CITY OF IQALUIT

WATER LICENCE 3AM-IQA1626

2022 ANNUAL WATER LICENCE REPORT

April 28, 2023

EXECUTIVE SUMMARY

Under a Type A Water Licence 3AM-IQA1626 (the Licence), the City of Iqaluit (the City):

- Extracts water from Lake Geraldine for municipal use;
- Discharges Landfill run-off from the West 40 Landfill; and
- Discharges wastewater from the West 40 Wastewater Treatment Plant and backup Sewage Lagoon.

This Licence was issued by the Nunavut Water Board (NWB) in 2016 and expires on June 16, 2026. During the 2022 calendar year, the City obtained Amendment No. 7 (emergency) to it's water licence, as a result of a state of emergency declared due to low raw water levels in Lake Geraldine. The amendment was not implemented, as the City was able to supplement water from the Apex River via existing Amendment No. 4.

This Annual Water Licence Report summarizes the activities conducted by the City in 2022, pursuant to the requirements stipulated in Schedule B of the Licence.

Monitoring Program

The City continued to perform monitoring requirements as per the City's approved Environmental Monitoring Program and Quality Assurance/ Quality Control Plan (the Monitoring Plan).

Long-Term Water Supply and Storage

The City completed a high-level options analysis evaluation for the long-term supply strategy for the City raw water supplemental supply. The options analysis considered two (2) options – the Sylvia Grinnell River and Unnamed Lake. Through this analysis, and completed consultations with the local Hunter's and Trappers Assocation, Qikiiqtani Inuit Association, a recommendation was provided to and accepted by City Council to proceed with Unnamed Lake as the long-term option for supplementing the City's Lake Geraldine raw water reservoir. The City will begin with planning for further assessment, design development and initial permitting activities in 2023.

Niaqunguk River (Apex River) Supplementary Pumping Program

The City executed the replenishment of the Lake Geraldine Reservoir, via supplemental pumping of water from the Apex River. Pumping activities were completed between June 18, 2022 and September 18, 2022 (apart from between July 10 and July 23, 2022, when flows in the Niaqunguk River were below 30% of the Mean Annual Discharge. The City was granted emergency amendment No. 7 in order to supplement further raw water supply from Unnamed Lake, as a result of high water consumption volumes and dry weather conditions in the Niaqunguk River. The City did not exercise activities under Emergency Amendment No. 7, as it was able to acquire required volumes from the Apex River prior to the winter season.

A total of 419,324 m^3 of water was pumped with maximum daily pumped volumes of 14,519 m^3. The Lake Geraldine water level as of October 1, 2021 was recorded at 111.239 mASL.

Water Treatment Plant

The City continued water quality monitoring and sampling efforts, as per the City's Public Water Systems Monitoring and Reporting Plan – a plan which was developed and implemented to petroleum hydrocarbon (PHC) contamination events in the City's municipal water distribution system.

In response to the 2021 WTP contamination event, the existing filter media material was removed and replaced with Granular Activated Carbon (GAC). Remediation and sealing of the concrete wall structures for the North Clearwell, South Clearwell, Mixing Chamber, Pumping Chamber, Backwash to Waste Chamber, and Surge Tank walls was completed. Lastly, two critical isolation valves located at the Mixing Chamber and South Clearwell were replaced in order to resume normal operation. Return to normal operation is being planned for April 2023, pending final review and approval from the Government of Nunavut.

Wastewater Treatment

In 2022, the City estimates that it discharged approximately 1,115,694 m^3 of effluent from the Wastewater Treatment Plant. It also estimates that it removed approximately 424 m^3 of sludge from the Wastewater Treatment Plant, which was deposited at the City's West 40 Landfill.

The final completion certificate was presented to the City in March 2022 for construction related to the WWTP Upgrades project. The WWTP has been in operation; however, with outstanding deficiency and troubleshooting items still ongoing.

Solid Waste Management

Construction of the new landfill began in the summer of 2022, along with the installation of the thermosyphon system supporting the foundation of the new Waste Transfer Station. The project has began the procurement of major long-lead equipment, such as the biomass boiler and conveyance systems.

The City continues to accept and manage waste at the West 40 Landfill – this will be continued until the construction of the new landfill and waste transfer station is completed in Q4-2024.

Lake Geraldine Dam

In 2022, the City completed concrete crack repairs, the installation of survey monuments and signage at the dam, and obtained a stockpile of riprap, granular and medium sized fill material to support annual maintenance related activities at the dam. The City also completed the installation of monitoring stations and data loggers (at the same location of the survey monuments) in order to monitor activities at the dam for asset integrity purposes. This work was initiated based on recommendations identified in previous DSI's.

The City will continue to advance necessary engineering studies and design assignments in 2023, in support of previous dam safety inspections. In addition, the City will continue to undertake continued concrete delamination and crack repair work.

ᐊᖏᖅᑲᐅᑎᓄᑦ ᐅᓂᒃᑳᓴᑦ ᐱᓪᓗᐊᑕᐅᖅᓯᓂᑦ

ᒪᓕᑦᑐᑎᒃ ᐆᕙᖓ ᐃᒪᓕᕆᔪᓐᓇᐅᑎᒥᑦ ᓚᐃᓴᒥᑦ (Type A Water Licence 3AM-IQA1626) (ᓚᐃᓴ), ᓄᓇᓕᐸᐅᔭᐃᑦ ᐃᖃᓗᐃᑦ (ᓄᓇᓕᐸᐅᔭᒃᑯᑦ):

- ᐃᒥᖅᑕᐸᑦᑐᑦ ᐃᒥᖅᑕᕕᒻᒥᑦ ᓄᓇᓕᓐᓂ ᐊᑐᖅᑕᐅᖅᑦᓴᒥᑦ;
- ᐊᑦᓯᕕᒻᒥᑦ ᑭᓈᖅᒥᑦ ᐃᒥᕈᖅᒻᒥᑦ ᑯᕕᑎᑦᓯᕙᑦᑐᑦ ᑰᓕᐊᕆᐊᒥᑦ ᐊᑦᓯᕕᒻᒥᑦ; ᐊᒻᒪ
- ᑯᕕᑎᑦᓯᕙᑦᑐᑦ ᐃᒥᕈᖅᒻᒥᑦ ᓴᓂᕐᒥᑦ ᑰᓕᐊᕆᐊᒥ ᐃᒥᕈᖅᒻᒥᑦ ᐃᒋᑕᑦᓴᒥᑦ ᓴᓗᒻᒪᖕᓴᐃᕕᒻᒥᑦ ᐊᒻᒪ ᑭᙳᕝᕕᐅᑎᒥᑦ ᑭᓈᓗᓐᓄᑦ ᑕᕐᓯᓗᒻᒥᑦ.

ᐅᓇ ᓚᐃᓴ 2016-ᖑᑎᓪᓗᒍ ᖃᐃᑕᐅᓚᐅᖅᑐᖅ ᓄᓇᕗᑦ ᐃᒪᓕᕆᓂᕐᒥᑦ ᑲᑎᒪᔨᓂᑦ ᐊᒻᒪ ᐃᓱᓕᕝᕕᑦᓴᖃᖅᑐᓂ ᔪᓂ 16, 2026. 2022-ᖑᓂᖓᓂ, ᓄᓇᓕᐸᐅᔭᒃᑯᑦ ᐱᑎᑕᐅᓚᐅᖅᑐᑦ ᐊᓯᔾᔨᐅᑎ 7-ᒥᑦ (ᑐᐊᕕᕐᓇᑐᒃᑯᑦ) ᐃᒥᓕᕆᔪᓐᓇᐅᑎᒥᓄᑦ ᓚᐃᓴᑎᒍᑦ, ᐱᔾᔪᑎᐅᓗᓂ ᑐᐊᕕᕐᓇᖅᑐᓕᕆᔾᔪᑎᐅᓚᐅᖅᑐᖅ ᐃᒪᑭᑦᓴᓕᕐᓂᖓᓄᑦ ᐃᒥᖅᑕᕐᕕᐅᑉ. ᐊᓯᔾᔨᐅᑎᐅᔪᖅ ᐱᒋᐊᖅᑎᑕᐅᓚᐅᖏᑦᑐᖅ, ᓄᓇᓕᐸᐅᔭᒃᑯᑦ ᐃᒥᖅᑕᕈᓐᓇᕐᓯᓚᐅᕐᒪᑕ ᓂᐊᕐᑯᙱᑎᐅᑉ ᑰᖓᓂᑦ ᐊᑐᖅᑕᐅᓗᓂ ᐊᓯᔾᔨᐅᑎ 4 ᓱᓕ ᐊᑐᖅᑕᐅᔪᓐᓇᓚᐅᖅᑐᖅ.

ᐊᕿᒍᑕᒫᕐᓯᐅᑎ ᐅᓇ ᐃᒥᓕᕆᔪᓐᓇᐅᑎ ᓚᐃᓴ ᐱᓪᓗᒍ ᐅᓂᒃᑳᓕᐊᖅ ᐱᓪᓗᐊᑕᖏᓐᓂᑦ ᐱᓯᒪᔪᖅ 2022-ᒥ ᖃᓄᐃᓕᐅᕈᑎᒋᓚᐅᖅᑕᖏᓐᓂᑦ ᓄᓇᓕᐸᐅᔭᒃᑯᑦ, ᒪᓕᑦᑕᐅᓗᑎᒃ ᒪᓕᒋᐊᓖᑦ ᑎᑎᕋᕐᓯᒪᔪᑦ ᐅᐃᒍ B ᓚᐃᓴᒧᑦ.

<u>ᖃᐅᔨᓴᐃᓐᓇᓂᕐᒥᑦ ᐱᓕᕆᐊᑦᓴᖅ</u>

ᓄᓇᓕᐸᐅᔭᒃᑯᑦ ᖃᐅᔮᓴᖃᐃᓐᓇᓚᐅᖅᑐᑦ ᒪᓕᑦᑕᐅᓗᑎᒃ ᐊᑐᖅᑕᐅᒋᐊᓖᑦ ᓄᓇᓕᐸᐅᔭᒃᑯᑦ ᐊᕙᑎᒥᑦ ᖃᐅᔨᓴᐃᓐᓇᓂᕐᒥᑦ ᐱᓕᕆᐊᑦᓴᖓᑦ ᐊᒻᒪ ᖃᓄᐃᖏᓐᓂᖓᓄᑦ ᓇᓗᓇᐃᔭᐃᑎᓂᑦ/ᖃᓄᐃᖏᓐᓂᖓᓂᑦ ᐊᐅᓚᑦᑎᔾᔪᑎᓂᑦ ᐸᕐᓇᐅᑎ (ᖃᐅᔨᓴᐃᓐᓇᓂᕐᒧᑦ ᐸᕐᓇᐅᑎ).

