeds new supply, as demand increases over summer, resulting in reduced water levels and exposed muddy shorelines and banks. These changes can influence availability of desired spawning and rearing habitat.

In the SLR, most littoral habitat is restricted to the northernmost basin and shoreline where flooded emergent vegetation persists from late spring through mid-June (see Appendix F1, Figure F1-10) It is suitable for Northern Pike spawning (and forage fish). Juvenile Northern Pike (suspected age 1+ and 2 based on length) were sampled from this littoral zone during spring and/or summer fish population inventories. Juveniles were not abundant. Results may be a sampling artifact in that Northern Pike are challenging to catch with a float electrofisher and juveniles more so since they are less vulnerable to capture using this technique. Furthermore, pH is relatively high in the shallow littoral habitat (up to 8.9 units). Northern pike eggs are not viable at pH 9 (Inskip, 1979).

Regardless, presence of juveniles implies that adults may spawn in the reservoir, or juveniles have become entrained in the reservoir once diverted into the east canal from the Bow River.

Under current operation, and what is predicted for the future, Northern Pike spawning habitat is viable through to the period when fry are free swimming. Whether entrained by the canal or hatched within the flooded emergent vegetation along the north edge of the SLR is not known. Under current operation, as water is drawn out of the reservoir, flooded emergent vegetation becomes exposed. It dries out and becomes senescent until the following spring when it grows again as water level in the SLR increases. This phenomenon is common across all reservoirs and lakes in southern Alberta. Drawdown can begin in late May and peaks over summer into fall. This habitat and water chemistry is suitable throughout early spring when the reservoir is at FSL (littoral zone is largest in area and water chemistry diluted) and when Northern Pike spawn in early May after ice-out with eggs hatching and fry free swimming by late May (Joynt & Sullivan, 2003; Nelson & Paetz, 1992).

8.5.3.3 Changes in Species Richness and Abundance

The fluctuating nature of reservoirs water level alters habitat available for species. While some species may be affected adversely, others benefit. These species may become healthier, larger, and change the dynamics of the existing food web. That in the extant SLR is typical of that found in reservoirs and nearby lakes (e.g., Lake Newell). However, the proportionate increase in surface area of littoral to pelagic habitat will be similar once the expanded reservoir is filled: littoral zone in the expansion is 16%; the pelagic is 84%, like that in the extant basin. Consequently, species composition within the expanded SLR is anticipated to be similar as will their relative abundance. Recall that colonization of fish in the reservoir is passive – those that become entrained at Bassano Dam canal inlet end up in SLR and canal infrastructure beyond it.

Adult Lake Whitefish sampled were consistently large (average 2.3 kg/fish) in the extant reservoir. They should thrive in the deeper and more abundant habitat afforded in the expanded basin. No juveniles were caught during inventories which suggests they do not spawn there. This may have been a sampling artifact since boat electrofishing and traps were used to collect fish within shallow habitat, while gill nets were used within pelagic habitat where adults were caught.

Increased volume of deep water will benefit Lake Whitefish (and Burbot). Prussian Carp are an introduced exotic species that adapts to any habitat available. Their abundance is anticipated to increase once the expanded reservoir is filled. This species has proliferated across watersheds in Alberta. Additionally, increased area of rocky shoreline that will bound the expanded reservoir could provide additional nursery habitat for juvenile Burbot. No change in species composition or relative abundance of aquatic biota is anticipated between the expanded versus the extant SLR; more and larger specimens will just occur over time if they remain in the footprint and do not move into the canal downstream.

8.5.3.4 Increase in Recreational Use

With a greater reservoir area available post-expansion on which to recreate, public use of the reservoir is anticipated to grow along with boating, angling and harvesting opportunities. The reservoir supports a sport fishery which attracts an unknown number of anglers. It is not advertised as a “destination” per se. Anglers that fish there do so year-round despite the limitations posed by fluctuating water level over the irrigation season. This fluctuation may be less pronounced in the expanded SLR given increased volume overall. Note that by freeze-up, the extant reservoir is at or near FSL.

For example, 2023 was a dry year and the FSL dropped by 8 m in the extant reservoir by late October. By mid-November 2023, the SLR had filled to near FSL and was "topped off" by spring of 2024. One would expect less than half of this drop with attenuation for the same demand once the expanded reservoir is operational. In turn, recreational opportunities will improve as a result. Although water level in the reservoir will fluctuate from mid-to late summer, anglers will continue to fish there once it is filled.

8.5.3.5 Bioaccumulation of Methylmercury

Methylmercury is present in low concentrations across the Alberta landscape, including soil, rocks, organic matter, and water. It is known to accumulate in the tissue of predators as it is ingested across trophic levels (food web). Once released, methylmercury is absorbed by lower trophic levels and bio-accumulated through the food web. Top predators (fish) carry the highest body burden of methylmercury (see Appendix F4).

To minimize the uptake of mercury from the expanded SLR, topsoil and subsoil will be stripped and a layer of clay placed over sedimentary rock to make it watertight. By capping the reservoir bottom, the methylation of mercury typical of recently inundated reservoirs will be slowed, if not prevented from becoming mobilized. As part of a water quality monitoring program, it is recommended that the expanded SLR fishery be monitored for MeHg as has been the case to date for most reservoirs and large rivers in Alberta. The provincial MeHg monitoring program should be extended to the expanded SLR to capture and test for MeHg concentration in Northern Pike muscle tissue. At minimum this should examine MeHg over the initial 5 years after filling following Alberta EPA protocol. Based on the outcome, and should methylmercury levels prove high, warnings should be posted to anglers with respect to the appropriate amount of fish flesh that can be consumed to protect human health.

Results from baseline monitoring in 2023 of Northern Pike muscle tissue caught by angling from SLR found both fish sampled had elevated mercury concentration. These results are difficult to draw conclusions from given limited sample size. Additional sampling is required to generate a statistically significant outcome regarding MeHg concentration in their muscle tissue.

8.5.3.6 Habitat Suitability During Construction and Operation

Movement of Fish

A reality associated with reservoir construction in river ("on stream") is impairment of fish migration associated with dams. The SLR was established more than 25 years ago for off-stream water storage. Any fish that enter the EID canal system become entrained and could not migrate upstream. There is no fish passage facility to move them from the reservoir back to the Bow River. Movement of fish is unidirectional: from Bow River to the canal and into SLR whenever water is diverted from the Bow River from May to September. No mechanism to prevent entrainment of fish is present at the headworks of the canal.

Trout Unlimited has estimated entrainment of fish in southern Alberta canals based on annual fall rescue efforts in several irrigation districts since rescues began. Data is qualitative and results are interpreted carefully. Nevertheless, thousands of sport, coarse and forage fish are entrained in southern Alberta annually in irrigation district canal networks (EID, LNID, WID and UID). Since 1998, more than a million have been rescued by Trout Unlimited and returned to the river(s) that feed them in the four irrigation districts listed. The headworks of these canals do not have fish exclusion structures to avoid entrainment.

Survival of Fish at Multiple Life-Stages

Five species of native fish (and exotic Prussian Carp) were caught during seasonal inventories in the SLR. This is likely a sampling artifact, since many more reside in the Bow River. Based on length distribution, juvenile and adult Burbot, adult Lake Whitefish, all life-stages of Northern Pike, Prussian Carp, Spottail Shiner, and White Sucker are resident in the reservoir. It is unlikely that Lake Whitefish and White Sucker spawn there, nor will they once the reservoir expands. There is no suitable habitat for them to do so (windswept cobble shoals for Lake Whitefish and unembedded gravel/cobble mix in flowing water for White Sucker).

The reservoir is home to a (suspected) self-sustaining population of Northern Pike, as evidenced by the presence of adult, sub-adult, and three juvenile length classes. Spawning of Northern Pike will not be impeded, since expansion of the reservoir is south of the east dam at the opposite side of the reservoir; notching of the east dam to begin filling the expanded basin can be timed to coincide with fry “emergence”/release in early June as not to compromise Northern Pike spawning and incubation of eggs.

Trout Unlimited Canada directs the salvage of fish from the canal systems each fall. Fish rescue is coordinated through the irrigation districts and timed to coincide with dewatering of canals. Thousands of fish are rescued each year and returned to the river, or nearby waterbodies. The expanded reservoir will support fish year-round.

Changes to Riparian Areas

No change to riparian areas is anticipated since no shoreline will be lost. There is no true riparian area (i.e., shrubby or treed areas) around many prairie reservoirs. It is often all upland grassland. Rather a net gain in wetland habitat within the shallow littoral zone is expected. The perimeter of the reservoir outside the littoral habitat will be armoured entirely from the top of FSL to bottom on three sides. Instability around the perimeter of the lake is not conducive to growth of riparian vegetation, as water level will vary over the growing season. Wetland vegetation is anticipated to surround the shallow northwest portion of the expanded reservoir and consist of a similar combination of emergent macrophytes (rushes and sedges) similar in composition to that in the extant SLR. A net gain in wetland habitat associated with an expanded littoral zone) is anticipated once the new reservoir is at FSL.

Change to Benthic Invertebrate Communities

A net gain in benthic invertebrates is anticipated. Quadrupling of available benthic habitat intuitively will support more invertebrates. It will take time for sediment to settle in the basin and create larval chironomid (midge) habitat; however, the littoral zone to the northwest will be colonized steadily once inundated in spring. Pelagic plankton and benthos will colonize deeper water over time. They will do so from the extant SLR. The community will be identical to that already resident there. No change in abundance is anticipated; rather, similar species composition and distribution by depth will result over time. A net gain in total benthic biomass is anticipated with reservoir expansion.

Change in Water Quality and Quantity in the Bow River

There will be no new water diversion required; the existing allocation will not need to be increased to support the expansion. The rate of water extraction varies depending on need, as more water is extracted in higher flow events when water can be used to fill off-stream reservoirs while also beginning to irrigate fields. The total rate of withdrawal may also increase in midsummer when demand is greater, but only if sufficient flow is available to maintain the provincially mandated IO of 11.3 m^3/s downstream of Bassano Dam. In high demand years, an increasing proportion of irrigation supply will come from drawing down the reservoirs to allow maintenance of the IO. The IO is designed to ensure fish and their habitats are protected in the Bow River. Water quantity entering the SLR will be what is permitted to be diverted at the canal headworks under the EID's diversion licence for water from the Bow River. Over the years examined, the EID has never withdrawn more than 75% of the permitted annual diversion per the licence issued. As new storage becomes available EID will be able to make use of a greater volume of water while still within the allocation and while maintaining the IO.

As initial filling of the expanded reservoir will require up to 94 million m^3 in the first year of operation, this may put some additional demand on the river; however, the available allocation and high flows of the river in early season should be sufficient to refill all existing reservoirs, plus the expanded SLR in most years. Even if water supply to fill the reservoir is limited, EID will continue to work within its existing allocation. Two situations may affect the availability of water to fill the new reservoir:

- In a year following an extreme drought, with higher-than-average drawdown in many reservoirs, sufficient water may not be available to fill the existing reservoirs and the expansion, while continuing to supply irrigation to fields, and meet the IO.
- In a year with low river discharge (e.g., due to low snowpack melt or low rainfall), sufficient water may not be available to fill reservoirs and to meet irrigation demand while meeting the IO.

In these cases, the filling will be extended over multiple months or years, until sufficient water becomes available. For example, in 2023 there was insufficient river water through the growing season, but in fall rainfall increased river discharge and allowed most reservoirs to be refilled late in the year. Despite the possibility of increasing droughts, there are no plans to change water management, and IO will continue to be maintained. Thus, no effects on Bow River water quality and quantity are expected, nor will there be effects on fish, fish habitat, and aquatic resources, due to the Project (Volume 2, Appendix A, FTOR 3.5.2.9).

Change in Water Quality and Quantity in the SLR

Most water quality parameters sampled seasonally across depths in the extant SLR are all within the standard for protection of aquatic life. Exceptions were fluoride and two of four samples for total mercury. *In-situ* pH of one sample was >9.0 units. These exceedances do not affect the overall quality of water for fish given the vigour of fish sampled: all were in good condition (had normal condition indices). Acute and/or chronic effects are not likely to occur since retention time in the reservoir is short and the lake turns over frequently (discussed in Volume 2, Section 7). For much of the year, the lake is isothermal and chemistry uniform across depths. Increased stress from contaminants (fluoride from urban sources upstream), bioaccumulation of methylmercury, sedimentation, change in water level, or from temperature and habitat change are not anticipated (see Volume 2, Appendix A, FTOR 3.5.2.1). Since the fishery that will develop will do so passively (unless stocking of fish is undertaken), monitoring for methylmercury to avoid human health concerns is recommended.

Retention time of water once the reservoir expansion is built will remain relatively short (months) and given fetch, water quality is expected to remain consistent across seasons in both basins. The deeper east basin has potential to stratify by late winter (as does the extant SLR); however, stratification is not severe and late winter DO concentration is anticipated to share a similar profile as that experienced in the original basin. DO tension declined at depth (12-13 m in the deepest basin) however still retained sufficient DO to maintain aquatic life and specifically, cold water Lake Whitefish (>5 mg/L). There was ample thermal habitat volume for this species to survive year-round in the extant SLR. The same will be true for the expanded basin.

Peak demand for water extends from May through mid-August. Water quantity in the reservoirs will change based on irrigation demand. Temperature will warm as water level decreases through August into September. However, the expanded basin is sufficiently deep to retain thermal habitat volume to support fish that require cold-cool water year-round. The drought of 2023 drew down SLR to its lowest level without adverse effects to fish (angling catch and release effort for Northern Pike was 8.7 fish/angler hour in late October). High catch-per-unit-effort is a function of concentration of fish within a relatively small area; regardless, no sign of distress, nor any dead fish were observed in the balance of the reservoir after it had drawn down 8 m. The SLR refilled rapidly to near FSL between then and mid-November. Once constructed, surface area will be much greater so drawdown is anticipated to be less, but rate of recovery comparable (Table 8-12).

The long fetch of the expanded reservoir aligned with the prevailing wind will keep water turned over in the west basin (extant reservoir) and is anticipated to influence that in the east (expanded) basin. Over the course of both summer and winter, the east basin will stratify to a greater extent than the west since it is appreciably deeper. Consequently, the expanded reservoir may become dimictic (develop a thermocline: abrupt change in water temperature separating pelagic and euphotic zones). Development of a thermocline can impair a lakes ability to turn over during peak summer; this encourages oxygen to deplete at depth because of biological oxygen demand as organic material decomposes depleting oxygen in the process (respiration). However, given the relatively short residence time of water in the SLR, and frequent windy days, this may not be realized.

Acidification / Eutrophication

No evidence of either acidification or eutrophication has happened at SLR. This is because of its function and operation. Berms surrounding the expansion will prevent runoff from most of the surrounding lands; per engineering studies for this assessment, total area contributing runoff to the expansion is 1.6 km^2. This low contributing area will restrict the accumulation of nutrients that cause algal blooms. Input from agriculture will not occur since the surrounding upland is used for grazing and the terrain is largely flat. The extant reservoir is isothermal for much of the year because of wind driven mixing. This combined with a relatively short residency time of water as the reservoir fills and empties, results in water chemistry that remains static and suitable for all fauna in and vegetation around it. No change in trophic status and pH will result once the expanded basin is filled.

Groundwater – Surface Water Interactions

Since the new reservoir occurs over an aquitard (see Hydrogeology, Volume 2, Section 6), and as the surface clay is highly plastic with little groundwater infiltration potential, interaction between surface and groundwater is not anticipated. Most surface water is alkaline within the footprint given higher salinity in the surrounding soils. No potential for heated ground water to influence habitat viability in the reservoir (thermal plumes) given the footprint does not overlie thermal vents or heated groundwater. The area is geologically inert.

8.5.3.7 Distribution and Occurrence of Aquatic Invasive Species

The EID has an Aquatic Invasive Species Prevention Program established in 2018 to prevent the spread of exotic species such as Zebra or Quagga Mussels (*Dreissena polymorpha*), European Common Reed (*Phragmites australis*), Eurasian Milfoil (*Myriophyllum spicatum*), and Flowering Rush (*Butomus umbellatus*). This initiative works to prevent recreational watercraft from unknowingly spreading invasives through restricted launch areas, required check ins, and cleaning protocols. Prussian Carp are another exotic species already present in SLR. Crayfish, another exotic, are also likely resident since they are present in the Bow River having expanded from the Cold Lake district where they are native.

Prussian Carp have spread throughout Alberta, are prolific and adaptable and can thrive in a variety of habitats which contributes to their spread (GOA, 2018b). At SLR, they could be removed opportunistically during dam breach and filling of the new basin using a short fish fence and trap. However, their presence in the Bow River may make this effort futile since there is no way to exclude fish at the headworks of the east canal. When abundant, Prussian Carp can interrupt native cyprinid (minnow) spawning since they typically increase turbidity by disrupting benthic sediments for feeding. They may also carry pathogens capable of affecting native species.

Whirling disease, which affects all salmonids (except for Brown Trout [*Salmo trutta*]), is present in the Bow River. It has not been reported from SLR. The middle and lower Bow River (HUC 6s that feed the SLR) are designated high to moderate risk for whirling disease (GOA, 2020c). Watercourses within the Matzhiwin Creek watershed (i.e., HUC 6 that makes up the rest of the ARSA) are designated low risk for whirling disease.

Flowering rush is known to propagate in canals. When present, it can change or inhibit the flow of water, displacing native vegetation. It also supports great pond snail (carrier of swimmer's itch). It spreads by sucker - via rhizome and bulbil (rhizome bud). No seed has been found in Alberta. Measures to manage aquatic invasive species during Project works are explained in Volume 1, Section 11.

8.5.3.8 Angling Pressure

An increased number of anglers is anticipated with the bigger reservoir footprint. Angling pressure is anticipated to remain comparable to what is presently the case. Effort could increase in terms of the number of anglers, especially if they are targeting Lake Whitefish in a winter ice fishery since their habitat area will increase significantly. No formal record of angling effort is available for the extant SLR. In the Land Use and Management assessment (see Volume 2, Section 13), grey-literature information on angling was presented, listed as a catch-per-unit-effort of 1.8 pike/hour, and a slightly lower rate for "keepers" at 1.1 pike/hour. Given the reservoir water surface will increase from 299 ha to 1,069 ha (3.6 times larger), it is not unreasonable to predict about a tripling in angler numbers and total catch assuming the number of fish increase with the increase in area; effort (catch-per-unit-effort) should be comparable when adjusted for the expanded reservoir area. This may be an opportunity to exploit in terms of a fishery should the proponent or regulators choose to stock SLR once it is operational.

8.6 RESIDUAL IMPACT

There is no long term, negative residual impact from reservoir expansion on aquatic resources. Overall, they will experience a net gain (Table 8-13) once the three Project phases of construction, filling and operation are complete. These impacts are expected to occur during all three phases, including temporary, low negative impacts during construction and filling stages and positive impacts during reservoir operations. All anticipated residual effects are restricted to the Project footprint.

Table 8-13: Project residual impacts on aquatic resources during the Project phases

#	Impact Description	Direction	Key Criteria			Modifiers		Residual Impact Rating
			Magnitude	Geographical Extent	Duration	Confidence	Ecological and Social Context	
1	Loss of littoral zone habitat during filling of Reservoir	Negative	Medium	Footprint	Temporary	High	N/A	Low Negative
2	Loss of fish trapped in isolation when dam breached	Negative	Low	Footprint	Temporary	High	N/A	Low Negative
3	Sedimentation of water downstream during dam breach and armouring of reservoir edges	Neutral						Neutral
4	Net increase in fish habitat	Positive	High	Footprint	Long-term	High	N/A	High Positive
5	Altered Timing of Habitat Availability	Negative	Medium	Footprint	Temporary	High	N/A	Low Negative
6	Changes in Species Richness and Abundance	Neutral						Neutral
7	Change in the Survival of Fish & Benthos	Neutral						Neutral
8	Change in Recreational Use	Positive	Medium	Footprint	Long-term	High	N/A	Medium Positive
9	Bioaccumulation of Methyl Mercury in top predators	Negative	Low	Footprint	Medium-term	High	N/A	Low Negative
10	Change in Water Quality Late in Season	Neutral						Neutral
11	Ground and Surface Water Interaction	Neutral						Neutral

8.7 CUMULATIVE EFFECTS ASSESSMENT

This section describes how the Project may interact with other past, present or future projects and activities, and their combined impact on Aquatic Resources. For a full description of the Cumulative Effects Assessment Approach see Volume 2, Section 2. Only resources in which the Project was expected to result in high negative or medium negative residual impacts were addressed in the cumulative effects assessment (Table 8-13).

Since the Project is not expected to result in high negative or medium negative residual impacts on aquatic resources, a cumulative effects assessment was not completed.

8.8 MONITORING

Between the EID's existing water quality sampling program (Alberta Irrigation Districts Association, 2024), and recommended monitoring after one full year after filling (Volume 2, Section 7: Waterbodies), including:

- in-situ water measurements, (temperature, DO, conductivity, and pH);
- sampling for lab testing of reservoir water quality versus PAL guidelines; and
- testing of inorganic and methylmercury in water and sediment.

Ample information will be collected to address quality of aquatic habitat for fish. Thus, no further water or sediment measures are recommended.

Fish within the expanded reservoir are expected to undergo an increase in methylmercury within 2 - 5 years following dam inundation, which will then decline. Furthermore, the reservoir will be larger in size, which could result in increased levels of recreational fishing and fish consumption. Thus, sampling of methylmercury in fish is recommended. The Alberta Government has an existing government fish sampling program under Alberta Health in collaboration with Alberta EPA (Alberta Irrigation Districts Association, 2024; GOA, 2024b); it is recommended that Snake Lake Reservoir be added to this program. Then SLR results could test for changes in fish tissue methylmercury over the first five years and could be used by Alberta Health to set fish consumption limits. If this is not added to the above program full time, at minimum it is recommended to have fish sampled two years between 1 and 5 years after filling to assess trend. This would require capturing a minimum of three fish to provide 3 samples, plus a duplicate for lab measurement of methylmercury in muscle tissue. After year 5, if methylmercury concentration in tissue has not decreased, additional sampling needs would be discussed with Alberta Health and Alberta EPA.

8.9 CONCLUSIONS

The SLR provides habitat for a variety of fish species. Northern Pike reproduce in the reservoir despite higher pH levels plus they reside there year-round as do Lake Whitefish. Based on the size of Lake Whitefish caught, an abundant benthic invertebrate food source exists. Forage fish were not abundant in the reservoir.

Water level within the reservoir fluctuates 2 m in typical years. Water is released before winter to reduce damage from ice and stored for irrigation use throughout spring, summer and fall. In the 2023 drought, it fluctuated 8 m. Construction of the expansion is not anticipated to alter fish habitat within the existing reservoir, as little to no disturbance will occur within this area. The only expected construction within the existing reservoir will be excavation of a notch in the East Dam to connect the two.

Best management practices should be put in place to protect fish and their habitat during construction. These include but are not limited to:

- temporary and permanent erosion control structures (i.e., silt fencing, riprap placement, etc.);
- completing any activities within the existing SLR when the reservoir water level is drawn down; and
- raising water levels slowly in the newly formed reservoir to minimize mobilization of sediment within and downstream from the new basin.

The new reservoir will be 6 m deeper than the extant SLR and almost 4 times as large in area. It will store more than double the volume of water for release into the Snake Lake Canal than the extant reservoir. Retention time is anticipated to remain short, and the habitat conditions experienced in SLR are anticipated to be similar after expansion. The reservoir is not being built as fish habitat per se. However, it will support species found in the SLR and provide habitat for them year-round if reservoir water levels remain sufficiently high.

Expansion of SLR will provide a net gain in productive habitat for all aquatic resources. There will be no habitat lost, nor disrupted if best construction practices are followed. There is no change to the rate, timing or volume of water being diverted from the Bow River to fill or maintain water level in the expanded reservoir. This Project will not affect aquatic resources in the Bow River downstream.

Operation of the expanded reservoir will be identical to that of the extant SLR. With the expanded surface area of water, the new reservoir will attract anglers. It is recommended that the Alberta Government monitor mercury body burden in fish for up to 3 years and draw on information from Volume 2, Section 7, water quality monitoring to ensure it meets standards for the protection of aquatic life.

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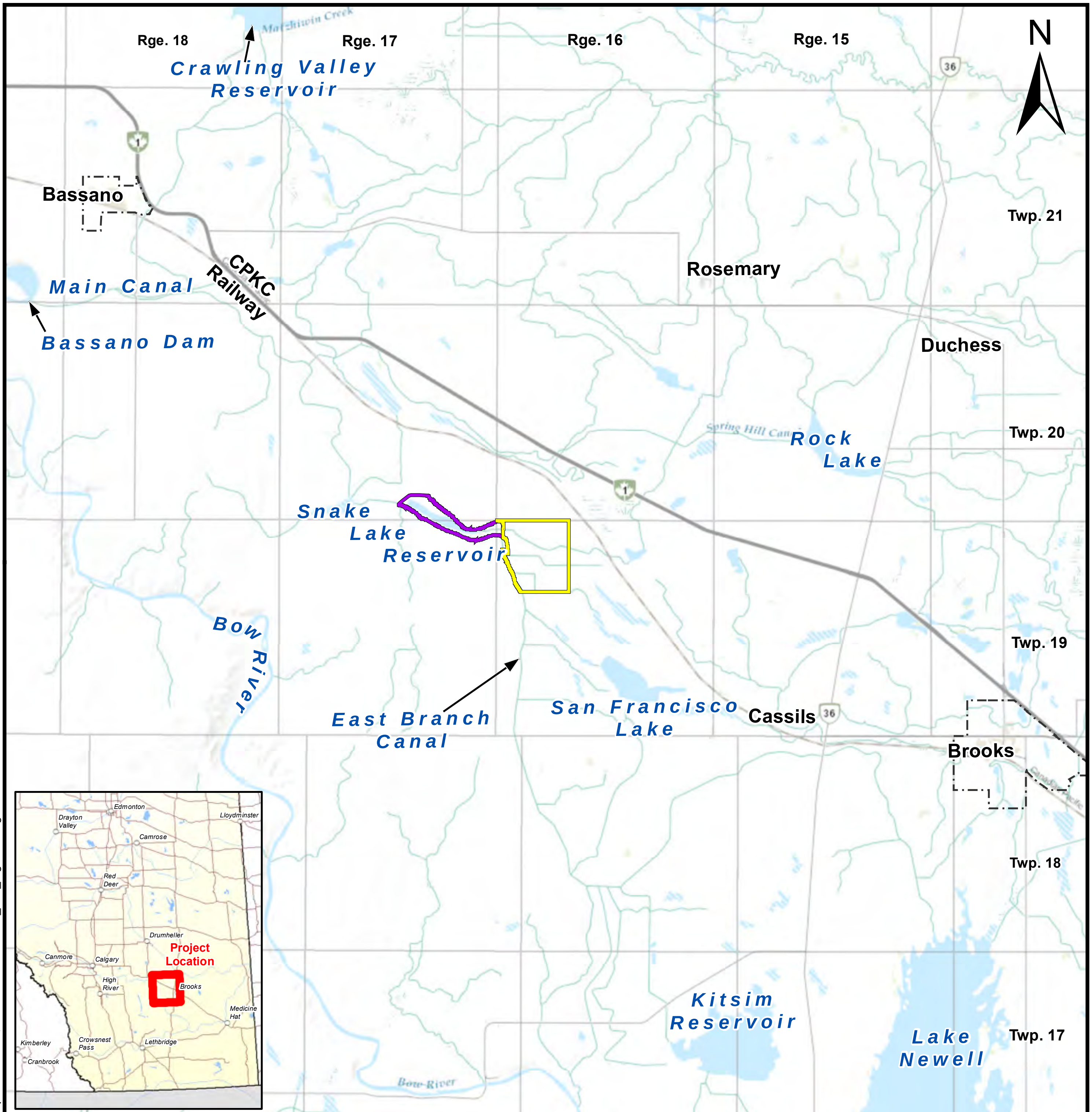

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Approved:	TB	Revision:	0
Route Source:		Date:	Feb 18, 2022
CAD Survey		Revision:	0

Data Sources:
ESRI World Topographic Map
ATS Grid: AltaLIS 2007.