<u>ᐊᑯᓂᐅᔪᒧᑦ ᐃᒥᖅᑖᑎᑦᑎᓂᖅ ᐊᒻᒪ ᓴᓂᕐᕙᐃᓯᒪᓂᖅ</u>

ᓄᓇᓕᐸᐅᔭᒃᑯᑦ ᐱᔭᕇᓚᐅᖅᑐᑦ ᓇᓖᕿᑭᑎᓕᕆᓪᓗᑎᒃ ᖃᐅᔨᓴᖅᑐᑎᒃ ᓇᓖᕿᑭᑎᑦᓴᖏᓐᓂᑦ ᐊᑯᓂᐅᔪᒧᑦ ᐃᒥᖃᖅᑎᑦᓯᓂᕐᔫᖓᔪᓂᑦ ᐸᕐᓇᒍᑎᑦᓴᓂᑦ ᓄᓇᓕᐸᐅᔭᒃᑯᑦ ᐃᒥᖄᕕᑦᓴᖏᓐᓄᑦ. ᓇᓖᕿᑭᑎᓂᑦ ᖃᐅᔨᓴᐅᑎᒍᑦ ᐃᓱᒪᑦᓴᕐᓯᐅᑭᑎᖃᓚᐅᖅᑐᑦ ᒪᕐᕉᓐᓂᒃ (2) ᓇᓖᕿᑮᓐᓂᑦ - ᐃᖃᓗᐃᑦ ᑰᖓᓂᑦ ᐊᒻᒪ ᐊᑎᖃᖏᑦᑐᒥᑦ ᑕᓯᕐᒥᑦ. ᖃᐅᔨᓴᓚᐅᖅᑐᑎᒃ ᐊᒻᒪ ᑐᑭᓯᒋᐊᕈᑎᓕᕆᓚᐅᖅᑐᑎᒃ ᓄᓇᓕᓐᓂ ᐆᒪᔪᕐᓂᐊᑎᒃᑯᓐᓂᑦ, ᕿᑭᖅᑕᓂ ᐃᓄᐃᑦ ᑲᑐᔾᔨᖃᑎᒌᓂᑦ, ᐊᑐᕐᑯᔭᐅᔪᒥᑦ ᓴᖅᑮᓕᓚᐅᖅᑐᑦ ᐊᒻᒪ ᓈᒻᒪᒋᔭᐅᓗᓂ ᓄᓇᓕᐸᐅᔭᐃᑦ ᑲᑎᒪᔨᖏᓐᓄᑦ ᑲᔪᓯᒋᐊᕐᑯᔭᐅᓗᑎᒃ ᐊᑎᖃᖏᑦᑐᒥᑦ ᑕᓯᕐᒥᑦ ᐃᒥᖅᑕᕐᑯᔭᐅᓗᑎᒃ ᐊᑐᖅᑕᐅᓂᐊᕐᓗᓂ ᐊᑯᓂᐅᔪᒧᑦ ᐃᒥᖃᐅᑎᐅᓂᐊᕐᓗᓂ ᓄᓇᓕᐸᐅᔭᒃᑯᑦ ᐃᒥᖅᑕᕐᕕᖓᓐᓂᑦ ᐃᑲᔫᑎᐅᓗᓂ. ᓄᓇᓕᐸᐅᔭᒃᑯᑦ ᐸᕐᓇᐅᑎᓕᐅᕆᐊᕼᓕᖅᑐᑦ ᖃᐅᔨᓴᒃᑲᓂᕐᓗᑎᒃ, ᖃᓄᖅ ᓴᓇᔭᐅᒐᔭᕐᓂᖓᓄᑦ ᐅᐸᓗᖓᐃᔭᐃᓗᑎᒃ ᐊᒻᒪ ᓯᕗᓪᓕᐹᕐᓯᐅᑎᓂᑦ ᐹᕐᒥᑦᑎᕆᓗᑎᒃ ᐱᔪᓐᓇᐅᑎᑦᓴᓂᑦ ᖃᓄᐃᓕᐅᕈᑎᑦᓴᓄᑦ 2023-ᒥ.

<u>ᓂᐊᕐᑯᙱᑎᐅᑉ ᑰᖓᓂᑦ ᐃᒥᖅᑕᕐᓂᖅ ᒥᓪᓗᐊᕐᓯᓂᒃᑯᑦ ᐱᓕᕆᐊᑦᓴᖅ</u>

ᓄᓇᓕᐸᐅᔭᒃᑯᑦ ᐃᒻᒪᐃᒋᐊᓯᓚᐅᖅᑐᑦ ᐃᒥᖅᑕᕕᒻᒥᑦ, ᒥᓪᓗᐊᑎᑦᓯᓪᓗᑎᒃ ᓂᐊᕐᑯᙱᑎᐅᑉ ᑰᖓᓂᑦ. ᒥᓪᓗᐊᕆᓂᕐᒥᑦ ᐱᔭᕇᓚᐅᖅᑐᑦ ᐊᑯᓐᓂᖓᓐᓂ ᔪᓂ 18, 2022 ᐊᒻᒪ ᓯᑏᐱᕆ 18, 2022 (ᒥᓪᓗᐊᕋᑎᒃ ᐊᑯᓐᓂᖓᓐᓂ ᔪᓚᐃ 10 ᐊᒻᒪ ᔪᓚᐃ 23, 2022, ᓂᐊᕐᑯᙱᑎᐅᑉ ᑰᖓ ᑰᖏᓗᐊᓕᓚᐅᕐᒪᑦ ᑐᖕᖁᓃᑦᑐᓂ 30%-ᐳᓴᓐᑦ ᑰᓐᓂᕆᕙᑦᑕᖓᓂᑦ. ᓄᓇᓕᐸᐅᔭᒃᑯᑦ ᐱᑎᑕᐅᒍᓐᓇᓚᐅᖅᑐᑦ ᑐᐊᕕᕐᓇᖅᑐᖅ ᐱᓪᓗᒍ ᐊᓯᔾᔨᐅᑎᒥᑦ 7 ᐃᒥᖅᑕᕈᓐᓇᕈᒪᓪᓗᑎᒃ ᐊᑎᖃᖏᑦᑐᒥᑦ ᑕᓯᕐᒥᑦ, ᐱᔾᔪᑎᐅᓗᑎᒃ ᐃᒥᖅᑐᓗᐊᕆᓚᓕᓚᐅᖅᑐᑦ ᐊᒻᒪ ᓂᐊᕐᑯᙱᑎᐅᑉ ᑰᖓ ᐃᒪᑭᓕᓂᕆᓚᐅᖅᑕᖓ ᐱᓪᓗᒍ ᓯᓚᓗᓗᐊᖃᑦᑕᖏᓐᓂᖓ. ᓄᓇᓕᐸᐅᔭᒃᑯᑦ

ᖃᓄᐃᓕᐅᕈᑎᖃᓚᐅᖕᒋᑦᑐᑦ ᐊᑐᖅᑕᐅᓗᓂ ᑐᐊᕕᕐᓇᖅᑐᖅ ᐱᓪᓗᒍ ᐊᓯᔾᔨᐅᑎ 7, ᓂᐊᕐᑯᖕᖑᑎᐅᑉ ᑯᖓᓂᑦ ᐃᒥᖅᑕᕈᓐᓇᕐᓯᓚᐅᕐᓂᖕᒋᓐᓄᑦ ᓈᒻᒪᑦᑐᒥᑦ ᐅᑭᐅᓚᐅᖅᑎᓐᓇᒍ.

ᑲᑎᑦᑐᒍ 419,324 m^3 ᐃᒥᕐᒥᒃ ᒥᓪᓗᐊᕐᓯᒍᓐᓇᓚᐅᖅᑐᑦ ᖃᐅᑕᒫᑦ ᐊᖏᖾᖑᔪᓐᓇᖅᑐᒥᑦ ᒥᓪᓗᐊᕐᓯᕙᑦᑐᑎᒃ ᐃᒪᓐᓇᓂᒃ 14,519 m^3. ᐃᒥᖅᑕᕐᕕᐅᑉ ᐃᒪᖓ ᐃᑎᓂᖓ ᐋᑦᑑᑉ 1-ᒥ, 2021 ᓇᓗᓇᐃᖅᑕᐅᓯᒪᓚᐅᖅᑐᖅ ᐃᒪᓐᓇᐅᓂᖓᓄᑦ 111.239 mASL.

ᐃᒥᕐᒥᒃ ᓴᓗᒻᒪᖅᓴᐃᕕᒃ

ᓄᓇᓕᐸᐅᔭᒃᑯᑦ ᓱᓕ ᐃᒥᐅᑉ ᖃᓄᐃᓐᓂᖓᓂᑦ ᖃᐅᔨᓴᐃᓐᓇᖅᑐᑦ ᐊᒻᒪ ᐆᑦᑕᐃᖕᒋᓐᓇᖅᑐᑎᒃ ᖃᓄᐃᓐᓂᖓᓂᑦ, ᒪᓕᑦᑐᑎᒃ ᓄᓇᓕᐸᐅᔭᒃᑯᑦ ᑮᒃᑯᑐᐃᓐᓇᕐᓂᑦ ᐃᒥᓕᕆᔾᔪᑎᓂᑦ ᖃᐅᔨᓴᐃᓐᓇᕆᐊᖃᕐᓂᖕᒋᓐᓂᑦ ᐊᒻᒪ ᐅᓂᒃᑳᓕᐅᕈᑎᐅᕙᓪᓗᑎᒃ ᐸᕐᓇᐅᑎᒥᑦ - ᐸᕐᓇᐅᑎᐅᔪᖅ ᓴᓇᔭᐅᓚᐅᕐᓯᒪᔪᒥᓂᖅ ᐊᒻᒪ ᐱᒋᐊᖅᑎᑕᐅᓗᓂ ᐅᕐᓱᐊᓗᕈᔪᒻᒧᑦ ᓱᕈᑦᑕᐅᓚᐅᖅᑎᓪᓗᒍ ᐃᒥᖅ ᓄᓇᓕᐸᐅᔭᒃᑯᑦ ᓄᓇᓕᖕᒋᓐᓂ ᐃᒥᓕᕆᔾᔪᑎᖕᒋᕝᕚᑉᐸᑦᑐᓂᑦ.

ᓴᖅᑭᕈᑎᐅᓗᑎᒃ 2021-ᒥ ᐃᒥᕐᒧᑦ ᓴᓗᒻᒪᖅᓴᐃᕕᒃ ᓱᕈᑦᑕᐅᓚᐅᖅᑎᓪᓗᒍ, ᐊᑐᖅᑕᐅᓚᐅᖅᑐᑦ ᑲᖕᖔᑎᑦᑎᓯᔾᔪᑎᖕᒋᑦ ᐲᖅᑕᐅᓚᐅᖅᑐᑦ ᐊᒻᒪ ᑭᖑᕝᕕᑕᐅᓗᑎᒃ ᑐᐊᐸᓄᑦ ᐲᔭᐃᔪᓐᓇᖅᑐᓂᑦ ᓱᕈᓐᓇᖅᑐᓂᑦ ᐸᐅᕈᔪᓐᓂᑦ. ᐱᔭᕇᖅᑕᐅᓗᑎᒃ ᓴᓇᔭᐅᕆᐊᓚᐅᖅᑐᑦ ᐊᒻᒪ ᓯᒻᒥᑦᑐᑕᐅᓗᑎᒃ ᕐᑯᐊᖅᑕᖅᑐᑦ ᐊᑭᓐᓇᖕᒋᑦ ᐅᐊᖕᓇᖕᒐᓂ ᐃᒥᒃᑯᕕᐅᑉ, ᓂᕆᐊᓂ ᐃᒥᒃᑯᕕᐅᑉ, ᐃᓚᐅᕈᑎᓕᕆᔾᔪᑎᖓ, ᒥᓪᓗᐊᕈᑎᖃᕐᕕᖓ, ᑭᖑᕝᕖᕕᖓ ᓴᓂᖃᕐᕕᒻᒧᑦ, ᐊᒻᒪ ᑯᕕᓯᔾᔪᑎᖕᒋᓐᓂ ᐊᑭᓐᓇᐃᑦ. ᑭᖑᓪᓕᖅᐹᒥ, ᒪᕐᕿᓐᓂᒃ ᐊᑐᖅᑐᒻᒪᓇᓐᓂᒃ ᑯᕕᓯᔾᔪᑏᓐᓂᒃ ᐃᓚᐅᕈᑎᖃᕐᕕᖕᒋᓐᓃᑦᑑᓐᓂᒃ ᐊᒻᒪ ᓂᕆᐊᓂ ᑭᖑᕝᕕᖅᑕᐅᓚᐅᖅᑑᒃ ᐱᐅᓯᖕᒋᓐᓂᑦ ᐊᐅᓚᑕᐅᔪᓐᓇᕐᑯᓪᓗᒍ ᐱᓕᕆᔾᔪᑎ. ᐃᐳᕈ 2023 ᐱᐅᓯᖕᒋᓐᓄᑦ ᐅᑎᔾᔭᖕᖑᕆᔭᐅᔪᖅ ᐱᓕᕆᔾᔪᑎ ᐸᕐᓇᐅᑕᐅᓗᓂ, ᑭᖑᓪᓕᖅᐹᕐᓯᐅᑎᒥᑦ ᖃᐅᔨᓴᖅᑕᐅᓚᐅᖅᑎᓪᓗᒍ ᐊᒻᒪ ᑲᔪᓯᑎᑕᐅᓚᐅᖅᑎᓪᓗᒍ ᐊᑐᕈᓐᓇᓕᕐᓂᖓᓄᑦ ᒐᕙᒪᒃᑯᖕᒋᓐᓂᑦ ᓄᓇᕗᑉ.