AAR Environmental Services

Please contact AARES for all other sources.

Please note that the topographic map is from 2010 (NRCAN) and although we have no reason to doubt the accuracy and completeness of it, users should be aware discrepancies may be present.

Legend

- Snake Lake Reservoir Expansion Project Area
- Existing Reservoir
- Corporate Limits

EID

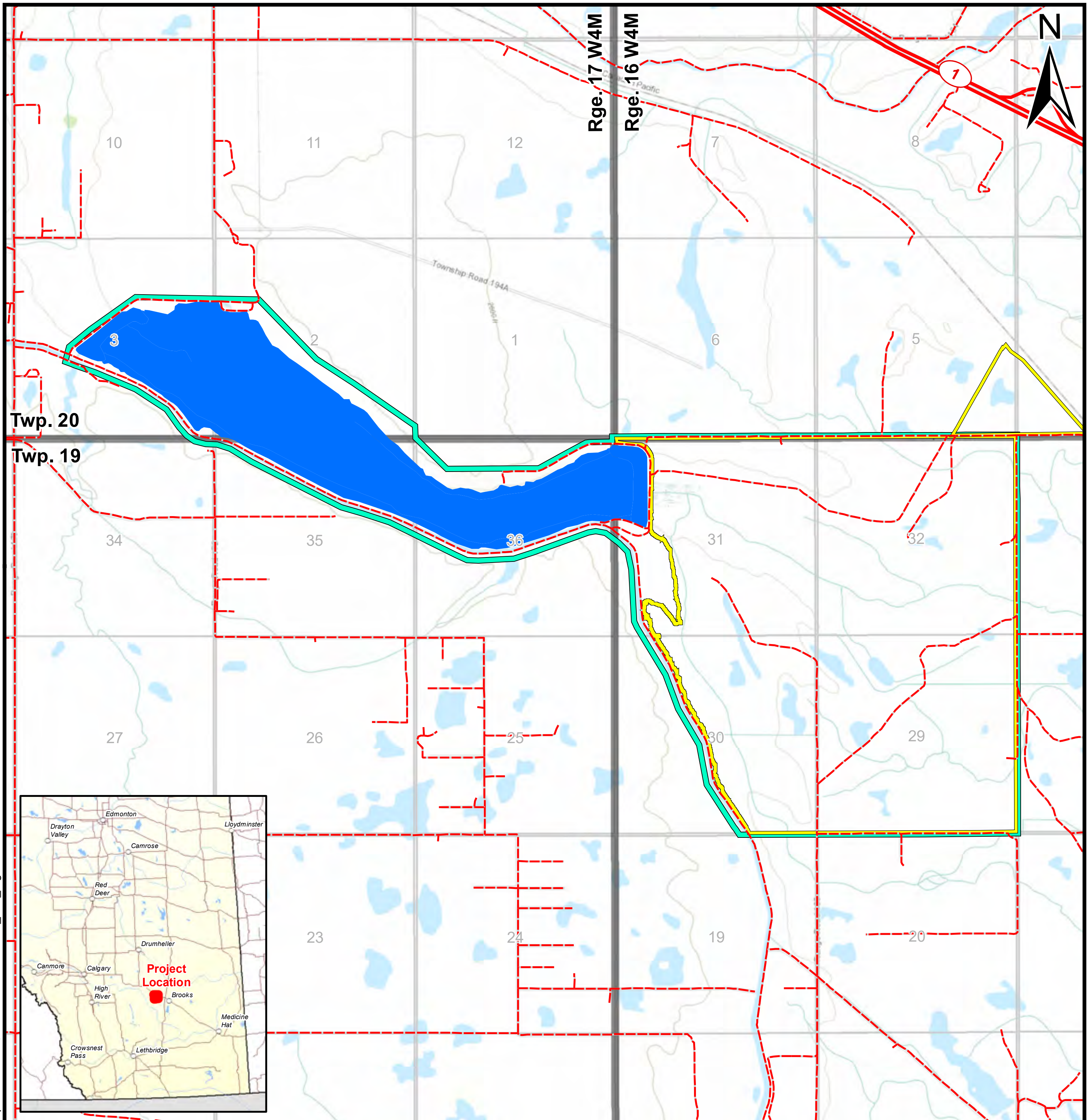
Regional Overview of the Proposed Snake Lake Reservoir Expansion

January 2025

REF.: AARES21-127 (Aquatics)

Figure F1-1

Map Location: Y:\01_GISProjects\AARES_21\AARES21_127 (5653)\Aquatics\Jan 10, 2025 edits\AARES21_127_FigF1-1 Regional Location.mxd



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Approved:	TB	Revision:	0
Route Source:		Date:	Feb 18, 2022
CAD Survey		Revision:	0

Data Sources:
ESRI World Topographic Map
ATS Grid: AltaLIS 2007.

AAR Environmental Services

Please contact AARES for all other sources.

Please note that the topographic map is from 2010 (NRCAN) and although we have no reason to doubt the accuracy and completeness of it, users should be aware discrepancies may be present.

Legend

- Aquatic Local Study Area
- Snake Lake Reservoir Expansion Project Area
- Highway
- Unpaved Road
- Extant Snake Lake Reservoir at Full Supply Level

EID

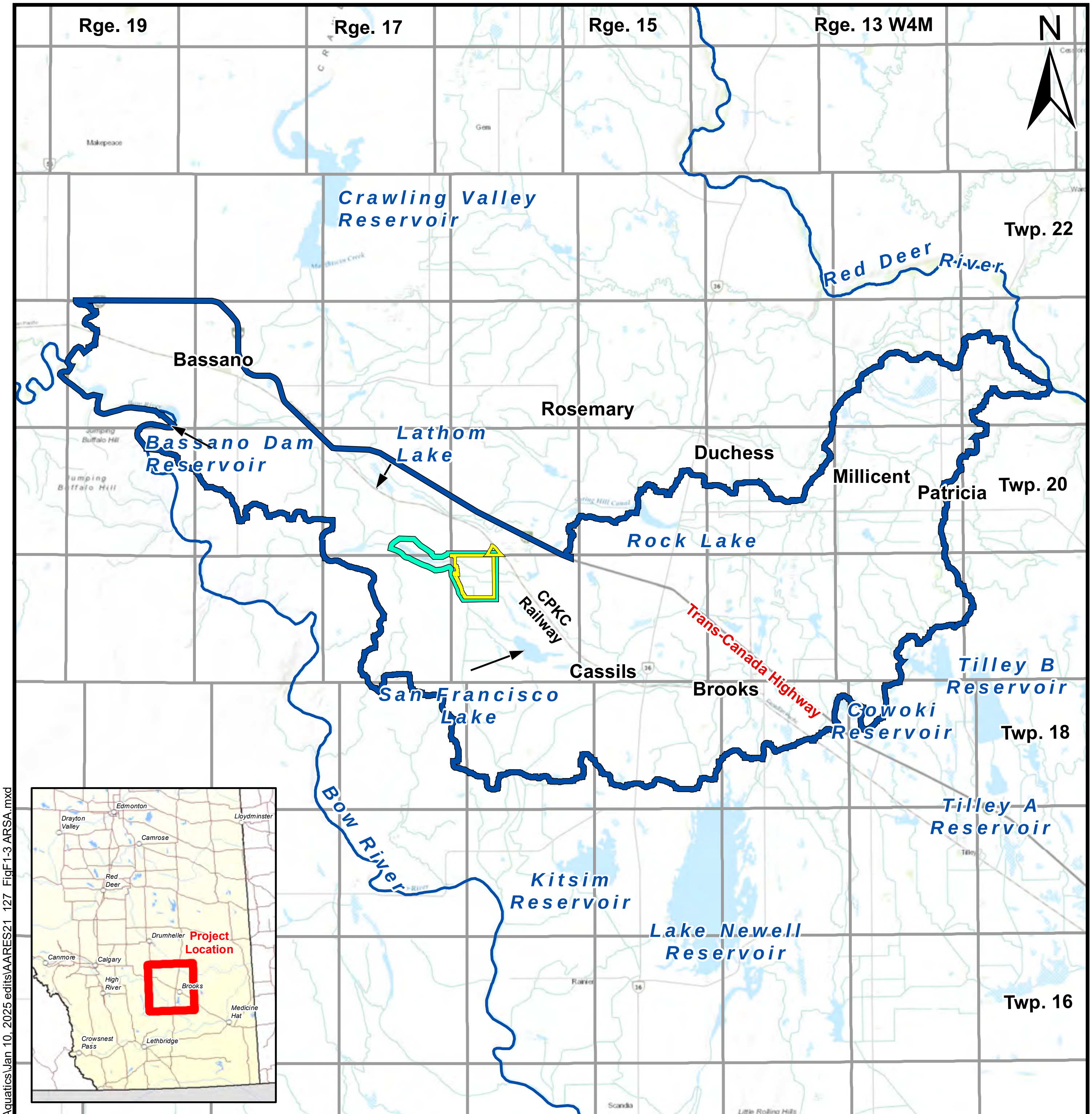
Aquatic Local Study Area

March 2025

REF.: AARES21-127 (Aquatics)

Figure F1-2

Map Location: Y:\01_GISProject\AARES_21\AARES21_127 (5653)\Aquatics\Jan 10, 2025 edits\AARES21_127_FigF1-2 ALSA.mxd



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Km
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Approved:	WB	Revision:	0
Route Source:		Date:	Feb 18, 2022
CAD Survey		Revision:	0

Data Sources:
ESRI World Topographic Map
ATS Grid: AltaLIS 2007.

AAR
Environmental Services

Please contact AARES for all other sources.

Please note that the topographic map is from 2010 (NRCAN) and although we have no reason to doubt the accuracy and completeness of it, users should be aware discrepancies may be present.

Legend

- Aquatic Regional Study Area (ARSA)
- Aquatic Local Study Area (ALSA)
- Snake Lake Reservoir Expansion Project Area

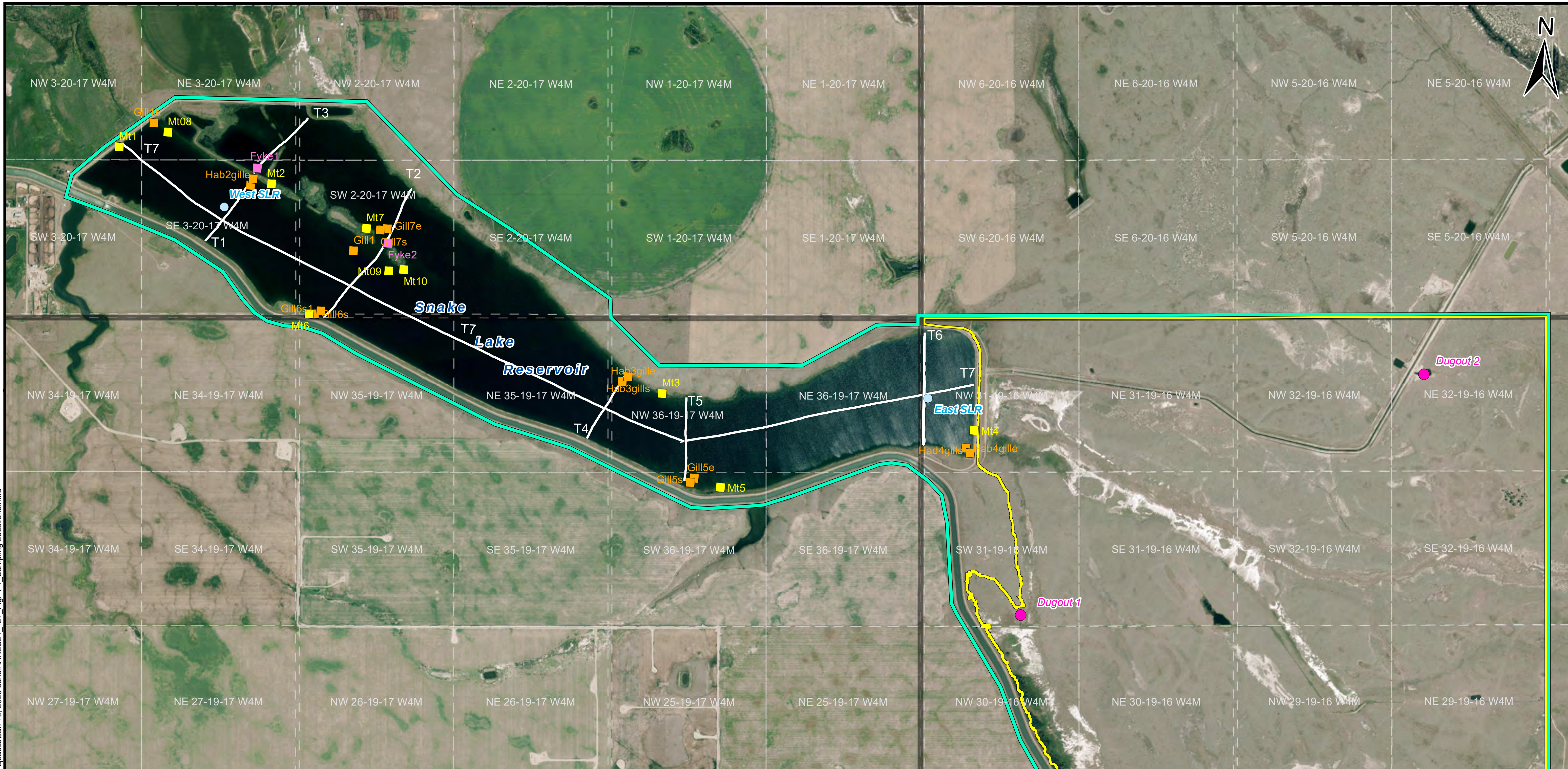
EID

Aquatic Regional Study Area

March 2025

REF.: AARES21-127 (Aquatics)

Figure F1-3



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Approved:	WB	Revision:	0
Route Source:		Date:	Feb 18, 2022
CAD Survey		Revision:	0

Data Sources:
Imagery Reference: ESRI 2019/08/05
ATS Grid: AltaLIS 2007.

*Approximate location based on field survey.

AAR Environmental Services

Please contact AARES for all other sources.

Please note that the imagery is from 2019 and although we have no reason to doubt the accuracy and completeness of it, users should be aware that discrepancies may be present.

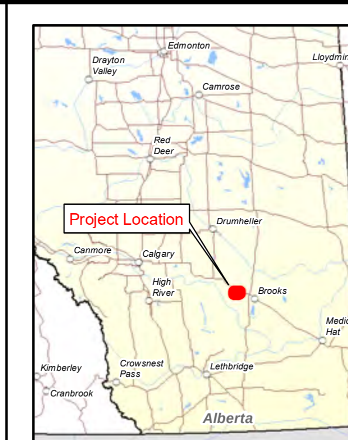
Legend

Routing:

- Aquatic Local Study Area (ALSA)
- Snake Lake Reservoir Expansion Project Area

Fisheries Survey Data*:

- Depth Transect
- Dugout Water Quality Sample Sites
- Water Quality Sample Sites
- Fyke Net Locations
- Gill Net Set Locations
- Minnow Trap Locations



EID

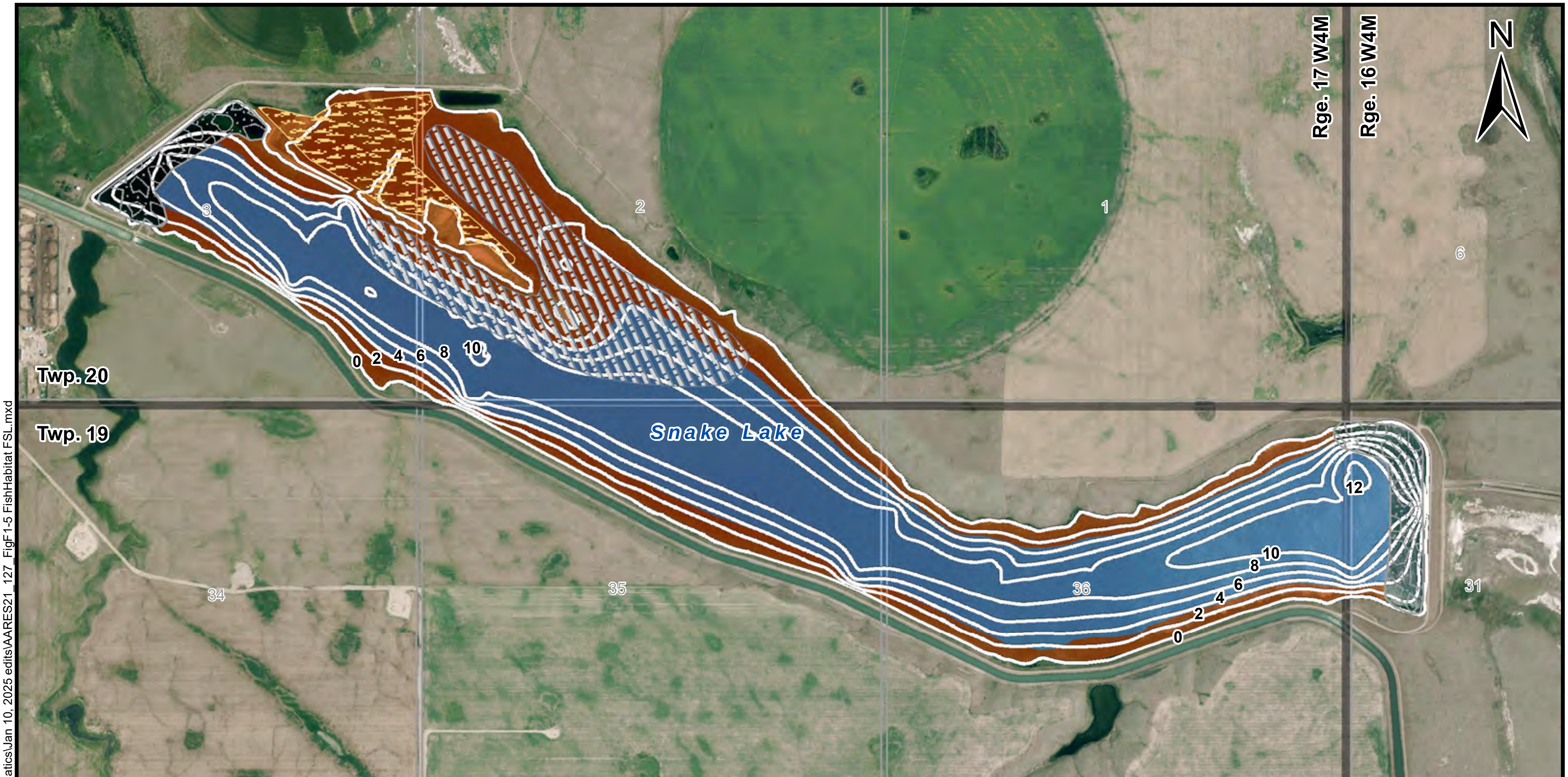
Sampling Locations For Water Chemistry, Bathymetry and Fishes

January 2025

REF.: AARES21-127 (Aquatics)

Figure F1-4

Map Location: Y:\01_GISProject\AARES_21\AARES21_127 (5653)\Aquatics\Jan 10, 2025 edits\AARES21_127_FigF1-4_Sampling Locations.mxd



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Approved:	EM	Revision: 0
Route Source:		Date: Feb 14, 2022
KML		Revision: 0

Data Sources:
Imagery: ESRI. Date 1/15/2018
ATS Grid: AltaLIS 2007.

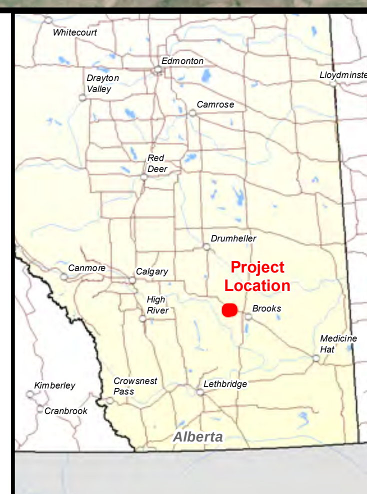
AAR
Environmental Services

Please contact AARES
for all other sources.

Please note that the imagery is from 2018 and although we have no reason to doubt the accuracy and completeness of it, users should be aware that discrepancies may be present.

Legend

- Boulder Habitat
- Deep Water Habitat (Pelagic Zone)
- Littoral Zone
- Rearing Habitat
- Temporary Rearing Habitat
- Bathymetry (2m Interval)



EID

Bathymetry and Fish Habitat of Snake Lake Reservoir at Full Supply Level (781.7 m)

March 2025

REF.: AARES 21-127 (Aquatics)

Figure F1-5

Map Location: Y:\01 GISProject\AARES 21\AARES21 127 (5653)\Aquatics\Jan 10, 2025 edits\AARES21 127 FigF1-5 FishHabitat FSL.mxd

SCALE: 1:20,000

250 0 250 500 m

Drafted:	DJS	Date: Mar 17, 2025
Approved:	EM	Revision: 0
Route Source:		Date: Feb 14, 2022
KML		Revision: 0

Data Sources:
Imagery: ESRI. Date 1/15/2018
ATS Grid: AltaLIS 2007.

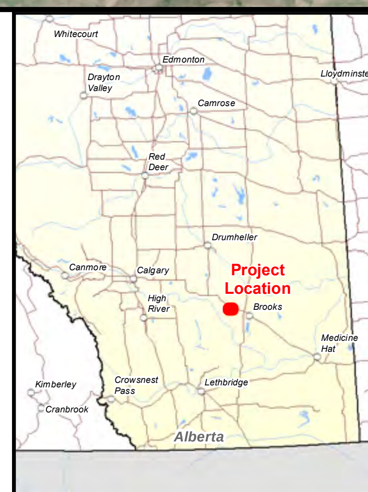
AAR Environmental Services

Please contact AARES for all other sources.

Please note that the imagery is from 2018 and although we have no reason to doubt the accuracy and completeness of it, users should be aware that discrepancies may be present.

Legend

- Boulder Habitat
- Approximate Deep Water Habitat (Pelagic Zone)
- Approximate Littoral Zone
- Bathymetry (2m Interval)



EID

Bathymetry and Fish Habitat of Snake Lake Reservoir at September 2023 Drawdown (773.7 m)

March 2025

REF.: AARES 21-127 (Aquatics)

Figure F1-6

Map Location: Y:\01 GISProject\AARES 21\AARES21 127 (5653)\Aquatics\Jan 10, 2025 edits\AARES21 127 FigF1-6 FishHabitat Sept2023 Drawdown.mxd

Figure F1-7: Water Quality Parameters Sampled at Snake Lake Reservoir 2021-2022

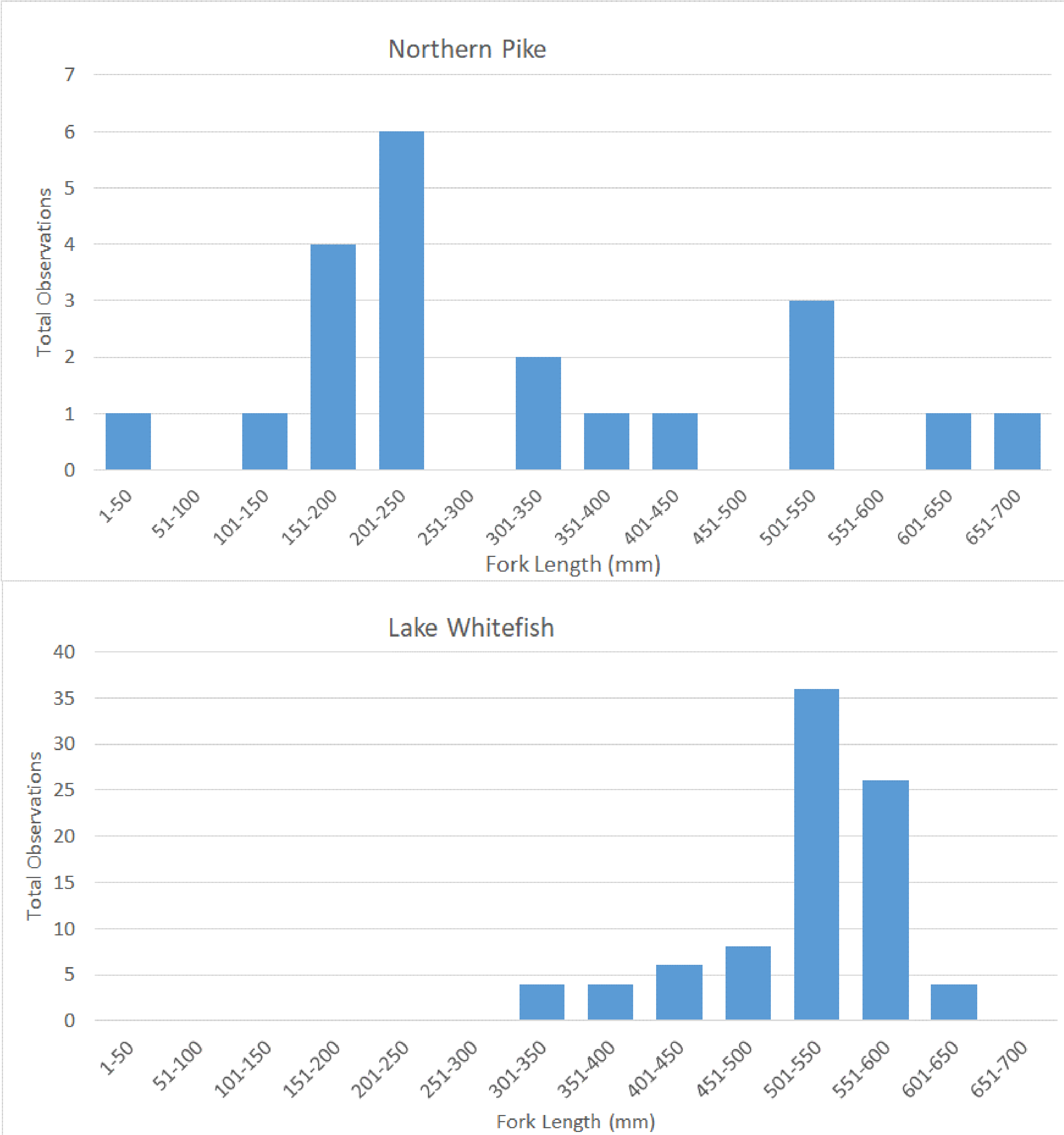
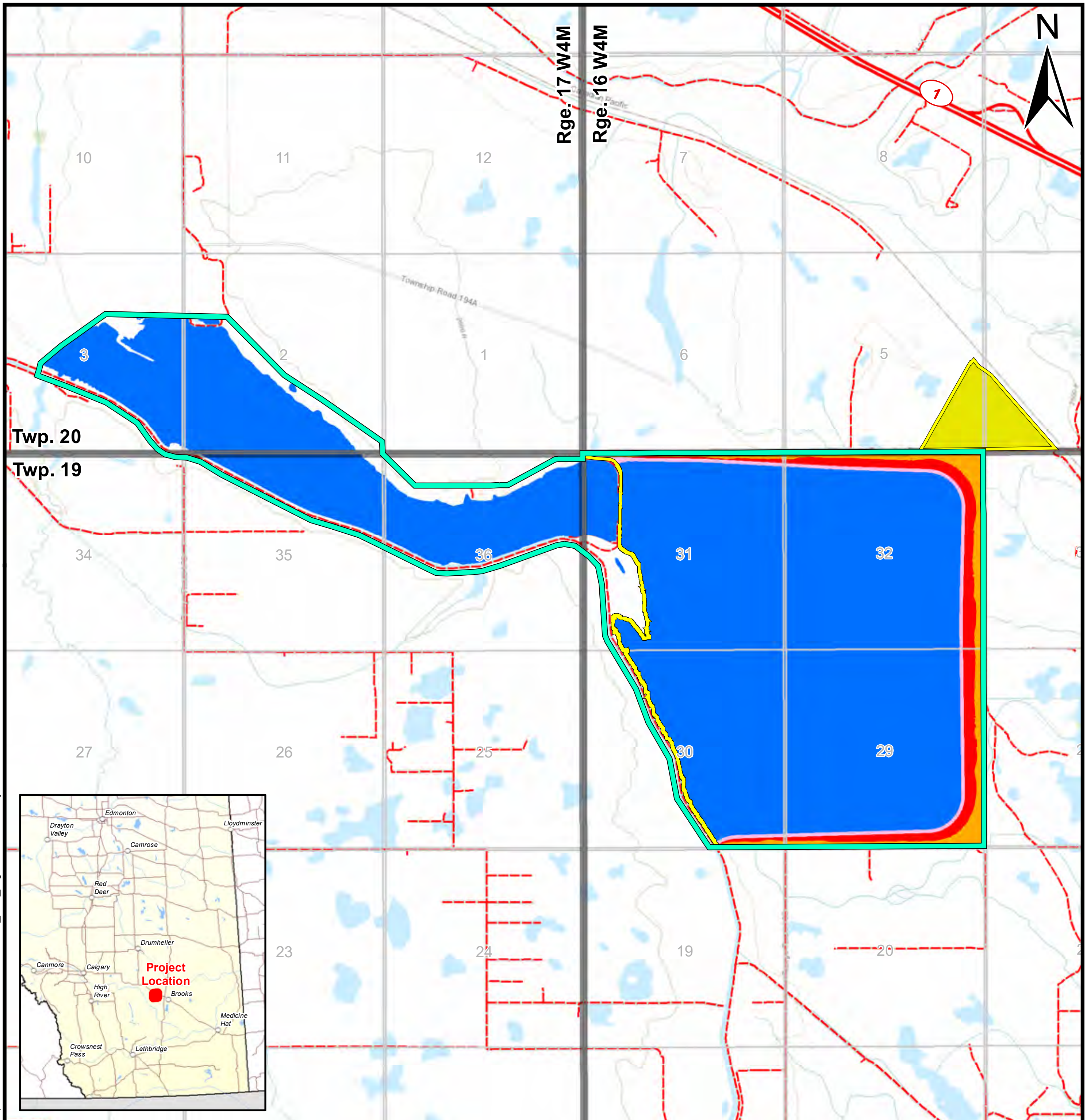