ᐃᒥᕈᔪᒻᒥᑦ ᐃᒋᑕᑦᓴᒥᑦ ᓴᓗᒻᒪᖅᓴᐃᓂᖅ

2022-ᒥ, ᓄᓇᓕᐸᐅᔭᒃᑯᑦ ᓇᓚᐅᑦᑖᓚᐅᖅᑐᑦ ᑯᕕᓯᓯᒪᓂᕐᒥᓂᒃ ᐃᒪᓐᓇᓂᒃ 1,115,913 m^3 ᑭᓈᒥᓂᕐᓂᒃ ᐃᒥᕈᔪᒻᒥᑦ ᐃᒋᑕᑦᓴᒥᑦ ᓴᓗᒻᒪᖅᓴᐃᕕᒻᒥᑦ. ᓇᓚᐅᑦᑖᕐᓯᒪᒻᒥᔪᑦ ᐲᕐᓯᓯᒪᓂᕐᒥᓂᒃ ᐃᒪᓐᓇᓂᒃ 14,976 m^3 ᑲᖕᖔᒥᓂᕐᓂᒃ ᑕᖕᒋᓕᓐᓂᑦ ᐃᒥᕈᔪᒻᒥᑦ ᐃᒋᑕᑦᓴᒥᑦ ᓴᓗᒻᒪᖅᓴᐃᕕᒻᒥᑦ, ᐃᒋᑕᐅᓚᐅᖅᑐᓂᑦ ᓄᓇᓕᐸᐅᔭᒃᑯᑦ ᑰᓕᐊᓇᐊᒥ ᐊᑦᓯᕕᖕᒐᓐᓄᑦ.

ᐱᔭᕇᕈᑎ ᓇᓗᓇᐃᔭᐃᑎ ᑭᖑᓪᓕᖅᐹᖅ ᓄᓇᓕᐸᐅᔭᒃᑯᓐᓅᖅᑕᐅᓚᐅᖅᑐᖅ ᒫᕐᓯ 2022 ᓴᓇᔭᐅᕆᐊᓕᓐᓄᑦ ᐊᑦᑐᐊᔪᓂᑦ ᐃᒥᕈᔪᒻᒥᑦ ᐃᒋᑕᑦᓴᒥᑦ ᓴᓗᒻᒪᖅᓴᐃᕕᒻᒥᑦ ᓴᓇᕆᐊᕈᑎᑦᓴᓄᑦ. ᐃᒥᕈᔪᒻᒥᑦ ᐃᒋᑕᑦᓴᒥᑦ ᓴᓗᒻᒪᖅᓴᐃᕕᒃ ᐱᓕᕆᕝᕕᐅᕙᑦᑐᖅ; ᑭᓯᐊᓂᓕ, ᐃᓚᖕᒋᑦ ᓱᕋᒐᔪᑉᐸᑦᑐᑦ ᓱᓕ ᐊᒻᒪ ᖃᐅᔨᓴᖅᑕᐅᕙᑦᑐᑎᒃ ᓱᕋᓐᓂᐅᓴᓕᖕᖕᒋᒃᑲᓗᐊᕐᒪᖕᖔᑕ ᐃᓚᖕᒋᑦ.

ᑎᓯᔪᓂᑦ ᓴᓂᕐᓂᒃ ᐊᐅᓚᑦᑎᓂᖅ

ᓴᓇᔭᐅᕆᐊᓕᓚᐅᖅᑐᖅ ᓄᑖᖅ ᐊᑦᓯᕕᑦᓴᖅ ᐊᐅᔭᖓᓂ 2022, ᐋᖅᑭᑦᑕᐅᕆᓪᓗᑎᒃ ᐆᓇᐃᓐᓇᕐᓂᖓᓄᑦ ᐱᓕᕆᔾᔪᑎᐅᔪᑦ ᐃᑲᔪᕐᓯᐃᔾᔪᑎᐅᔪᑦ ᑐᖕᖓᕕᖓᓂᑦ ᓴᓂᓕᕆᕝᕕᑦᓴᐅᑉ. ᐱᓕᕆᐊᑦᓴᖅ ᐱᒋᐊᕐᓯᒪᓕᖅᑐᖅ ᓂᐅᕕᐊᖑᕙᓪᓕᐊᓕᖅᑐᑎᒃ ᐱᒻᒪᕆᐅᓂᖕᒋᑦ ᓴᕕᕋᔭᑯᑖᑦ ᓱᓇᒃᑯᑖᑦᓴᖕᒋᑦ, ᓱᕐᓗ ᐊᖕᒋᔪᖅ ᐸᐊᓗᖓ ᐊᒻᒪ ᐊᐅᓚᑦᑎᔾᔪᑎᑦᓴᖕᒋᑦ ᐱᓕᕆᔾᔪᑏᑦ.

ᓄᓇᓕᐸᐅᔭᒃᑯᑦ ᐊᑦᓯᕕᖓᑦ ᓱᓕ ᐃᒋᑦᓯᕕᐅᕙᑦᑐᑦ ᐊᐅᓚᑕᐅᕙᑦᑐᓂᑦ ᑰᓕᐊᓇᐊᒥ ᐊᑦᓯᕕᒻᒥ - ᑕᒪᓐᓇ ᑲᔪᓯᓂᐊᖅᑐᖅ ᓄᑖᖅ ᐊᑦᓯᕕᑦᓴᖅ ᐊᒻᒪ ᓴᓂᓕᕆᕝᕕᑦᓴᖅ ᐱᔭᕇᖅᑕᐅᓇᓱᐊᕐᓂᖕᒋᓐᓂ ᑕᖅᑭᕐᓂ ᑭᖑᓪᓕᖅᐹᓕᓚᖕᒋᓐᓂ 2024.

ᐃᒥᖅᑕᕐᕕᐅᑉ ᓴᐳᓗᑎᖓ

2022-ᒥ, ᓄᓇᓕᐸᐅᔭᒃᑯᑦ ᐱᔭᕇᓚᐅᖅᑐᑦ ᓱᕋᑦᓯᒪᓂᖏᓐᓂᑦ ᓴᓇᓂᕐᒥᑦ, ᖃᐅᔨᓴᐅᑎᑦᓴᓂᑦ ᐋᖅᑭᑦᓱᐃᓗᑎᒃ ᐊᒻᒪ ᑎᑎᕋᕐᓯᒪᔪᓂᑦ ᓵᓗᑕᒥ, ᐊᒻᒪ ᐃᓗᓪᓕᕐᓱᐃᔾᔪᑎᑦᓴᓂᑦ ᓱᓇᑐᐃᓐᓇᕐᓂᑦ, ᑐᐊᐸᓂᑦ ᐊᒻᒪ ᐊᑯᓐᓈᕿᔪᓂᑦ ᐃᑲᔪᕐᓱᐃᔾᔪᑎᑦᓴᓂᑦ ᐊᕐᕌᒍᑕᒦᖅ ᖃᐅᔨᓴᐅᑎᓄᑦ ᖃᓄᐃᓕᕐᒪᖔᖅ ᓵᓗᑕᐅᑉ. ᓄᓇᓕᐸᐅᔭᒃᑯᑦ ᐱᔭᕇᓚᐅᕐᒥᔪᑦ ᐋᖅᑭᑦᓱᐃᓂᕐᒥᑦ ᖃᐅᔨᓴᐅᑎᑦᓴᓂᑦ ᐊᒻᒪ ᐱᓕᕆᔾᔪᑎᓂᑦ ᑎᑎᕋᕐᕕᑦᓴᓂᑦ (ᑕᐃᑲᓂᑦᓴᐃᓐᓇᖅ ᖃᐅᔨᓴᐅᑎᖏᑕ ᐃᓂᖓᓄᑦ) ᖃᐅᔨᓴᖅᑕᐅᕐᑯᓪᓗᒋᑦ ᖃᓄᐃᓕᐅᕈᑎᐅᕙᓐᓂᐊᖅᑐᑦ ᓵᓗᑕᒥ ᐱᕐᑯᑎᓕᕆᓂᕐᒥᑦ ᐱᔾᔪᑎᖃᕐᓗᑎᒃ. ᐱᓕᕆᐊᑦᓴᖅ ᐱᒋᐊᖅᑎᑕᐅᓚᐅᖅᑐᖅ ᒪᓕᑦᑕᐅᓗᑎᒃ ᐊᑐᖅᑕᐅᓯᒪᔪᑦ ᓇᓗᓇᐃᔭᖅᑕᐅᓯᒪᔪᑦ ᓱᕗᓪᓕᕐᓂ ᓵᓗᑕᒥᑦ ᖃᐅᔨᓴᐅᑎᓂᑦ.

ᓄᓇᓕᐸᐅᔭᒃᑯᑦ ᑲᔪᓰᓐᓇᓂᐊᖅᑐᑦ ᖃᐅᔨᒪᔨᑕᐃᑦ ᓴᓇᒋᐊᓕᓐᓂᑦ ᖃᐅᔨᓴᖅᑎᑕᐅᕙᓪᓗᑎᒃ ᐊᒻᒪ ᖃᓄᖅ ᓴᓇᓯᒪᓂᐊᕐᓂᖓᓄᑦ ᐱᓕᕆᐊᑦᓴᓂᑦ 2023-ᒥ, ᐃᑲᔪᕐᓱᐃᔾᔪᑎᒋᓪᓗᒋᑦ ᓵᓗᑕᒥᑦ ᖃᐅᔨᓴᐅᑎᐅᓚᐅᖅᑐᑦ ᐊᑦᑕᓇᔾᔭᐃᒃᑯᑎᖏᓐᓂᑦ. ᐊᒻᒪᑦᑕᐅᖅ, ᓄᓇᓕᐸᐅᔭᒃᑯᑦ ᐱᓕᕆᐊᖃᐃᓐᓇᓂᐊᖅᑐᑦ ᕐᑯᐊᖅᑕᖅᑐᖓᑕ ᖃᓄᐃᓐᓂᖓᓂᑦ ᐊᒻᒪ ᓴᓇᒋᐊᖃᕐᓂᖏᓐᓂᑦ ᓴᓇᕙᓪᓗᑎᒃ.

INTRODUCTION

In June 2016, the City of Iqaluit (the City) was issued Water Licence number 3AM-IQA1626 (the Licence) by the Nunavut Water Board (NWB). This licence was issued for a ten-year period concluding in June 2026. The City has been granted seven (7) amendments to its licence so far to date, the last being an emergency Amendment No. 7 in 2022 due to a State of Emergency declared by the Territorial Government.

A requirement of the Licence is an annual report due March 31 of each year, summarizing activities governed by the Licence for the previous calendar year. The City was granted an extension on the submission of the 2022 Annual Report until April 28, 2023. In accordance with Schedule B of the Water Licence, this Annual Water Licence Report summarizes the activities conducted by the City of Iqaluit in 2022.

ANALYSIS

A. The monthly and annual quantities in cubic metres of fresh water withdrawn from the Lake Geraldine Reservoir (Monitoring Station No. IQA-01).

Table 1 summarizes the estimated monthly and annual quantities of water drawn from Lake Geraldine, the City of Iqaluit's raw water source. The total water usage for 2022 was 1,238,380 cubic metres, which is below the maximum allowable withdrawal allowance of 2,000,000 cubic metres (amended withdrawal allowance, as per Amendment No. 4).

Table 1 2022 Raw Water Drawn from Lake Geraldine Reservoir

Month	Volume (m^3)
January	105,520
February	101,500
March	118,610
April	111,037
May	126,059
June	113,603
July	93,571
August	87,797
September	84,980
October	98,539
November	99,268
December	97,896
Total	**1,238,380**

B. The monthly and annual quantities in cubic metres of any discharges from the Wastewater Treatment Facilities (Monitoring Stations No. IQA-02, IQA-04, IQA-08).

No effluent was discharged from the Sewage Lagoon to Frobisher Bay (Station ID IQA-02) between January 1, 2022 and December 31, 2022.

A total volume of 1,115,913 cubic metres of effluent was discharged from the City's WWTP to Frobisher Bay (Station ID IQA-04) in 2022. As summary of this is presented in Table 2.

Table 2 IQA-04 – Discharge from the WWTP in 2022

Month	Volume (m^3)
January	100,258
February	97,232
March	112,641
April	70,357
May	88,914
June	107,975
July	88,914
August	83,378
September	85,363
October	93,601
November	94,229
December	93,052
Total	**1,115,913**

A total volume of 1,500 cubic metres of effluent was discharged from West 40 Landfill Pond #2 to the environment (Station ID IQA-08). The effluent was discharged from Pond #2 to the environment between August 22, 2022 to August 26, 2022. Testing was completed at the start and at the end of the discharge period.

C. Reports generated from Dam Safety Inspections and Dam Safety Reviews and proposed actions to address issues identified and/or updates on continuing actions to address issues.

The City undertook Dam Safety Inspections (DSI) in 2022, as per requirements of the Canadian Dam Association (CDA) *Dam Safety Guidelines*. Four (4) separate inspections were conducted between April and September 2022. A Dam Safety Review (DSR) was not completed in 2022, as one was previously completed in 2021. The requirement for a DSR is every five (5) years as part CDA guidelines.

Details of the DSI's are highlighted below.

<u>Lake Geraldine Dam Safety Inspection</u>

Concentric Associates International Inc. was retained to conduct a Dam Safety Inspection in 2022. Four (4) inspections were completed April 28, 2022, June 22, 2022, August 4, 2022, and September 29, 2022. The purpose of the DSI is to assist the City by identifying any visual changes in the condition of the dam, identifying any new concerns, and making recommendations on maintenance, repairs, or further investigations. It is conducted in order to ensure adherence to the Canadian Dam Safety Guidelines.

The DSI produced the following recommendations:

- Items deemed to be of an urgent need include:
  - The contaminated soil around the base of the hydro pole adjacent to the south berm should be removed.
  - Replace stockpile material that Nunavut Excavating (contractor) used.
- Updating of the permanent record file and its storage in a central location with an index that documents the date and contents of all records. The permanent record file needs to include:
  - As-built drawings and specification for work undertaken at the dam.
  - Weekly/ monthly inspections completed by City staff.
  - Dam Safety Inspections and Dam Safety Reviews generated by third parties on behalf of the City of Iqaluit.
  - All maintenance records.
  - Correspondence with regulatory agencies.
  - Dam operation, maintenance, and surveillance documents.
  - Reports and documentation generated by third parties on behalf of the City of Iqaluit.
- Implement a public awareness program to educate and inform the public that:
  - The dam and earthen berms are a "*no trespass area*."
  - Dog walkers should not allow their pets to travel atop and across the earthen berms due to risk of (dog) fecal matter contamination of the potable water supply.
  - ATV and skidoos should not be traveling atop the berms and across Lake Geraldine.
- The protective galvanized metal enclosure installed over the pipeline from the dam to the water treatment plant should be re-instated.
- The metal posts/ markers that were installed along the north side of the south access road should be re-instated.
- The aggregate stockpiles maintained at the west side of the north berm should be replenished by Nunavut Excavating.
- The installation of video surveillance should be considered with a scheduled implementation in the summer of 2023.
- Exercising and testing of the valves within the valve chamber is required as part of preventative measures. The condition of the valves within the valve chamber at the base of the dam was previously identified as being in an advanced state of corrosion. To our knowledge no maintenance or

testing has been completed on the control valves in the last 5+ years. There is a significant potential for the valves to fail and not operate correctly when needed in an emergency. A study to address this issue is currently underway.
- Underwater survey of the concrete dam and spillway in 2023.
- Undertake a test opening on the downstream side of the concrete dam and center berm in late January – early February 2023 to ascertain the source of the water that forms large ice sheets within the valley in the winter months.
- Repair of cracks within the concrete dam, this work is tentatively scheduled for summer 2023.
- Repair of spalled concrete within the concrete dam, this work is tentatively scheduled for summer 2023.

A copy of the DSI's completed in 2022 have been included in Appendix A.

As it relates to construction works completed in 2022, the City performed the following work which was identified in previous DSI's:

- Installation of survey monuments.
- Stockpile of riprap, granular and medium sized fill material to support annual maintenance related activities at the dam.
- Installation of monitoring stations and data loggers (at the same location of the survey monuments) in order to monitor activities at the dam for asset integrity purposes.
- Installation of signage at the dam.
- Concrete crack injection at the dam.

In 2023, the City will be planning to undertake the following:

- <u>Engineering Studies/ Investigations and Design Works:</u>
    - Annual Dam Safety Inspections
    - Intake Valve Replacement Study
    - Dam Underwater Survey
    - Dam Structural Upgrades, which considers:
        - Increase the height of the concrete core wall.
        - Raise the crests of the north, centre, and south berms.
    - Scoping Study to evaluate the implementation of a warm water return line or bubbler system to prevent ice build-up/ loading against the concrete dam wall.
- <u>Construction Works:</u>
    - Installation of pressure and temperature sensors for all monitoring stations, as well as, a water depth sensor to monitor reservoir levels.
    - Concrete delamination and crack repairs.

D. The monthly and annual quantities in cubic metres of sludge removed from the Wastewater Treatment Facility.

Table 3 summarizes the monthly and annual quantities of sludge removed from the City of Iqaluit's Wastewater Treatment Plant (WWTP) in 2022 and disposed of at the City's West 40 Landfill.

Table 3 Sludge removed from the WWTP Treatment Plant (2022)

Month	Volume (m^3)
January	35.3
February	35.3
March	35.3
April	35.3
May	35.3
June	35.3
July	35.3
August	35.3
September	35.3
October	35.3
November	35.3
December	35.3
Total	**424**

On average, approximately 1,248 cubic metres of sludge was removed from the WWTP on a monthly basis and deposited at a designated area in the West 40 Landfill. This equated to an annual total of approximately 424 cubic metres of sludge deposited at the West 40 Landfill.

E. The monthly and annual quantities of waste disposed at the West 40 Landfill.

A survey and assessment of airspace consumption of the West 40 Landfill was completed by City consultant AECOM. The airspace consumption compares the waste surface and includes deposited waste and cover soil placement.

Table 4 summarizes the estimated monthly and annual quantities of waste deposited at the West 40 Landfill.

Table 4 Waste deposited at the West 40 Landfill (2022)

Month	Volume (m^3)
January	1,460
February	1,460
March	1,460

Month	Volume (m^3)
April	1,460
May	1,460
June	1,460
July	1,460
August	1,460
September	1,460
October	1,460
November	1,460
December	1,460
Total	**17,520**

A total volume of 17,520 cubic metres of airspace consumed, or waste disposed of at the West 40 Landfill in 2022. This translates to approximately 1,460 cubic metres of airspace consumed per month.

F. A summary report which includes all data and information generated under the Monitoring Program, including the QA/QC program, in electronic and printed formats acceptable to the Board.

In 2022, the City continued testing procedures as described in the City's Type A water licence 3AM-IQA1626, and Environmental Monitoring Program and Quality Assurance/ Quality Control Plan. Table 5 lists all samples that were taken in 2022. The complete monitoring results are provided in Appendix B.

Table 5 Summary of 2022 Sampling Conducted

Date	Test	Station ID	Sample Name	Lab Sample ID
07-Jan-2022	A	IQA-01	WTP Raw	B22-00715-1
07-Jan-2022	A	IQA-01	WTP Raw (Total)	B22-00715-2
07-Jan-2022	A	IQA-01	WTP Potable	B22-00715-3
07-Jan-2022	A	IQA-01	WTP Potable (Total)	B22-00715-4
07-Jan-2022	F	IQA-05	WWTP Influent	B22-00719-1
07-Jan-2022	F	IQA-04	WWTP Effluent	B22-00719-2
07-Feb-2022	F	IQA-05	WWTP Influent	B22-03737-1
07-Feb-2022	F	IQA-04	WWTP Effluent	B22-03737-2
14-Feb-2022	A	IQA-01	WTP Raw	B22-04569-1
14-Feb-2022	A	IQA-01	WTP Raw (Total)	B22-04569-2
14-Feb-2022	A	IQA-01	WTP Potable	B22-04569-3
14-Feb-2022	A	IQA-01	WTP Potable (Total)	B22-04569-4

Date	Test	Station ID	Sample Name	Lab Sample ID
10-Mar-2022	F	IQA-05	WWTP Influent	B22-06771-1
10-Mar-2022	F	IQA-04	WWTP Effluent	B22-06771-2
10-Mar-2022	A	IQA-01	WTP Raw	B22-06774-1
10-Mar-2022	A	IQA-01	WTP Raw (Total)	B22-06774-2
10-Mar-2022	A	IQA-01	WTP Potable	B22-06774-3
10-Mar-2022	A	IQA-01	WTP Potable (Total)	B22-06774-4
04-Apr-2022	F	IQA-05	WWTP Influent	B22-09300-1
04-Apr-2022	F	IQA-04	WWTP Effluent	B22-09300-2
05-Apr-2022	A	IQA-01	WTP Raw	B22-09529-1
05-Apr-2022	A	IQA-01	WTP Raw (Total)	B22-09529-2
05-Apr-2022	A	IQA-01	WTP Potable	B22-09529-3
05-Apr-2022	A	IQA-01	WTP Potable (Total)	B22-09529-4
04-May-2022	F	IQA-05	WWTP Influent	B22-13155-1
04-May-2022	F	IQA-04	WWTP Effluent	B22-13155-2
04-May-2022	A	IQA-01	WTP Raw	B22-13165-1
04-May-2022	A	IQA-01	WTP Raw (Total)	B22-13165-2
04-May-2022	A	IQA-01	WTP Potable	B22-13165-3
04-May-2022	A	IQA-01	WTP Potable (Total)	B22-13165-4
01-May-2022	F	IQA-05	WWTP Influent	B22-16642-1
01-May-2022	F	IQA-04	WWTP Effluent	B22-16642-2
08-Jun-2022	E	IQA-08	Detention Pond 2	B22-17677-1
13-Jul-2022	E	IQA-08A	Landfill Station Up-Gradient	B22-22252-1
13-Jul-2022	E	IQA-08B	Landfill Station Down-Gradient	B22-22252-2
13-Jul-2022	F	IQA-02	Pond #2 (Middle Decant)	B22-22252-3
19-Jul-2022	F	IQA-08	Pond #2 (End Decant)	B22-23005-1
03-Aug-2022	F	IQA-05	WWTP Influent	B22-24732-1
03-Aug-2022	F	IQA-04	WWTP Effluent	B22-24732-2
06-Sep-2022	F	IQA-05	WWTP Influent	B22-28893-1
06-Sep-2022	F	IQA-04	WWTP Effluent	B22-28893-2
03-Oct-2022	A	IQA-01	WTP Raw	B22-31153-1
03-Oct-2022	A	IQA-01	WTP Raw (Total)	B22-31153-2
03-Oct-2022	A	IQA-01	WTP Potable	B22-31153-3

Date	Test	Station ID	Sample Name	Lab Sample ID
03-Oct-2022	A	IQA-01	WTP Potable (Total)	B22-31153-4
04-Oct-2022	F	IQA-05	WWTP Influent	B22-31298-1
04-Oct-2022	F	IQA-04	WWTP Effluent	B22-31298-2
07-Nov-2022	F	IQA-05	WWTP Influent	B22-33946-1
07-Nov-2022	F	IQA-04	WWTP Effluent	B22-33946-2
30-Nov-2022	A	IQA-01	WTP Raw	B22-35266-1
30-Nov-2022	A	IQA-01	WTP Raw (Total)	B22-35266-2
30-Nov-2022	A	IQA-01	WTP Potable	B22-35266-3
30-Nov-2022	A	IQA-01	WTP Potable (Total)	B22-35266-4
01-Dec-2022	F	IQA-05	WWTP Influent	B22-35431-1
01-Dec-2022	F	IQA-04	WWTP Effluent	B22-35431-2
12-Dec-2022	A	IQA-01	WTP Raw	B22-36009-1
12-Dec-2022	A	IQA-01	WTP Raw (Total)	B22-36009-2
12-Dec-2022	A	IQA-01	WTP Potable	B22-36009-3
12-Dec-2022	A	IQA-01	WTP Potable (Total)	B22-36009-4

G. A summary of all construction activities carried out for the facilities.

Solid Waste Facility

The City awarded the major civil contract for the construction of the new landfill and access road. Construction of the new landfill began, which included the commencement of construction activities for the west and south perimeter road, excavating and placement of excavated material for Cell Number 1.