Figure F1-8: Length-frequency (Age) Distribution of Northern Pike and Lake Whitefish Captured in Snake Lake Reservoir (2021)



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SCALE: 1:45,000

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Approved:	TB	Revision:	0
Route Source:		Date:	Feb 18, 2022
CAD Survey		Revision:	0

Data Sources:
ESRI World Topographic Map
ATS Grid: AltaLIS 2007.

AAR
Environmental Services

Please contact AARES for all other sources.

Please note that the topographic map is from 2010 (NRCAN) and although we have no reason to doubt the accuracy and completeness of it, users should be aware discrepancies may be present.

Legend

- Aquatic Local Study Area
- Snake Lake Reservoir Expansion Project Area
- Reservoir at Full Supply
- Berm Road
- Reclaimed Berm
- Reclaimed Berm to Section
- Reclaimed Soil Storage Area
- Unpaved Road

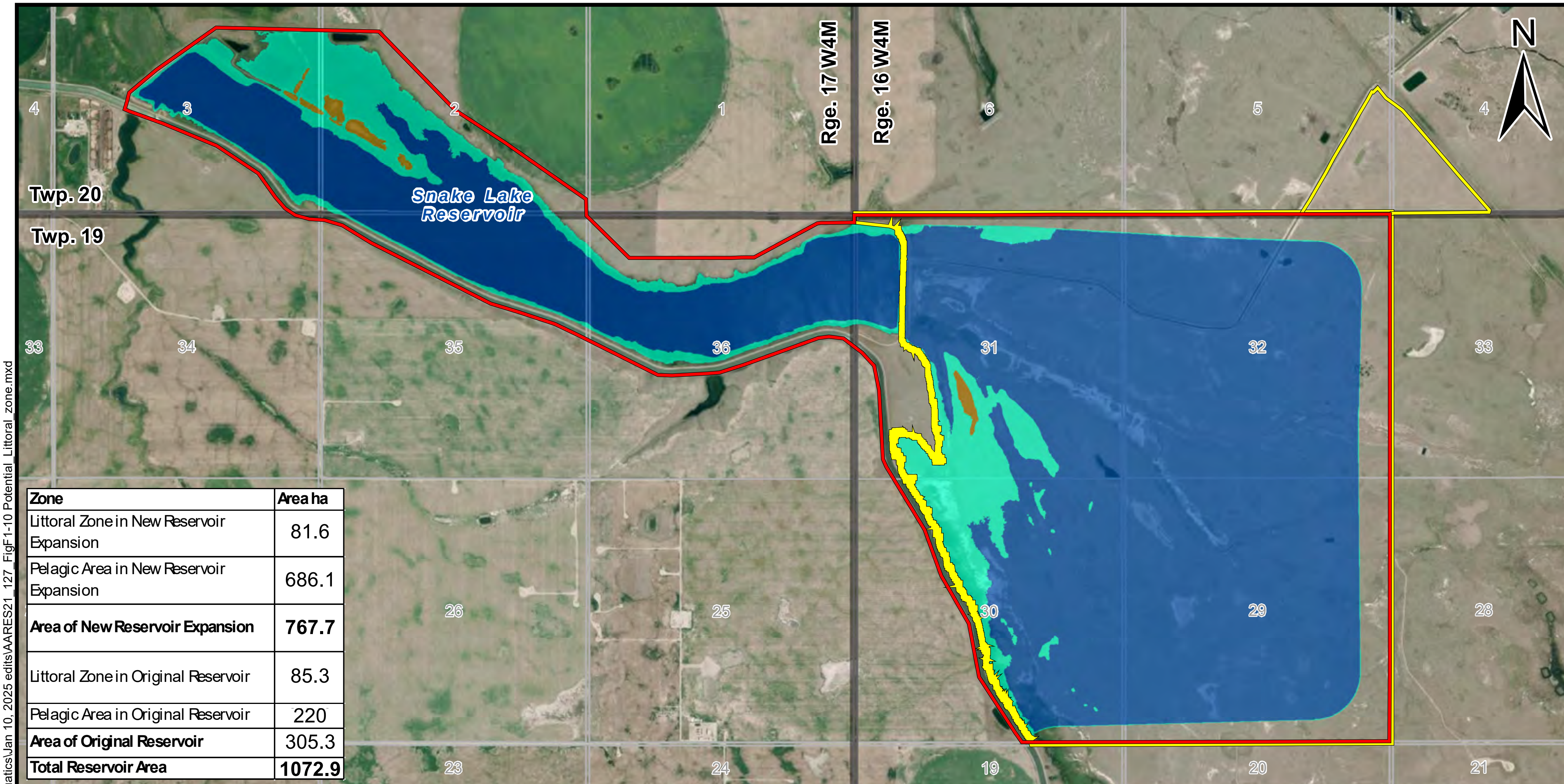
EID

Planned Project Components for the Snake Lake Reservoir Expansion

March 2025

REF.: AARES21-127 (Aquatics)

Figure F1-9



Zone	Area ha
Littoral Zone in New Reservoir Expansion	81.6
Pelagic Area in New Reservoir Expansion	686.1
Area of New Reservoir Expansion	**767.7**
Littoral Zone in Original Reservoir	85.3
Pelagic Area in Original Reservoir	220
Area of Original Reservoir	305.3
Total Reservoir Area	**1072.9**

SCALE: 1:35,000

300 0 300 600 m

Drafted:	JNB	Date: Mar 17, 2025
Approved:	WB	Revision: 0
Route Source:	SHP	Date: Feb 09, 2024
		Revision: 0

Legend

- Aquatic Local Study Area (ALSA)
- Snake Lake Reservoir Expansion Project Area
- Pelagic Habitat (Depth >3 m)
- Littoral Habitat (Depth 0-3 m)
- Area Above Water at FSL

Data Sources:
Imagery: ESRI. Date 7/10/2021.
ATS Grid: AltaLIS 2007.

AAR Environmental Services

Please contact AARES for all other sources.

Please note that the imagery is from 2021 and although we have no reason to doubt the accuracy and completeness of it, users should be aware that discrepancies may be present.

EID

Predicted Littoral Habitat for the Snake Lake Reservoir Expansion

March 2025

REF.: AARES 21-127 (Aquatics)

Figure F1-10

Map Location: Y:\01 GISProject\AARES 21\AARES21 127 (5653)\Aquatics\Jan 10, 2025 edits\AARES21 127 FigF1-10 Potential Littoral zone.mxd

Appendix F2: Photo Plates

Plate F2-1: Habitat Site 1 - SLR Deep open water near west dam - facing north.
(June 5, 2021; 12U 4097279 5613713; 10-3-20-17 W4M)

Plate F2-2: SLR Habitat Site 1 - Open water over riprap near west dam - facing northwest.
(June 5, 2021; 12U 409672 5613698; 10-3-20-17 W4M)

Plate F2-3: Habitat Site 2 – Northwest end of SLR from the main basin - remnant upland habitat with deeper water in background - facing north-northeast.
(June 5, 2021; 12U 410233 5613408; 8-3-20-17 W4M)

Plate F2-4: Habitat Site 2 – Northwest end of SLR from the northeast edge of the main deep central pool – shallow water adjacent to remnant upland habitat – facing west-northwest.
(June 5, 2021; 12U 410349 5613357; 8-3-20-17 W4M)

Plate F2-5: Habitat Site 3 – North side of SLR immediately north of the northwest bend – shallow edge habitat – facing northeast.
(June 5, 2021; 12U 412113 5612389; 13-36-19-17 W4M)

Plate F2-6: Habitat Site 3 – East end of SLR in deep water – facing the east dam.
(June 5, 2021; 12U 413855 5612012; 12-31-19-16 W4M)

Plate F2-7: Habitat Site 4 – East end of SLR in steeply sloping habitat with riprap armouring – faces the east dam.
(June 6, 2021; 12U 413977 5612059; 12-31-19-16 W4M)
Note: steep walls bounding the deep reservoir deep basin; reservoir drops off to 10 m.

Plate F2-8: Habitat Site 4 – East end of SLR facing the southeast corner of the SLR at the south end of the east dam.
(June 6, 2021; 12U 413977 5612019; 12-31-19-16 W4M)

Plate F2-9: Habitat Site 5 – South side of the SLR immediately east of the northwest bend – edge of the deep water facing the shallow shore with a narrow littoral zone.
(June 6, 2021; 12U 412692 5611798; 6-36-19-17 W4M)

Plate F2-10: Habitat Site 5 – The south side of the SLR immediately west of the northwest bend – shallow water near the south shore.
(June 6, 2021; 12U 412587 5611796; 6-36-19-17 W4M)

Plate F2-11: Habitat Site 6 – Southwest shore of the SLR where rock armour has been used to protect the steep approach to the SLR - absence of emergent vegetation.
(June 6, 2021; 12U 410720 5612672; 13-35-19-17 W4M)

Plate F2-12: Habitat Site 6 – Southwest shore of the SLR where a naturally eroded slope from the surrounding land forms a narrow littoral zone with emergent vegetation.
(June 6, 2021; 12U 410556 5612740; 4-2-20-17 W4M)

Plate F2-13: Habitat Site 7 – Shallow northwest bay with flooded emergent vegetation – ideal Northern Pike spawning habitat – facing southeast.
(June 6, 2021; 12U 410729 5613283; 5-2-20-17 W4M)

Plate F2-14: Habitat Site 7 – Shallow area between two deep bays in the northwest end of the SRL with flooded emergent vegetation.
(June 6, 2021; 12U 410229 5613389; 8-3-20-17 W4M)

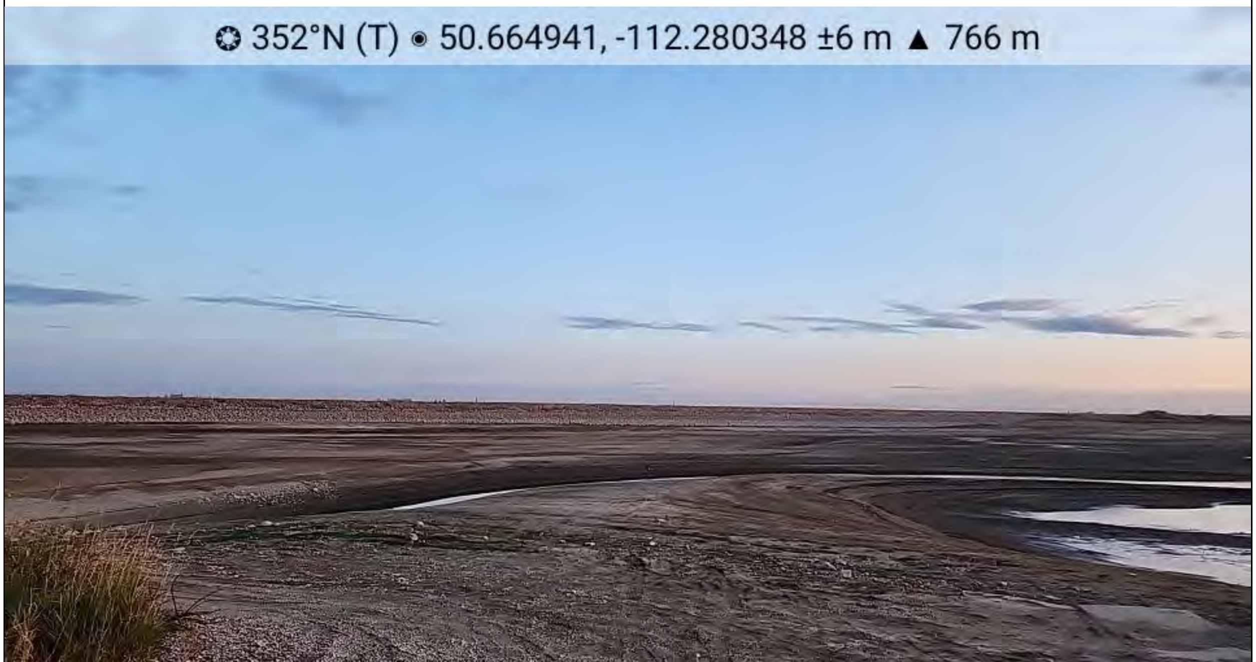


Plate F2-15: Drawdown conditions in fall 2023.
(west side of SLR; September 29, 2023; 12U 409514 5613346; 6-3-20-17 W4M)