Similarly, the City awarded the major contract for the construction of the new Waste Transfer Station. Construction activities consisted of preparatory work for the installation of the facility's thermosyphon system, Pilitak Enterprise was appointed and completed the installation of the thermosyphon system, which is a requirement for the construction works to commence during the 2023 construction season.

H. A summary of any modifications and/or major maintenance work carried out at the facilities and any associated structures.

Water Treatment Plant

Several upgrades and improvements were made to the WTP. The heating system was updated by replacing the existing boilers, burners, heat exchangers, and adding a flow transmitter. Additionally, the laboratory and washrooms were renovated to enhance the functionality of the facility. This included installing new stainless-steel countertops and dual sinks, replacing overhead cupboards and counter cabinets, flooring and new toilets.

In response to the 2021 WTP contamination event, the existing filter media material was removed and replaced with Granular Activated Carbon (GAC). Remediation and sealing of the concrete wall structures for the North Clearwell, South Clearwell, Mixing Chamber, Pumping Chamber, Backwash to Waste Chamber, and Surge Tank walls was completed. Lastly, two critical isolation valves located at the Mixing Chamber and South Clearwell were replaced in order to resume normal operation. The City anticipates that the WTP will return to normal operation in April 2023, pending final approval from the Government of Nunavut.

In 2023, the City will undertake the replacement of the UV disinfection system, as the current system has exceeded its design services life and is no longer supported for spare parts by the Original Equipment Manufacturer (OEM).

Reheat Station 222

Reheat Station 222 underwent several upgrades and improvements to its equipment and infrastructure. The stations boilers, glycol pumps, water service pumps, heat exchangers, and fuel transfer pumps were replaced with new technology. Old piping and chimney flues were also replaced, while the existing instrumentation (integrated with the WTP SCADA system) was recalibrated. The work was completed in order to improve the efficiency, reliability, and safety of the station. The new boilers, pumps, and heat exchangers will improve the heating performance, while the new fuel transfer pumps will ensure that the fuel is delivered efficiently to the boilers. The replacement of the old piping and chimney flues will improve the safety of the station, while the recalibration of instrumentation will ensure that the station is being monitored accurately – this will better serve operations and maintenance requirements for the facility.

Lift Station #1

A temporary by-pass of Lift Station #1 wet-well was in place in order to perform cleaning of the wet-well. An engineered by-pass system was constructed in order to divert flows away from the wet-well in order to perform the work safely. The work was successfully completed on June 7, 2022.

I. A progress report and revisions (if applicable) to any studies requested by the Board that relate to waste management, water use, or reclamation and a brief description of any future studies planned by the Licensee including, a non-technical executive summary for the general public, translated into Inuktitut.

Apex River Supplemental Pumping

In 2022, supplementary pumping of water from the Niaqunguk River to Lake Geraldine was undertaken in support of recharging the City's raw water reservoir prior to the forthcoming winter season. Pumping activities took place between June 13 and September 18, 2022 (apart from between July 10 and July 23, 2022, when flows in the Niaqunguk River were below 30% of the Mean Annual Discharge (MAD)).

On August 12, 2022 the City declared a public health situation due to a raw water shortage. This situation arose due to unforeseen water usage over the prior winter and spring seasons (contamination of treated water and firefighting), and ongoing exceptionally dry conditions (including historically low flow conditions in Apex

River). In line with the City's existing water licence (Type A Water Licence 3AM-IQA1626, Amendment No. 4), the City sought and received authorization from Fisheries and Oceans Canada (DFO) to take additional water from the Apex River. At the completion of pumping activities, and once Lake Geraldine approached its capacity limit, pumping activities were stopped with a total of 419,324 m³ transferred to Lake Geraldine Reservoir during the season. The maximum daily pumped volume was 14,519 m³. Pumping records were maintained by the contractor at the pumping site and were provided to City's representative (Nunami Stantec Limited) for review and tabulation throughout the program.

It is noted that supplementation from Unnamed Lake, as authorized through Emergency Amendment No. 7, was not undertaken during the 2022 calendar year.

The final DFO/ CIRNAC report can be found in Appendix C.

A non-technical executive summary can be found in Appendix D.

J. Any revisions required, in the form of addenda, to Plans, Manuals and Reports approved under the Licence.

Revisions were made to the following O&M manuals, as the City undertook projects to either replace or upgrade existing equipment that was either at end of service life, or had failed.

- WTP Heating System Upgrades
  - Replacements of existing boilers, burners, heat exchangers, and flow meters
- Reheat Station 222 Mechanical Upgrades
  - Replacements of existing boilers, burners, heat exchangers, and flow meters

K. A list and description, including volumes and Spill Report Line Identification Numbers, of all un-authorized discharges, spills and summaries of follow-up action taken.

Table 6 below provides a summary of all reported spills/ un-authorized discharges that occurred in 2021.

Table 6 Summary of spills/ un-authorized discharges in 2020

Spill ID	Date	Location	Type	Volume	Cause	Follow-Up Action
2022044	17-Feb-2022	WWTP (63.745833, -68.538889)	Wastewater	Unknown	Other	Electrical repairs conducted to start the pumps and blasting of the over flow line into the lagoon.
2022070	09-Mar-2022	MH69 (63.748574369774104, -68.50649598466433)	Wastewater	Unknown	Overflow Event	Clean up of sewage overflow and remediation work carried out on overflow line done by the city crew
2022090	20-Mar-2022	Qikitani Correctional Facility (63.758933762490535, -68.54340355102609)	Wastewater	Unknown	Other	Clean out of the blockage in the manhole and cleanup of the sewage spill done by city crew
2022093	23-Mar-2022	MH23B (Behind Lift Station #2)	Wastewater	Unknown	Overflow Event	Clean up conducted by city crew

2022110	03-Apr-2022	AV253 (63.74889469999999, -68.5203835)	Wastewater	Unknown	Breakage	Pump out and blasting of the backed up sewer line. Clean up of the overflow
2022129	12-Apr-2022	WWTP (63.7450875, -68.5452656)	Wastewater	Unknown	Unknown	Pumping out of the sewage backup and cleanup of the spill
2022174	09-May-2022	MH69 (63.7480625, -68.5061094)	Wastewater	Unknown	Overflow Event	Pumping out of the sewer blockage to restore flow
2022219	20-May-2022	MH76 (63.7483155, -68.5067765)	Wastewater	Unknown	Overflow Event	Pumping out of the manhole and blasting of the main to cleanout debris. Cleanup of the sewage spill
2022247	09-Jun-2022	MH76 (63.7483155, -68.5067765)	Wastewater	Unknown	Breakage	Pumping out of the manhole and cleanup of spill
2022268	13-Jun-2022	Nakasuk School (63.74669300000001, -68.5169669)	Wastewater	Unknown	Breakage	Pumping out of the manhole and blasting of the main to cleanout debris. Cleanup of the sewage spill and dump the sewer spill at the lagoon
2022428	21-Aug-2022	WWTP (63.745833, -68.538889)	Wastewater	Unknown	Overflow Event	PLC failure addressed by onsite electrician. Cleanup of the sewage spill at the pump dump station
2022431	23-Aug-2022	Lift Station #1 (63.745278, -68.522778)	Wastewater	Unknown	Unknown	Pump out and blasting of the blocked sewage main. Clean up of the spill
2022452	08-Sep-2022	MH58 (63.742222, -68.503611)	Wastewater	Unknown	Unknown	Pump out and blasting of the blocked sewage line
2022482	02-Oct-2022	Between MH63B and MH63A	Wastewater	Unknown	Other	Pump out and blasting of the sewer main

L. A summary of any closure and reclamation work undertaken and an outline of any work anticipated for the next year, including any changes to implementation and scheduling.

No closure and reclamation work was undertaken in 2022.

M. A summary of actions taken to address concerns or deficiencies listed in the inspection reports and/or compliance reports filed by an Inspector.

No inspections or compliance reports were filed requiring actions to address concerns or deficiencies in 2022.

N. A brief update on the implementation plan of all facilities within the scope of this Licence including projected implementation and status of the Upgraded Wastewater Treatment Plant.

Wastewater Treatment Plant

No further works were completed in 2022 with all substantial completion of the generator granted in November 2021. The City continued to manage the completion of deficiencies and troubleshooting activities with the General Contractor in 2022. Final completion certificate presented to the City in March 2022.

Landfill and Waste Transfer Station

Construction began on the new landfill in 2022. The City also awarded the major construction contract for the construction of the new Waste Transfer Station (WTS). Construction mobilization and installations began for the thermosyphon foundation system for the new WTS. The project also began procurement of major long-lead equipment, such as the biomass boiler and conveyor system. Construction efforts will resume in 2023.

The City continued to engage its consultant and NWB on leachate characterization plan, and lagoon constructability options for the new Landfill.

O. A summary of any studies, reports and plans requested by the Board that related to waste disposal, water use, or reclamation and a brief description of any future studies planned.

Long-Term Water Supply and Storage

In 2022, the City's Consultant Nunami Stantec (Stantec) continued their high-level options analysis evaluation of the two alternatives being considered for Long-Term Water Supply – i.e.: Sylvia Grinnell River and Unnamed Lake. Through this engagement, the City and Nunami Stantec completed stakeholder engagement activities with both the local Hunters and Trappers Association (HTA), as well as the Qikiqtani Inuit Association (QIA). A further presentation to the City's Public Works and Engineering Committee of the Whole meeting was completed. Following presentation of the options analysis outcomes to the City's Council, the City has now identified the Unnamed Lake water supply source as the preferred option to take forward for further assessment, design development and permitting activities. Also in 2022, the City has secured Infrastructure Canada funding (through the Disaster Mitigation and Adaptation Fund) to secure Iqaluit's Long Term Water security, and specifically to progress the supply and storage aspects of the Long-Term Water project. A copy of Stantec's final evaluation report can be found in Appendix E.

In 2023 and beyond, the City will progress a combined approach to the preferred Long-Term storage and supply alternatives under one project. With the engagement of an overall project management consultant in late 2022, the City will now look to commence Preliminary Engineering Design for the recommended options in Q2-2023. Future preliminary engineering design (set to commence in Q2-2023) will consider the technical, constructability, environmental, and economic viability of the supply source to the Lake Geraldine and adjacent independent reservoirs.

P. Any other details on the use of water or waste disposal requested by the Board by November 1st of the year being reported.

There are no additional details to be shared.

R. Monthly and annual quantities in cubic metres of fresh water withdrawn from Imiqtarviviniq (Dead Dog Lake) at Monitoring Station No. IQA-14.

A total volume of 150 cubic metres of water was withdrawn from Dead Dog Lake (Station ID IQA-014) in 2022. A summary of this is presented in Table 7.

Table 7 IQA-14 – Water Withdrawn from Dead Dog Lake

Month	Volume (m^3)
January	0
February	0
March	0
April	0
May	90
June	60
July	0
August	0
September	0
October	0
November	0
December	0
Total	**150**

APPENDIX A

DAM SAFETY INSPECTION REPORTS

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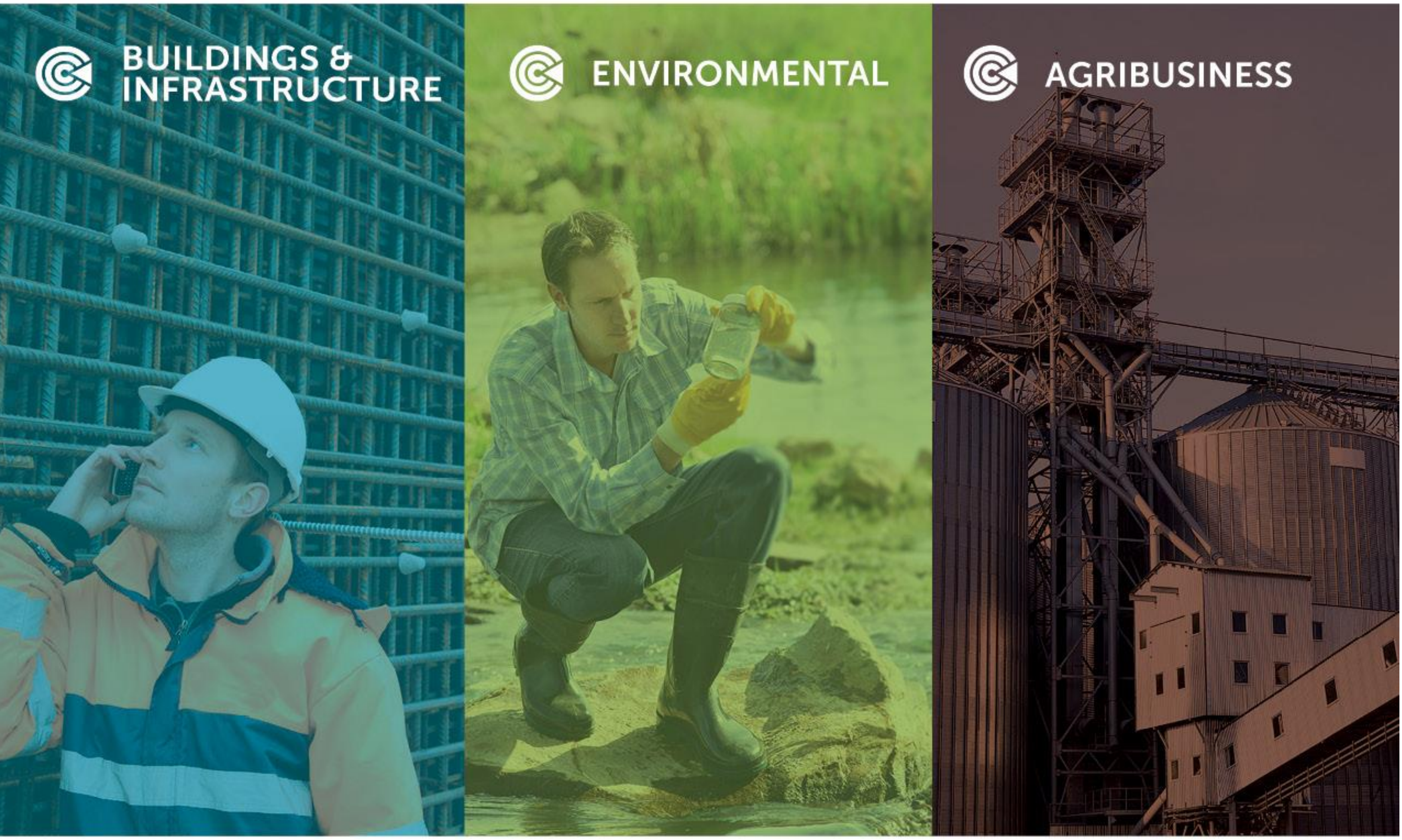

LAKE GERALDINE DAM
DAM SAFETY INSPECTION 2022 #1
IQALUIT, NUNAVUT

PRODUCED FOR: THE CITY OF IQALUIT
C/O COLLIERS PROJECT LEADERS

PRODUCED BY: CONCENTRIC ASSOCIATES INTERNATIONAL INCORPORATED

CONCENTRIC REFERENCE NUMBER: 21-9162

DATE: JUNE 30, 2022

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1. INTRODUCTION AND SCOPE OF WORK

This Dam Safety Inspection (DSI) of the Lake Geraldine Dam (LG Dam) has been prepared for the City of Iqaluit (City). As the owner and operator of the LG Dam, the City of Iqaluit is responsible for its safe management and operation. The intent of this DSI is to assist the City by identifying any visual changes in the condition of the LG Dam, identifying any new concerns, and making recommendations on maintenance, repairs, or further investigations.

1.1 Dam Safety Guidelines

The most recent Dam Safety Guidelines (DSG), published by the Canadian Dam Association, were first released in 2007 and further revised in 2013. The DSG applies, in general, to those structures that are at least 2.5 meters in height, and which have at least 30,000 cubic meters of storage capacity. The LG Dam exceeds these minimum requirements and therefore requires annual DSI's. The DSI is considered to be an Engineering Inspection which is recommended by the DSG to be performed annually or semi-annually by a professional engineer. A Dam Safety Review (DSR) is required at a minimum, every 5 years. The most recent DSR was performed in 2021.

This DSI forms part of the dam's permanent record documentation along with other documentation that make up the historical record of the dam (and berms). Section 3.6 "Surveillance" of the DSG recommends more frequent visual inspections be performed. Routine inspections performed by City staff trained in dam surveillance are recommended on a weekly basis to identify any conditions that might indicate a change in the dam's performance.

1.2 Description of Structure

The LG Dam is comprised of a concrete section with an integral concrete spillway, and three earthen berms: the north, center, and south berms. See below for a reference site plan and Appendix A for site photographs.

The 15.3 m wide spillway has an upper elevation of 111.1 m (representing the current maximum operating level of the reservoir), while the concrete dam sections on either side of the spillway have an elevation of 112.3 m. At the maximum operating level of the reservoir, the concrete dam has approximately 0.95 m of freeboard.

The southern section of the concrete dam extends approximately 39.1 m to the south rock abutment. The northern section of the concrete dam extends 13.3 m to the north of the spillway section, where it joins the center earth berm.

The center earth berm extends north approximately 75 m where it meets the access ramp and north access road. The north earth berm is located to the north of the access road ramp and extends 60m to the north rock abutment.

The south earth berm is a separate structure that is located in a valley to the south of the main concrete dam. The south berm is approximately 68.5 m long. The north and center berms incorporate a concrete cutoff wall which is reportedly founded in rock at the base of the berms.

Site Plan

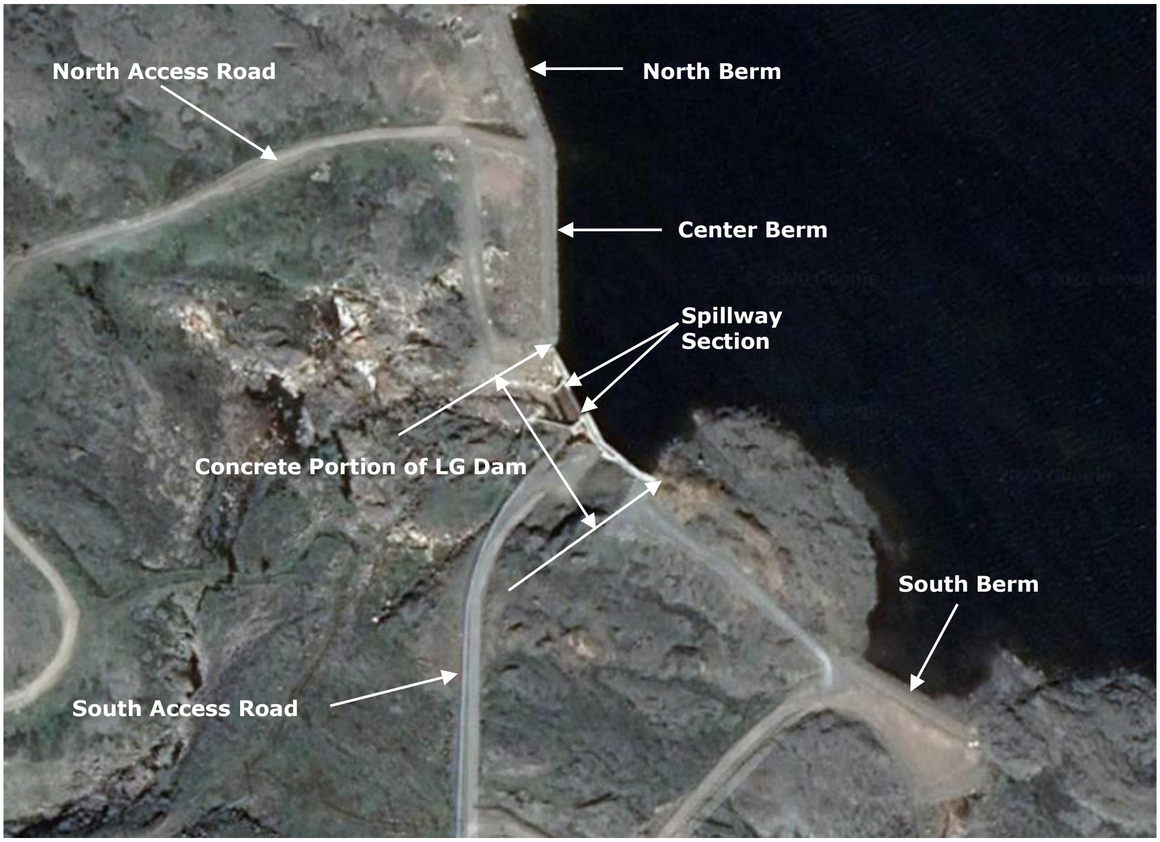

Table 1.1: Lake Geraldine Dam Summary*

Dam/Berm Segment	Length (m)	Crest Elevation	Base Elevation	Bedrock Elevation	Height of Dam/Berm (m)
North Berm	55.5	112.5	108.3	105.0	4.3
Center Berm	78.0	112.5	108.3	97.5	4.5
North Dam	13.3	112.3	102.6	97.5	11.0
Spillway	15.3	111.1	101.6	96	10.0
South Dam	39.1	112.3	102.6	67.5	11.0
South Berm	68.5	112.5	111.5	110.0	1.0

*Tabular data based upon Meco "Dam Safety Management Plan", July 2020

1.3 Scope of Work

As per the requirements of the Dam Safety Guide, the primary task of this DSI is to help identify any significant visual changes in the condition of the concrete dam and earthen berms based on a comparison with the previous inspections and reviews. A visual inspection can identify issues related to dam safety and provides the City of Iqaluit with the opportunity to mitigate any observed concerns or issues. This DSI report is the

primary deliverable and has been prepared in accordance with the Dam Safety Guide document.

The following is a summary of the scope of work for this assignment:

- Conduct a visual on-site assessment of the dam and berms above the water line;
- Prepare a photographic record documenting general and representative conditions;
- Identify, characterize, and risk-assess any significant visual changes in condition;
- Prepare a written report summarizing our observations, items of concern, and recommendations;
- Indicate any recommended repairs and outstanding recommendations from previous inspections and reviews;
- Submit final documents in electronic format.