Plate F2-16: Drawdown conditions in fall 2023.
(centre of SLR; September 29, 2023; 12U 412421 5611781; 5-36-19-17 W4M)

Plate F2-17: Drawdown conditions in fall 2023 SLR near east dam.
(September 29, 2023; 12U 413986 5612531; 13-31-19-16 W4M)

Appendix F3: Summarized Alberta Biodiversity Monitoring Institute Aquatic Data in the ARSA

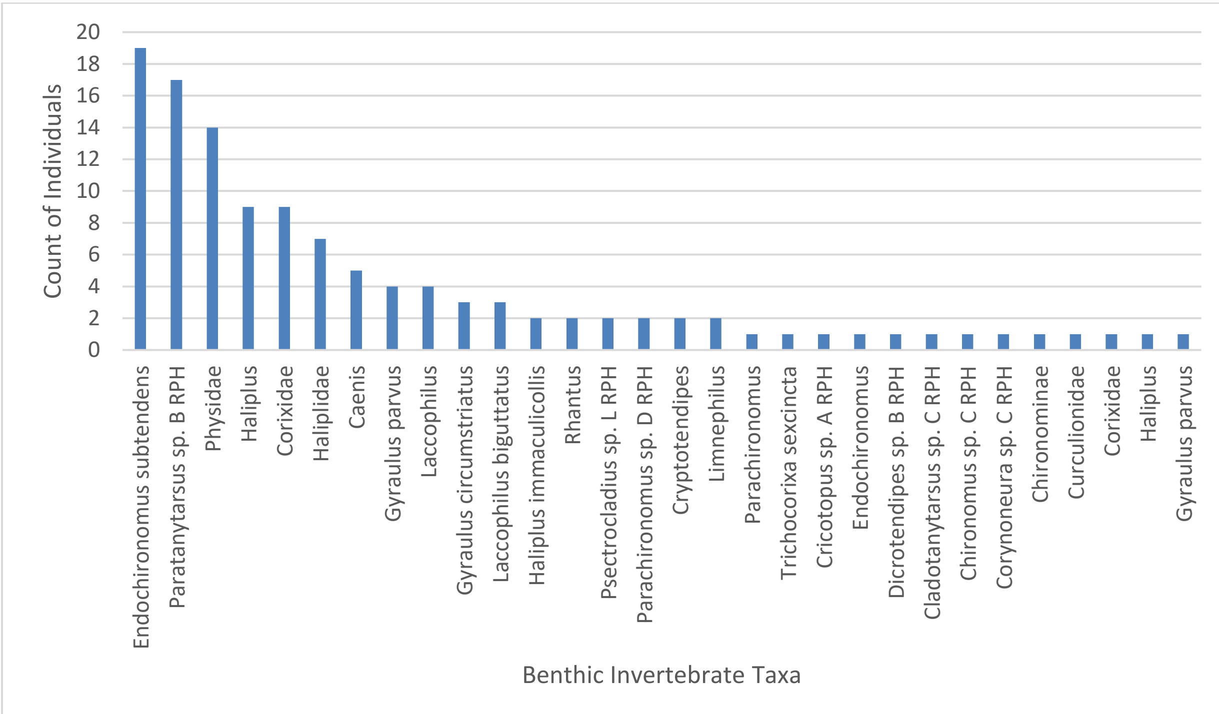


Figure F3-1: Benthic Invertebrates identified at ABMI Site 1498* in 2013.

*Source: Alberta Biodiversity Monitoring Institute (ABMI). (2024). *Species and Habitat Raw Data*. Retrieved in March 2025, from https://abmi.ca/abmi-home/data-resources/data-portal-main/rawdata.html.

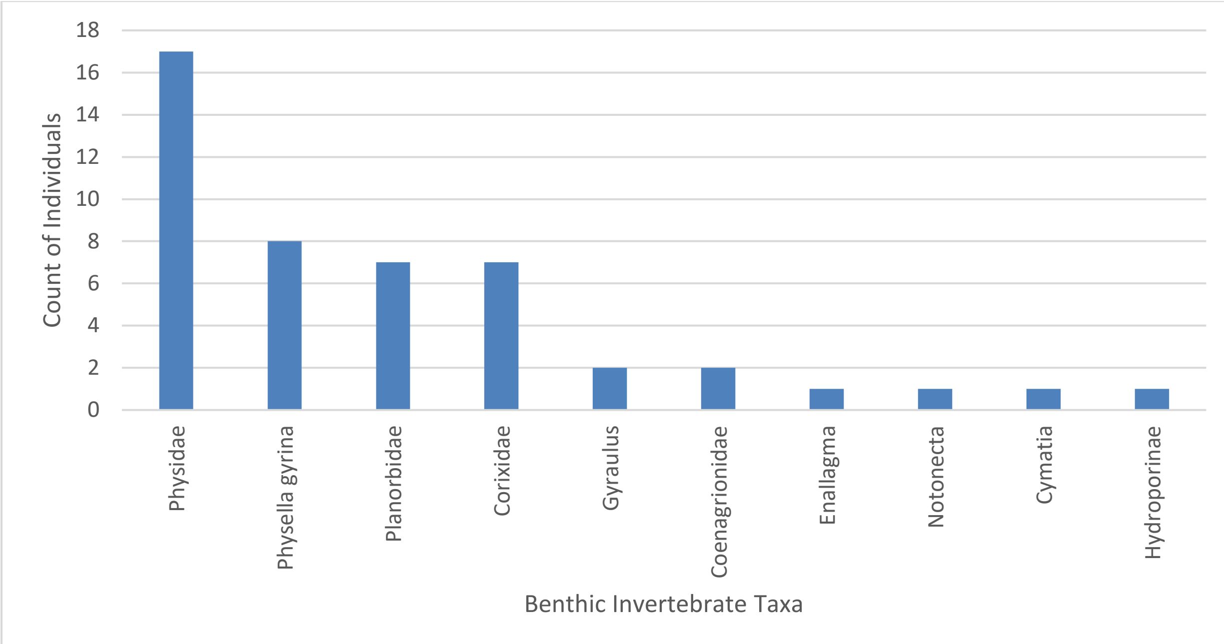


Figure F3-2: Benthic Invertebrates identified at ABMI Site 1498* in 2018.

*Source: Alberta Biodiversity Monitoring Institute (ABMI). (2024). *Species and Habitat Raw Data*. Retrieved in March 2025, from https://abmi.ca/abmi-home/data-resources/data-portal-main/rawdata.html.

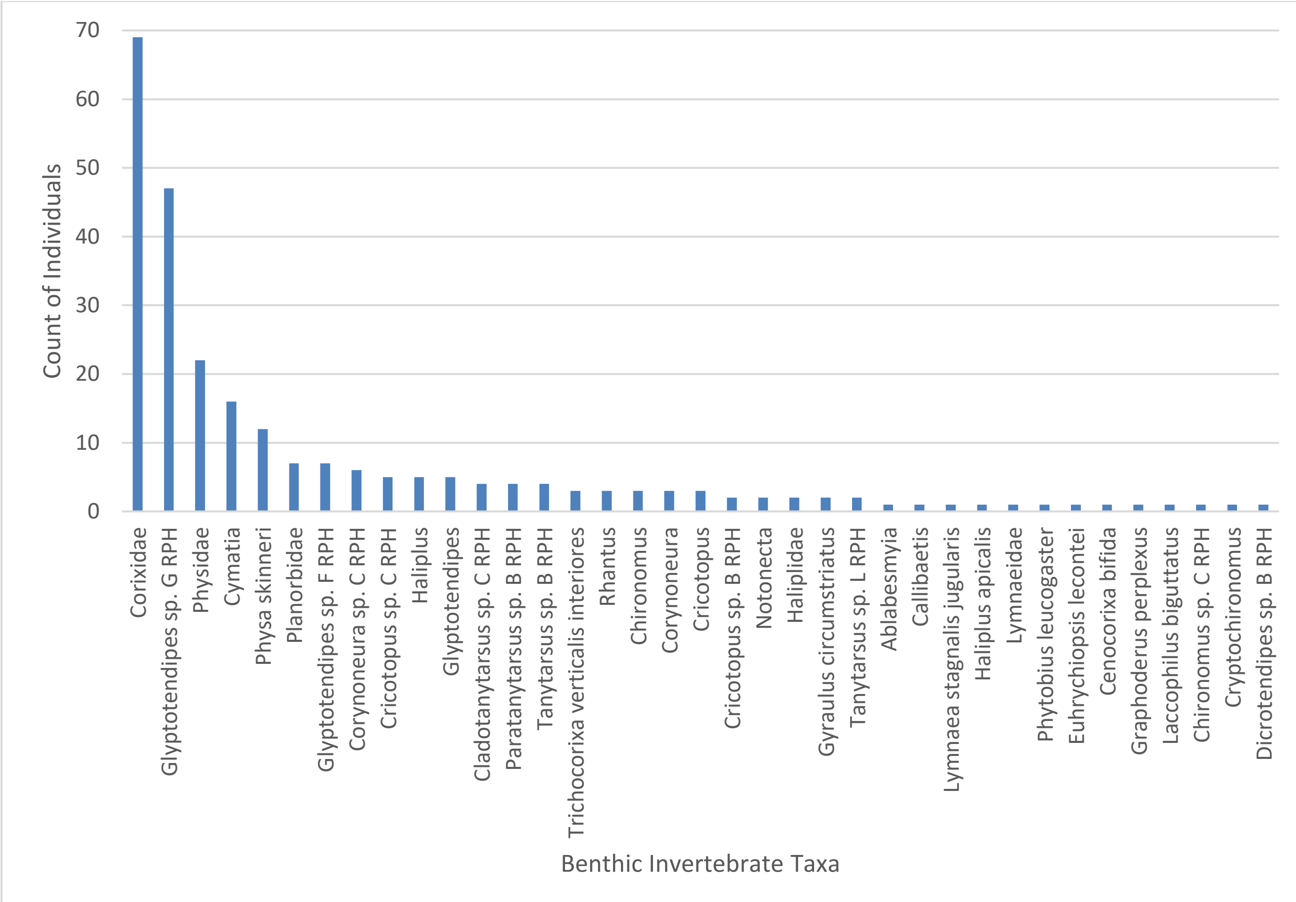


Figure F3-3: Benthic Invertebrates identified at ABMI Site 1499* in 2013.

*Source: Alberta Biodiversity Monitoring Institute (ABMI). (2024). *Species and Habitat Raw Data*. Retrieved in March 2025, from https://abmi.ca/abmi-home/data-resources/data-portal-main/rawdata.html.

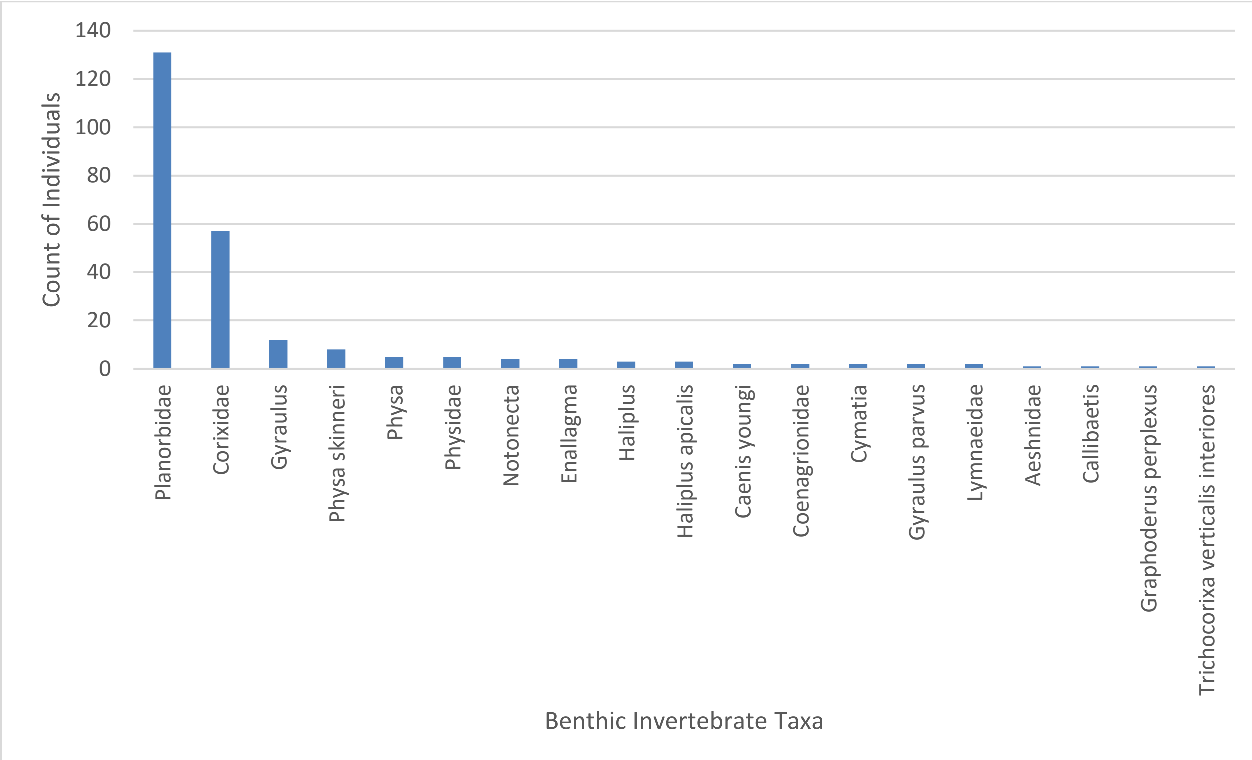


Figure F3-4: Benthic Invertebrates identified at ABMI Site 1500* in 2016.