2. HISTORY & BACKGROUND

2.1 Reservoir

The City of Iqaluit derives its water supply from Lake Geraldine, which is retained by a structure consisting of a cast in place concrete section incorporating an integral spillway, and three earthen berms. All concrete structures are reported to be founded on bedrock and engage the rock abutment at the south end of the concrete structure.

Lake Geraldine is a natural body of water in an irregularly shaped basin. It is fed by rainfall and snow/ice melt from a watershed with an area of approximately 385 hectares.

2.2 History

In the late 1950's, the demand for a reliable year-round source of water resulted in the construction of a cast in place concrete gravity dam and a section of earth berm with a central cast in place concrete cut off wall. The project was designed and built by the Department of National Defense. According to the literature, the original construction took place circa 1958.

Since that time, as the City has grown and water demands have risen, the dam has been raised four times to increase the storage capacity. In recent years, the City of Iqaluit has been pumping additional water into the reservoir in the fall of the year from a river located east of the reservoir.

The first height increase of the concrete dam and berms (0.3m) reportedly took place in 1979. This involved a concrete extension, which was dowelled into the existing structure.

The second height increase of the concrete dam and berms took place in 1985 and increased the height of the spillway structure by approximately 1.15m. The berm portion was widened and heightened as well to accommodate the increased storage capacity of the reservoir. The extension of the concrete dam was constructed of concrete dowelled into the existing structure and incorporated a steel formwork frame over the spillway section.

The third extension was undertaken in 1995 and increased the height of the concrete structures by a further 1.5m, with a corresponding increase in berm geometry. Based on analysis done prior to the extension, it was determined that the concrete structures would not have an adequate factor of safety against overturning if the extension was simply "dowelled-in" as before. The 1995 alteration therefore included an extensive rock-anchoring program for the concrete portions to provide the required stability to the structure.

The latest extension was completed in two phases over 2005/06. Additional rock anchors were installed thought the concrete structures in 2005 in preparation for a further height extension of 2 m in 2006. The existing berms were enlarged and the existing cut-of-walls within the north and center berms were extended in height. A new berm (south berm) and cut off wall were installed to the south of the main dam structure.

The last major repair program undertaken was completed in the summer of 2021, various repairs were undertaken to maintain the concrete structures, berms, and access roads. These repairs included:

- Placement of additional aggregate material and regrading of the north and south access roads.
- Installation of additional riprap/armor stone on the upstream face of the center and north berms.
- Installation of additional aggregate and regrading of the top of the center and north berms.
- Crack repair and sealing on the downstream face of the concrete structures.
- Concrete repair on the downstream face of the dam.

Replacement of the expansion joint sealant material on the downstream face of the concrete structures was not completed in 2021. This work is currently scheduled to be completed in June 2022.

In August 2019 various repairs were undertaken to repair the upstream face (below the water line) of the dam. These repairs included:

- Repair of the expansion joint.
- Polyurethane crack injection.
- Localized concrete repairs.

3. DAM SAFETY INSPECTION

3.1 Site Inspections and Staff Interviews

A visual site inspection of the LG Dam was performed on April 28-29, 2022 by Ryan Terpstra, B.Eng., of Concentric. The inspection was non-invasive in nature and did not include an underwater survey or assessment.

A summary of observed conditions is as follows:

- Ice had formed on Lake Geraldine and snow accumulation was present on and at the base the berms, concrete structures, and Lake Geraldine.

- The reservoir level (top of ice) was approximately 250 mm below the top of the spillway at the time of our review. The water level within the reservoir reported by Natural Resources Canada on April 29, 2022 was 108.657 m, approximately 2.4 m below the level of the spillway. For reference the water level within the reservoir on April 30, 2021 was 109.287 m, the water level this year (April 30, 2022) is approximately 0.63 m lower than this time in 2021.
- No significant changes were noted in the general condition of the concrete structures. No active seepage/leakage was observed within the visible portions of the concrete structures. Direct access to the base of the concrete structures and berms was obstructed by significant snow accumulation. Based upon our previous inspections and experience; water leakage/seepage is likely present at or near the base of the Gridline J5 expansion joint in the concrete structure.
- Although the majority of the north, center, and south berms were covered in snow and ice, no significant changes, such as sloughing, slides, bulging or displacement was noted in the earthen berms. No active seepage/leakage was observed within the visible portions of the berms however, based upon our previous inspections and experience; water leakage/seepage may be present.
- The aggregate stockpiles located on the downstream side of the north berm could not be verified due to the accumulation of snow and ice at this location. Stockpile levels will be verified during our next visit to the site.
- Examination of the access roads was undertaken, however; a detailed examination was not possible due to the accumulation of ice and snow. The roads will be re-examined during our next site visit.
- Members of the public continue to access the Dam, and Lake Geraldine (when iced over). Approximately 8 – 12 people were observed traveling across the lake during our site review (see photograph 6). There appears to be a trail that has been established that originates at the gap in the snow/wind fencing to the south of the south berm and continues across the lake.
- Ice accumulation within the valley on the downstream side of the dam (see photo 5). The timing of this visual inspection was called in part to reported ice buildup below the concrete dam and central earth berm, see photograph 5. Similar ice buildups have been reported over the years, usually reported to Concentric in spring time. Previous investigations have not concluded the source of the ice buildup, with further investigation in combination with additional monitoring have not been pursued by the City.
- The valve chamber adjacent to the south side of the concrete spillway was inaccessible due to heavy snow accumulation at this location. We did not inspect or exercise the valve controls. The 2015 DSI identified that the valve controls within the chamber appeared to be in an advanced state of corrosion and it remains unclear if this issue has been addressed and or the valves tested in recent years.

3.2 Dam Safety Analysis

A dam safety analysis was not completed as part of this inspection, however; there were no obvious indicators that the concrete structures have had significant changes since the last DSI in 2021. The deep snow and ice on and around the Lake Geraldine Dam at the time of our inspection may have obstructed visual indicators such as sloughing, slides, bulging or displacement.

3.3 Operation, Maintenance, and Surveillance

This DSI falls under the requirements of a visual inspection by an engineer as stated in Section 3.6 "Surveillance" of the Dam Safety Guide. The lack of a centralized repository of operational and maintenance records has been an ongoing issue. This, along with other issues regarding the operation and maintenance of the dam and reservoir, is noted within both the "Dam Safety Management Plan" dated July 16, 2020 prepared by MECO and the 2021 Dam Safety Review dated May 31, 2022 prepared by Concentric.

3.4 Recommendations and Required Action

Based on our inspection and review, we recommend the following:

1. Appoint a person or third party to control and update the Permanent Record File.
2. Updating of the permanent record file and its storage in a central location with an index that documents the date and contents of all records.

   The permanent record file needs to include:

   a) As-built drawings and specification for work undertaken at the dam.
   b) Weekly/monthly inspections completed by City staff.
   c) Dam Safety Inspections and Dam Safety Reviews generated by third parties on behalf of the City of Iqaluit.
   d) All maintenance records.
   e) Correspondence with regulatory agencies.
   f) Dam operation, maintenance and surveillance documents.
   g) Reports and documentation generated by third parties on behalf of the City of Iqaluit.
3. Appoint a person or third party to control and update the Emergency Preparedness Plan and Emergency Response Plan. Review EPP and ERP, issue to local authorities, and update the list of EPP document holders. Provide training to personnel and external responders.
4. Implement a public awareness program to educate and inform the public that:
   a) The dam and earthen berms are a no trespass area.
   b) Dog walkers should not allow their pets to travel atop and across the earthen berms due to the risk of (dog) fecal matter contamination of the potable water supply.
   c) ATV and skidoos should not be traveling atop the berms and across Lake Geraldine.
5. Implementation of a monitoring program to record data from the installed network of piezometers and thermistors used to monitor hydrogeologic and thermal environments within the backfill and foundations. This work is tentatively scheduled for implementation in summer of 2022.
6. The installation of video surveillance is tentatively scheduled for implementation in the fall of 2022 - summer of 2023.

7. Removal and replacement of the sealant installed within the expansion joints on the top and downstream face of the concrete dam (to be completed by Tower Construction in June 2022).
8. Exercising and testing of the valves within the valve chamber is required as part of preventative measures. The condition of the valves within the valve chamber at the base of the dam were previously identified as being in an advanced state of corrosion. To our knowledge no maintenance or testing has been completed on the controls valve in the last 5+ years. There is a significant potential for the valves to fail and not operate correctly when needed in an emergency.
9. Underwater survey of the concrete dam and spillway in 2022 - 2023.
10. Repair of cracks within the concrete dam, including crack injection. This work is tentatively scheduled for summer 2022.
11. Repair of spalled concrete within the concrete dam, this work is tentatively scheduled for summer 2022.
12. Install survey monuments and implement a biannual survey program as per the last DSR.
13. Install remote surveillance cameras as per the Last DSR.
14. The City should commit to determining the likely sources of ice buildup below the concrete dam and earth berms. This accumulation of ice is not seen in adjacent hills and valleys, it would be logical to believe that the ice accumulation is related to the water reservoir located directly up hill. We are aware of 3 potential sources of water; the north berm adjacent to the north road, the center berm at the low valley, and the south end of the concrete dam south of the spill way. Regular inspection and records of these locations should be included. Snow clearing may also be required to accommodate inspection and recording. The priority should be to identify the sources of water, and then determine if the water movement poses a threat to the stability of the dam and berm structures.

4. LIMITATIONS

This report was prepared for the sole use of the City of Iqaluit.

This report was prepared exclusively for the purposed project and site locations outlined in this report. The report is based on information provided to, or obtained by Concentric as indicated in the report, and applies solely to site conditions existing at the time of the site investigations.

The conditions of the site may change over time or may have already changed due to natural forces or human intervention, and Concentric takes no responsibility for the impact that such changes may have on the accuracy or validity of the observations, conclusions and recommendations set out in this report.

The report does not extend to any latent defect or other deficiency which could not have been reasonably discoverable or discovered within the scope of the report. Information supplied by the City of Iqaluit or third parties for use in this report has not been verified by Concentric unless stated otherwise.

Concentric's report represents a review of available information with an established work scope, schedule, and budget. The material in the report reflects Concentric's judgement in light of the information available to it at the time of preparation. Any uses that a third party makes of this report, or any reliance on decisions made based on it, are the responsibilities of such third parties.

Concentric accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made based on this report.

Should there be any questions, please contact the undersigned.

Yours sincerely,

CONCENTRIC

Ryan Terpstra, B.Eng.
Designer

Kathleen Perry-Theriault, P.Eng.
Project Manager

APPENDIX A
Site Photographs

Photograph 1 – Overview of concrete structure, center berm and north berm.

Photograph 2 – Typical center berm condition at the time of our review.

Photograph 3 – Typical north berm condition at the time of our review.

Photograph 4 – Typical snow and ice accumulation on the downstream face of the north and center berms.

Photograph 5 – Snow and ice accumulation within the valley downstream of the concrete dam and earthen berms.

Photograph 6 – Typical public access atop and over the dam and onto the reservoir.

Photograph 7 – Typical damage to the fencing atop the dam.

Photograph 8 – Typical concrete condition, south of the spillway.

APPENDIX B

Lake Geraldine Dam Inspection Checklist

Lake Geraldine Dam Inspection Check List

Inspector Name:	Ryan Terpstra, Concentric	Reviewer:	-
Inspection Date:	April 28, 2022	Review Date:	-
Weather:	Cold, cloudy -10°C	Action Required:	None at this time (snow covered)

Sketch the deficiency, and note its important characteristics.
Measure the deficiency.
Photograph the deficiency or describe its characteristics in writing.
Locate the deficiency relative to a recognizable reference point.