*Source: Alberta Biodiversity Monitoring Institute (ABMI). (2024). *Species and Habitat Raw Data*. Retrieved in March 2025, from https://abmi.ca/abmi-home/data-resources/data-portal-main/rawdata.html.

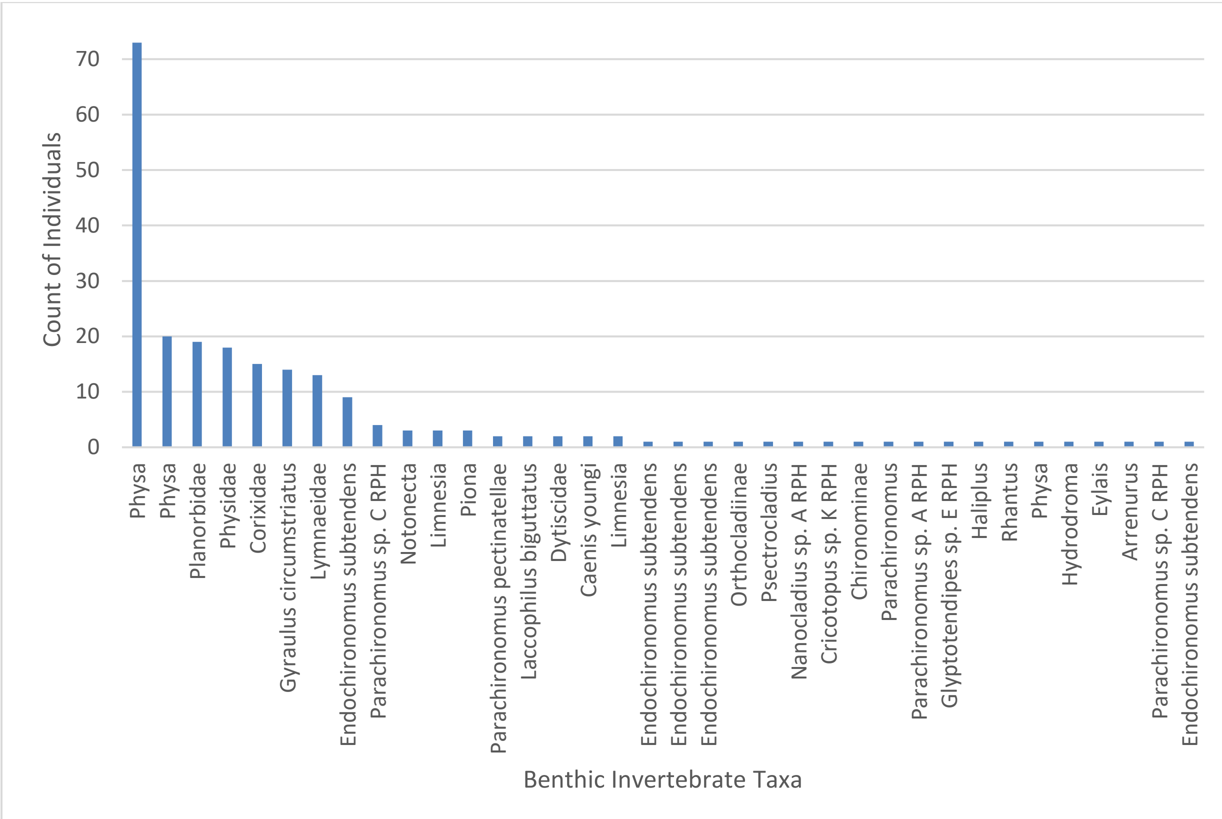


Figure F3-5: Benthic Invertebrates identified at ABMI Site 1500* in 2010.

*Source: Alberta Biodiversity Monitoring Institute (ABMI). (2024). *Species and Habitat Raw Data*. Retrieved in March 2025, from https://abmi.ca/abmi-home/data-resources/data-portal-main/rawdata.html.

Appendix F4: Review of Methylmercury in Prairie Reservoirs

EXECUTIVE SUMMARY

This report summarizes relevant information on how methylmercury (MeHg) bioaccumulation in fish can occur in new reservoirs, to help understand whether this is likely to occur in the proposed Snake Lake Reservoir (SLR) Expansion. This review includes information on chemical and bioaccumulation processes, fish consumption, and health effects on humans, and compares literature information from regional reservoirs to measurements at SLR on inorganic and methyl-mercury in water, sediments, and fish. This is used to help plan for future monitoring and management needs.

The Snake Lake Reservoir, built in 1997, is located within the Eastern Irrigation District (EID). The EID proposes to construct and operate the SLR Expansion Project; this will require construction of a new reservoir basin, doubling the existing reservoir's footprint. A challenge associated with reservoir creation (or in this case, expansion) is associated with the metabolism of metals at the sediment-water interface during the years immediately post-inundation. MeHg, which forms when mercury is metabolised under anoxic conditions in deep waters, is toxic to all animals. Effects of high concentrations of MeHg become pronounced at upper trophic levels of food webs where it accumulates within the tissues of "top predators". Humans are no exception, and will also accumulate MeHg, which is why lakes and reservoirs known to have high MeHg concentrations in fish are monitored by the Alberta Government's Health Services and why restrictions on fish consumption from these waterbodies may be implemented.

Literature on three reservoirs in Southern Alberta, including Pine Coulee, Twin Valley, and Gleniffer Lake is reviewed to compare with information collected from SLR. This review provides direction on environmental management following construction. The Project is expected to increase fish habitat and production; however, based on the experience with other southern Alberta irrigation reservoirs, harvest and consumption of fishes may need to be managed to avoid MeHg bioaccumulation in humans. Fish consumption advisories are also discussed.

It is impossible to predict the likelihood and intensity of a MeHg surge in the expanded reservoir once it fills. Unlike other reservoirs built to date, the EID proposes to remove about 80% of topsoil within the new reservoir basin to allow exposure of deeper shale for reservoir berm construction. This may reduce the amount of mercury available to be methylated, since accumulated organic matter in soils is a major source of mercury. However, about 20% of the expansion area will retain surface soil and vegetation, and only time will tell if decomposition of organic matter from these areas will cause an increase in MeHg in the trophic food web. A baseline for MeHg body burden in piscivorous fish (Northern Pike) in SLR has been established. After inundation, MeHg should be monitored for several years to ensure public safety.

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ABBREVIATIONS

AHS	Alberta Health Services
Alberta EPA	Alberta Environment and Protected Areas
BOD	Biological Oxygen Demand
DO	Dissolved Oxygen
EID	Eastern Irrigation District
GOA	Government of Alberta
MeHg	Methylmercury
SLR	Snake Lake Reservoir
TDI	Tolerable Daily Intake
TDS	Total Dissolved Solids
TSS	Total Suspended Solids

1 INTRODUCTION

1.1 Environmental Mercury

Mercury (Hg) occurs in various chemical forms: primarily mercury sulfide (HgS; cinnabar), but also mercury oxide (MgO), mercury chloride ($HgCl_2$), or simply elemental mercury (Hg). Most chemical forms of Hg have relatively low toxicity, except at high concentrations. Mercury occurs naturally in low concentration in rocks, soils, water, organic materials, and atmospheric particulate matter. Mercury is released into the environment during volcanic eruptions, forest fires, organic matter decomposition, and rock weathering, as well as by burning of fossil fuels: particularly coal (Cooke et al., 2005). Once in water, it may be dissolved or remain bound to suspended particles (Ullrich et al., 2001). Watershed sinks, such as lakes and reservoirs, can accumulate mercury transported by rivers as well as runoff from the surrounding landscape. Thus, mercury is distributed in low concentration almost everywhere by natural and anthropogenic means.

1.2 Mercury in Aquatic Environments

In aquatic environments, mercury is released through the breakdown of organic matter in soils, weathering of minerals in rocks, is imported during deposition of particulate matter, or by transportation of silt and dust to watercourses, or in runoff. As particulate matter settles in water, it becomes part of total suspended and total dissolved solids (TSS, TDS) measured as turbidity. This is the degree to which light is scattered when shone through a sample. The more turbid the water, mercury concentration within the suspended and dissolved fractions is higher. As water clarifies, dissolved and suspended particles are deposited onto substrate and can cycle back into the water through physical, chemical, or biological processes. Most of the mercury is stored within the substrate under deep water; total dissolved and suspended mercury in water represent only a small portion of the total mercury in elemental or inorganic forms that are available to be methylated in a waterbody.

1.3 Mercury Chemistry

A common challenge associated with reservoir creation is the metabolism of mercury (Hg) into methylmercury (CH_3Hg^+; MeHg) at the substrate-water interface post-inundation. In the benthic (deep) zone of reservoirs, dissolved oxygen (DO) is consumed during cellular respiration associated with decomposition - referred to as biological oxygen demand (BOD). Once oxygen is depleted (resulting in reducing conditions), inorganic and relatively inert forms of mercury are broken down by certain bacteria so that reactive mercury ions can be used as electron acceptors in place of oxygen. The exact pathway is not well understood, and many different species of bacteria appear capable of mercury methylation in different ways (Tang, et al., 2020).

Fluctuations in water level and declining water quality contribute to increased methylation rates. Eckley *et al.* (2017) found that instability in water level (e.g., annual drawdown) leading to exposed sediment can stimulate methylating bacteria by increasing both dissolved organic carbon and bioavailability of mercury. Surface sediment layers are known to have higher methylation rates than those that are deeper (Ullrich et al., 2001). Declining water quality often results from buildup of dead and decaying matter that increase BOD. As organic matter is decomposed, nutrients are released and oxygen is consumed, leading to anoxic conditions in the benthic zone. This can generate a positive feedback loop where the nutrient availability promotes primary production in the food web, leading to more waste entering the benthos, and ultimately compromising water chemistry over time (Mitchell & Prepas, 1990). As respiration increases with rising water temperature (optimized at 35°C), or under limited oxygenation (ice cover in winter), benthic water becomes even more (Ullrich et al., 2001), promoting metabolism of mercury at the sediment water interface (Livingston, 2006). Finally, water with lower pH also accelerates the rate of mercury methylation (optimized at pH of 6.5) (Ullrich et al., 2001).

1.4 Bioaccumulation of Methylmercury

The chemical properties of mercury and its effects on aquatic environments and across trophic levels has been well documented (Petersen et al., 2002; Government of Alberta [GOA], 2009; Brinkmann & Rasmussen, 2010). During the years immediately post-inundation, an initial pulse of MeHg is found through the food web. It is incorporated into the tissues of primary and secondary producers; the newly methylated mercury becomes adsorbed (stuck) and absorbed into tissues of single-celled phytoplankton and zooplankton consumed by larger zooplankton, then larger invertebrates and ultimately fishes. Most organisms lack the ability to metabolize MeHg, thus it accumulates within fatty and muscle tissues in a direct relationship to position in the trophic web (Brinkmann & Rasmussen, 2010). Consequently, top predators (piscivores) in these reservoirs, such as Northern Pike (*Esox lucius*), Walleye (*Sander vitreus*), or Rainbow Trout (*Oncorhynchus mykiss*) can accumulate MeHg as they grow (GOA, 2009). Over time bioaccumulation leads to elevated mercury concentration in fishes 2 to 5 years following reservoir impoundment (GOA, 2009). Elevated MeHg in biota is generally followed by a slow decline to background concentrations mediated through the removal of piscivorous fishes as well as the half-life of MeHg in the environment, the chemical conversion of MeHg back to inorganic forms, and the outflow of mercury in water (Feng et al., 2011). There is broad variation in the half-life of MeHg, as it depends on water/body temperature and diet but can range from <30 to >120 days (Rand & Caito, 2019). However, once incorporated into living tissues, it can take 30 years or more for MeHg to return to background levels in piscivorous fishes post-inundation (Feng et al., 2011).

In contrast to the low toxicity most mercurous compounds possess, MeHg is considered highly toxic. Symptoms of “mercury poisoning” refer to the negative outcomes of absorbing high amounts of MeHg, usually from diet. Accumulation of MeHg in the tissues of “top predators” (highest trophic-level organisms) can cause behavioural, neurochemical, hormonal, and reproductive changes, including infertility and birth defects.

1.5 Human Health

In humans, MeHg is a potent neurotoxicant, as it easily crosses the blood-brain barrier, and symptoms of MeHg poisoning may include irreversible blindness, deafness, impaired cognitive ability, impaired breathing, impaired coordination, impaired fertility, and seizures. In addition, there is increased risk of cerebral palsy, impaired growth, and microcephaly in infants whose mother was exposed to high concentrations of MeHg and in infants and children who consume large amounts of MeHg in fish or other foods. Other possible effects that have not been confirmed include immunotoxicity, carcinogenicity, and cardiovascular challenges (Hong et al., 2012).

Lakes and reservoirs known to have high MeHg concentrations in resident fishes are monitored by the Alberta Government. Health advisories are put in place when MeHg concentration in fish tissue exceeds the consumption guideline or when there is a lack of data in a target waterbody. MeHg concentration sampled from muscle tissue of top predators is used to set human consumption advisories to minimize the risk of adverse effects experienced over a person's life. Human consumption guidelines provide consumption limits, in grams, of top predators (e.g., Walleye, Northern Pike) that may be consumed (GOA, 2019a; 2019b). The guideline for MeHg consumption is 0.2 µg MeHg per kilogram body weight per day (MeHg/kg/d) as a tolerable daily intake (TDI) for women of childbearing age and children while the TDI for the remainder of the population is 0.47 µg MeHg/kg/d (GOA, 2019b; 2009). Women, specifically those of childbearing age, have a lower TDI given the risk of birth defects or miscarriage (Hong et al., 2012). Also, children are particularly susceptible to neurotoxicity during the period of brain development, usually up to 12 years of age (Hong et al., 2012) and as children, they have a longer future lifespan, in which they may accumulate more MeHg. Individuals who consumed >100 g of a piscivore daily caught from rivers within the South Saskatchewan River Basin exhibited higher concentrations of mercury in their bodies than those who consumed less than 100 g (Feng et al., 2011). Presently, there is no fish consumption advisory for fishes in Snake Lake Reservoir (SLR) (GOA, 2019a; 2019b). To our knowledge, nobody has been affected adversely from mercury poisoning in Alberta.

2 METHYLMERCURY IN SOUTHERN ALBERTA

2.1 Southern Alberta Reservoirs

Soils and vegetation from forested watersheds tend to be the source of mercury in eastern Canada's reservoirs (Brinkmann & Rasmussen, 2010). Runoff from agricultural development (e.g., cropland, or livestock rangeland) can carry elevated nutrient (phosphorus and nitrogen) concentrations (and other chemicals such as herbicides or pesticides) that serve to increase the rate of benthic methylation (Brinkmann & Rasmussen, 2010). The fate of MeHg and its metabolism in southern Alberta Reservoirs was reviewed for Gleniffer Reservoir in the Red Deer River Basin, Twin Valley Reservoir in the South Saskatchewan River Basin, and Pine Coulee Reservoir in the Old Man River Watershed. Alberta Health Services (AHS) has monitored MeHg body burden in Northern Pike in all three reservoirs (Feng et al., 2011). Results are representative of the range of how mercury is metabolized over time in Alberta reservoirs. This knowledge may help to forecast what is likely to occur in SLR and inform responses based on initial trends upon inundation of the expansion.

Gleniffer Lake is a 1,743-ha reservoir, filled in 1983, with a maximum depth of 32 m (Alberta Environmental Centre, 1989). The reservoir holds 203 million m^3 (165,000 acre-feet) and is stocked with Rainbow Trout, Cutthroat Trout (*Oncorhynchus clarki*), and Brown Trout (*Salmo trutta*). Methylmercury concentration was monitored before and after impoundment. Body burden of MeHg remained below the consumption guideline, as it was before the reservoir was impounded. No significant increase was observed following impoundment, so no consumption advisories were put in place (Alberta Environmental Centre, 1989).

Twin Valley Reservoir, located 20 km northeast from Pine Coulee within the Old Man River Basin, is an 835-ha irrigation reservoir filled in 2003 (GOA, 2009). Its mean depth is 3.06 m, resulting in a calculated volume of 25.6 million m^3 of water (Brinkmann & Rasmussen, 2010). Pre- and post-project MeHg body burden was monitored in fish tissue by AHS and trophic MeHg was tracked by Brinkmann and Rasmussen (2010) Initially, Twin Valley Reservoir experienced high concentrations of MeHg in benthic invertebrates. Northern Pike feeding solely on invertebrates were found to have high MeHg body burden and depressed growth rate because of the restricted diet (insects contain less energy than fish per gram consumed), since forage fishes were absent post-inundation. Following impoundment, MeHg body burden was higher in individuals within and downstream from the reservoir compared to those upstream (GOA, 2009). Generally, MeHg concentration in fish increased slightly 2 years after construction and decreased after-the-fact; however, concentration measured was no greater than in other similar waterbodies in North America (GOA, 2009). The authors also predicted that with an increase in trophic complexity through the introduction of Lake Whitefish (*Coregonus clupeaformis*; an insectivore and opportunistic piscivore also present in SLR), MeHg concentration would be lower in resident Northern Pike. This was the experience in Pine Coulee Reservoir in southwestern Alberta (Applied Aquatic Research, 2022).

Pine Coulee is a 625-ha reservoir with a storage capacity of 41,000 acre-feet (51 million m^3), located west from the Town of Stavely in southwest Alberta and filled in 1999. Pine Coulee is roughly half the size of the future expansion of SLR. Feng *et al.* (2011) measured MeHg concentration in fish before and after construction of the new reservoir to determine if an increase in body burden occurred following impoundment. Concentration of MeHg was highest between 2003 and 2005 (i.e., 4 to 6 years after impoundment) in piscivorous fishes and declined between 2004 and 2007 (i.e., 5 to 8 years after impoundment). Mercury body burden increased slightly in 2009 in Pine Coulee; although this may have been a sampling artifact (Feng, Hiltz, & Wharmby, 2011). In 2009, health advisories were in place for both Pine Coulee and Twin Valley reservoirs to limit consumption of large piscivorous fish to 480 g and 180 g of fish for men and women, respectively (Feng et al., 2011).

Pine Coulee and Twin Valley reservoirs are most comparable to SLR since they are also located within the Grassland Natural Region of Alberta. Vulnerable populations are recommended to avoid eating Walleye from Pine Coulee Reservoir (based on 2014 data) and Northern Pike from Twin Valley Reservoir (2013 data). Others should limit their consumption to 5 fish per week from either reservoir. Guidance issued in 2019 maintains these limits (GOA, 2019b). There are no advisories for Gleniffer Lake or the existing SLR (GOA, 2019b). Note that a consumption advisory exists for top predators in the Bow River below the Bassano Dam in the absence of any data to the contrary since they have not been tested but are anticipated to have some mercury in muscle tissue given geology of this reach of river (GOA, 2019b).

2.2 Snake Lake Reservoir

At present, SLR is not being monitored for MeHg in fish tissue (GOA, 2019a). The complexity of interacting parameters that contribute to MeHg bioaccumulation in reservoirs makes it difficult to predict accurately what will occur once the reservoir is expanded. Regardless, MeHg concentration is low. The reservoir does not stratify; a function of its fetch relative to prevailing wind, which also maintains high DO (Table F4-1). Water in the extant SLR possesses other favourable conditions to prevent the methylation of mercury, such as moderately high pH (8.1-9.4), and fresh (<500 uS/cm) to slightly brackish (500-2,000 uS/cm) conductivity, (making mercury a less attractive electron acceptor) and low temperatures (high of 15°C in deep water) (Table F4-1). Additionally, expansion of the SLR necessitates removal of topsoil with much of the organic layer that holds this metal before the reservoir is filled. This should lower MeHg appreciably once the reservoir is filled. The low residency time in the reservoir also reduces the potential precipitation of mercury to the substrate, reducing the amount of mercury to be methylated in the reservoir.

Fish from all trophic levels were caught from SLR during seasonal inventories. Given the presence of forage fishes in the reservoir, mercury body burden is anticipated to be lower in Northern Pike than observed in Twin Valley Reservoir, which lacked forage fishes (Brinkmann & Rasmussen, 2010). In that reservoir, Northern Pike obtained most of their food from benthic invertebrates that had a direct link to MeHg in the reservoir's substrate. Additionally, coarse or forage fishes such as White Sucker (*Catostomus commersoni*) and Prussian Carp (*Carassius gibbelio*), both of which have been captured in SLR, can grow too large for predation by piscivores; consequently, MeHg stored in the tissues, are unavailable to Northern Pike for a few years: until the fish dies and its tissues decompose. Additionally, the coarse and forage fish diet, consisting of phytoplankton and zooplankton, limits their exposure to MeHg compared fish which consume benthic invertebrates.

Table F4-1: Summary of SLR water quality 2021 to 2023

Time of Sampling	Site[1]	Temperature (°C)		Surface Water		Turbidity (NTU)	pH	Specific Conductivity µs/cm	TDS (mg/L)	Mercury (ng/L)	
		Surface Water	Deep Water[2]	DO (mg/L)	Deep Water[2]					Dissolved	Total
Spring 2021	1	15.6	12.2	8.65	3.08	0.81	7.78	542	342	0.18	0.32
	2	18.0	15.1	11.05	4.85	0.78	7.80	545	339	0.19	0.28
Fall 2021	1	12.5	12.4	10.90	8.28	-	8.85	218	-	<0.10	0.24
	2	12.4	12.4	7.56	7.75	-	7.56	233	-	<0.10	0.24
Winter 2022	1	1.7	1.8	22.32	21.60	0.41	8.25	523	326	129	478
	2	1.4	2.0	15.95	13.99	0.41	8.31	549	333	106	241
Fall 2023	1	-	-	-	-	-	7.92	422	240	N/A	570
	2	-	-	-	-	-	8.16	423	235	N/A	105

1. Sites were measured 1 m below surface at Site 1 (East Side of reservoir) and Site 2 (West Side of Reservoir).
2. Depths sample 1: East side: 12.5 m (spring 2021), 10 m, (fall 2021), 8 m (winter 2022) 3 m (Fall 2023); sample 2: West side: 9.5 m (spring 2021), 7 m (fall 2021), 6 m (winter 2022), 1 m (Fall 2023).

Northern Pike, the top SLR predator, were sampled to measure their MeHg body burden in fall 2023. Methyl- and inorganic mercury concentrations were measured in sediment and water samples, too (Table F4-2). Fish tissue sampled had an average body burden of 218 ng/g MeHg. For these values, if a 60 kg person consumed an average of 100 g of fish per day, they would consume 0.363 µg/kg, above the TDI values of 0.2 µg methylmercury per kilogram body weight per day for women of childbearing age and children and below the 0.47 µg methylmercury per kilogram body weight per day for the remainder of the population. Based on a review of information from southern Alberta reservoirs, the SLR expansion is expected to increase fish habitat and productivity (potential catch). Therefore, the harvest and consumption of fishes from the expanded SLR may need to be monitored and managed to avoid methylmercury bioaccumulation in the consumers.

Table F4-2: Inorganic and methylmercury in SLR water, sediment, and fish tissue, fall 2023.

Parameter and Medium	West Basin (2 m deep)	East Basin (5 m deep)	Average
Total Inorganic Mercury in Water (µg/L)	0.105	0.570	0.338
Methylmercury in Sediment (ng/g)	<0.4	<0.4	<0.4
Methylmercury in Fish Tissue (ng/g)	217	218	218

Once built, the expansion will be filled with water from the Bow River via the EID East Branch Canal, which diverts flow downstream from the Bassano Dam. Mercury concentration in Bow River water was recorded downstream from Bassano Dam and downloaded from the Irrigations Districts Irrigation Water Quality Data Tool (Station E2-1, at EID's "Little Dam Reservoir"). This data included laboratory analysis for total metals between 2006 and 2012. It showed that there was no detectable inorganic mercury in the incoming river water. The lack of new mercury input from Bow Rier sources water, reduces the likelihood that additional mercury will be transported to the site and stored in the reservoir, its sediments and its fish. Mercury will likely only be added from the surface substrate, and from any precipitation of particles in the reservoir. Furthermore, as most of the mercury accumulated over several years would be found in the organic material of topsoil, and as most of this will be stripped prior to filling the new reservoir basin, the source of new mercury in the reservoir should be limited.

The SLR expansion will be roughly square in shape (3 km by 2.5 km), up to 20 m deep with steep walls (limited littoral habitat) and a rock armoured dam face. The combination of shape and depth of the expanded basin will continue to be mixed by the prevailing wind but may stratify for short periods. The benthic zone below a thermocline could experience depressed oxygen concentrations both in late summer and late winter permitting the methylation of mercury and the mobilization of MeHg into the trophic web. Residency time in the new reservoir may also affect methylation of mercury, since the longer residency of water within the expanded reservoir may increase the risk of mercury being mobilized into the food chain.

3 CONCLUSIONS

Although the SLR expansion design requires removal of topsoil and subsoil to expose clay till, it is expected that a small increase in MeHg concentration will be experienced by fish within the reservoir. The amount of MeHg released into the SLR expansion will depend on mercury stored in remaining substrate and vegetation left to decay within the project footprint. Construction requires removal of most, but not all, of the soil and vegetation from the footprint to expose underlying shale and use the extracted material to build surrounding berms. Removal of soil and organic matter before inundation will reduce the main source of mercury appreciably and limit organic matter available to create anoxic conditions. However, a small amount of mercury is likely stored in the bedrock and could be mobilized over time.

As with other reservoirs, MeHg metabolism is expected to increase within 2 to 5 years and decrease steadily thereafter as the compound is metabolized over time. No information was found on reservoirs without organic substrate, so the outcome of removing the soil is difficult to predict conclusively. Intuitively, it is expected that the removal of organic matter, an essential component in mercury methylation, will reduce the amount of mercury methylated. Given much of the soil burden will be removed from the reservoir's footprint, the increase in uptake is anticipated to be low. Ultimately, both sediment and water will be monitored post inundation of the expanded reservoir.

3.1 Recommendations

Based on this literature review, it is recommended that the proponent:

1. Collect water quality data (DO and temperature profiles, and pH) following inundation of the expanded reservoir.
2. It is recommended that the Snake Lake Reservoir be added to the existing government fish sampling program under Alberta Health in collaboration with Alberta Environment and Protected Areas (Alberta EPA; GOA, 2024). This recommendation is based on the Project baseline assessment results which revealed elevated baseline levels of methylmercury in adult pike and the subsequent literature review. Fish within the expanded reservoir are expected to have a small increase in methylmercury within 2 - 5 years following dam inundation and then decline. Furthermore, the reservoir will be larger in size which could result in increased levels of recreational fishing.
3. In addition, mercury in water should be sampled once the reservoir has been filled annually for one year minimum.

Recommendations are based on current management objectives, which may evolve over time. They may require consideration if new objectives are developed, or new information is collected. AHS may want to incorporate annual sampling and monitoring of top predator MeHg body burden in SLR as part of their provincial agenda.

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