General Observations

Description	Yes	No	Observations	Action Required
Snow and ice present on dam & berms	X		Snow up to berms, top of berm exposed 50%	
Snow and ice present on the lake	X		Evidence of ice about 20’ down from top of dam/berm	
North access road, gate secured (Any visible damage)	X		No damage	
South access road, gate secured (Any visible damage)		X	No gate present	Yes
Gates on the concrete dam locked (north and south ends on top of dam)	X		Yes locked	
Gates and fencing on top of dam intact or damaged		X	Damage to berm wire on top of north gate Damage to top of chain link of south fence next to gate	

Lake Geraldine Dam
Inspection Check List

Description	Yes	No	Observations	Action Required
Vandalism		X	None	
Debris on site or in the lake		X	No debris	
Dam signage intact or damaged	X		Intact, no damage	
Valve chamber condition and damage (Indicate if there is any cracking, displacement, physical damage, cover is in place, etc)		X	None that could be seen	
Uncontrolled breach in the concrete dam or earthen berms (embankments)		X		
Animal Activity:		X		

Additional Comments, Sketches or Observations

Concrete Dam and Spillway

Description	Yes	No	Observations	Action Required
Water level relative to sill of spillway (measure from top of the concrete dam) Is there flow over the spillway		X	Ice observed about 15' below spillway wall	
Cracking / spalling present on top (surface) of the concrete dam (Indicate if new, existing, expanded, length, width, depth)		X	None present on north side	
Cracking / spalling present on upstream face (surface) of the concrete dam (Indicate if new, existing, expanded, length, width, depth)		X	Snow covered not visible	
Cracking / Spalling present on Downstream face (surface) of the concrete dam (Indicate if new, existing, expanded, length, width, depth)	X		Small areas of efflorescence on north face down stream side + same on south side Small minor areas of spalling	
Active seepage / leakage through dam Is there silt / sand within the leaking water (Indicate location and rate of leakage in liters per minute)		X	None visible	
Sealant Condition – Top of Dam	X		Fair to good	
Sealant Condition – Up stream face of Dam			Not visible	
Sealant Condition – Downstream face of Dam	X		Good from what is visible	
Active seepage / leakage at: - Interface between concrete and ground (bedrock) - Sealant joints		X	None visible	

Description	Yes	No	Observations	Action Required
Displacement, settlement or misalignment of sections of the dam		X	None visible	
Debris / blockage within the spillway and or drainage channel at base of dam		X	None visible	
Erosion at the base of the spillway	X		Not visible due to snow cover	
Monitoring stations (condition, damage, other)			Not is place yet	

Additional Comments, Sketches or Observations

North Berm				
Description	Yes	No	Observations	Action Required
Sloughing, slides, bulging, collapse or displacement within the earthen berm – Top of Berm		X	Snow covered	
Sloughing, slides, bulging, collapse or displacement within the earthen berm - Upstream Face		X	Snow covered	
Sloughing, slides, bulging, collapse or displacement within the earthen berm - Downstream Face		X	Snow covered	
Depressions or sink holes within the top (crest) of the berm		X	Not visible/snow covered	
Depressions or sink holes within the upstream face of the berm		X	Not visible/snow covered	
Depressions or sink holes within the downstream face of the berm		X	Not visible/snow covered	
Rock, gravel or aggregate displacement or washout (erosion) with the top of the berm	X		Minor erosion at downstream side of berm top	
Rock, gravel or aggregate displacement or washout (erosion) within the upstream face of berm		X	Not visible/snow covered	
Rock, gravel or aggregate displacement or washout (erosion) within the downstream face of berm		X	Not visible/snow covered	

Description	Yes	No	Observations	Action Required
Displaced rip-rap /armor stone on the upstream face of berm		X	Not visible/snow covered	
Displaced rip-rap /armor stone on the downstream face of berm		X	Not visible/snow covered	
Transverse / longitudinal cracking, within the Top / crest of the berm (Indicate if new, existing, expanded, length, width)		X	Not visible/snow covered	
Transverse / longitudinal cracking, within the Upstream face of the berm (Indicate if new, existing, expanded, length, width)		X	Not visible/snow covered	
Transverse / longitudinal cracking, within the Downstream face of the berm (Indicate if new, existing, expanded, length, width)		X	Not visible/snow covered	
Wet area or active leakage / seepage within the downstream side face of berm Is there silt / sand within the leaking water		X	Not visible/snow covered	
Ponding water at base of the berm (downstream), is there sand or silt suspended within the water		X	Not visible/snow covered	

Additional Comments, Sketches or Observations

Center Berm				
Description	Yes	No	Observations	Action Required
Sloughing, slides, bulging, collapse or displacement within the earthen berm – Top of Berm		X	Not visible/snow covered	
Sloughing, slides, bulging, collapse or displacement within the earthen berm - Upstream Face		X	Not visible/snow covered	
Sloughing, slides, bulging, collapse or displacement within the earthen berm - Downstream Face		X	Not visible/snow covered	
Depressions or sink holes within the top (crest) of the berm		X	Not visible/snow covered	
Depressions or sink holes within the upstream face of the berm		X	Not visible/snow covered	
Depressions or sink holes within the downstream face of the berm		X	Not visible/snow covered	
Rock, gravel or aggregate displacement or washout (erosion) with the top of the berm		X	Not visible/snow covered	
Rock, gravel or aggregate displacement or washout (erosion) within the upstream face of berm		X	Not visible/snow covered	
Rock, gravel or aggregate displacement or washout (erosion) within the downstream face of berm	X		Minor erosion of side face of berm	

Description	Yes	No	Observations	Action Required
Displaced rip-rap /armor stone on the upstream face of berm		X	Not visible/snow covered	
Displaced rip-rap /armor stone on the downstream face of berm		X	Not visible/snow covered	
Transverse / longitudinal cracking, within the Top / crest of the berm (Indicate if new, existing, expanded, length, width)		X	Not visible/snow covered	
Transverse / longitudinal cracking, within the Upstream face of the berm (Indicate if new, existing, expanded, length, width)		X	Not visible/snow covered	
Transverse / longitudinal cracking, within the Downstream face of the berm (Indicate if new, existing, expanded, length, width)		X	Not visible/snow covered	
Wet area or active leakage / seepage within the downstream side face of berm Is there silt / sand within the leaking water		X	Not visible/snow covered	
Ponding water at base of the berm (downstream), is there sand or silt suspended within the water		X	Not visible/snow covered	

Additional Comments, Sketches or Observations

South Berm				
Description	Yes	No	Observations	Action Required
Sloughing, slides, bulging, collapse or displacement within the earthen berm – Top of Berm		X	Not visible/snow covered	
Sloughing, slides, bulging, collapse or displacement within the earthen berm - Upstream Face		X	Not visible/snow covered	
Sloughing, slides, bulging, collapse or displacement within the earthen berm - Downstream Face		X	Not visible/snow covered	
Depressions or sink holes within the top (crest) of the berm		X	Not visible/snow covered	
Depressions or sink holes within the upstream face of the berm		X	Not visible/snow covered	
Depressions or sink holes within the downstream face of the berm		X	Not visible/snow covered	
Rock, gravel or aggregate displacement or washout (erosion) with the top of the berm		X	Not visible/snow covered	
Rock, gravel or aggregate displacement or washout (erosion) within the upstream face of berm		X	Not visible/snow covered	
Rock, gravel or aggregate displacement or washout (erosion) within the downstream face of berm		X	Not visible/snow covered	

Description	Yes	No	Observations	Action Required
Displaced rip-rap /armor stone on the upstream face of berm		X	Not visible/snow covered	
Displaced rip-rap /armor stone on the downstream face of berm		X	Not visible/snow covered	
Transverse / longitudinal cracking, within the Top / crest of the berm (Indicate if new, existing, expanded, length, width)		X	Not visible/snow covered	
Transverse / longitudinal cracking, within the Upstream face of the berm (Indicate if new, existing, expanded, length, width)		X	Not visible/snow covered	
Transverse / longitudinal cracking, within the Downstream face of the berm (Indicate if new, existing, expanded, length, width)		X	Not visible/snow covered	
Wet area or active leakage / seepage within the downstream side face of berm Is there silt / sand within the leaking water		X	Not visible/snow covered	
Ponding water at base of the berm (downstream), is there sand or silt suspended within the water		X	Not visible/snow covered	

Additional Comments, Sketches or Observations

Lake Geraldine Dam Location Plan

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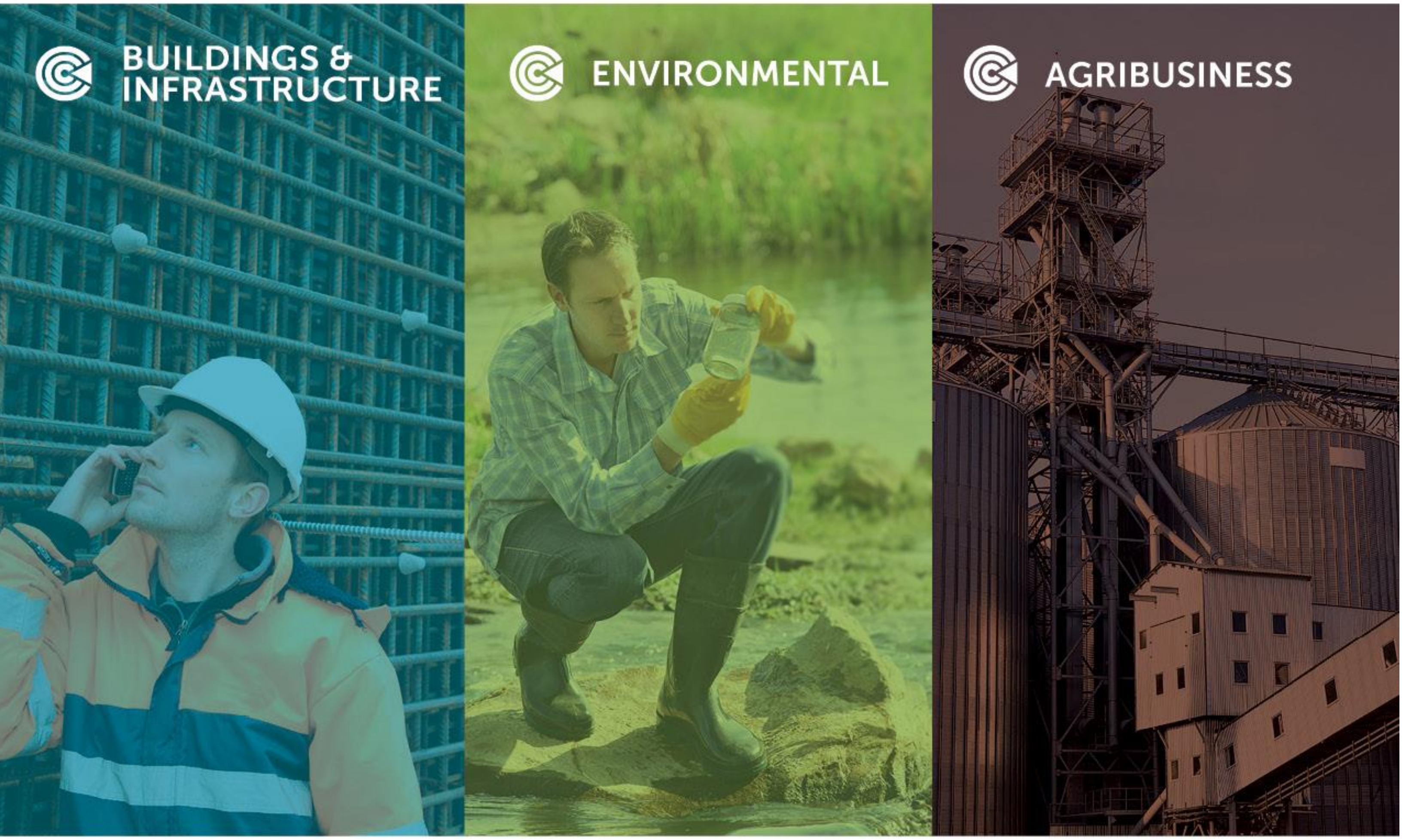

LAKE GERALDINE DAM
DAM SAFETY INSPECTION 2022 #2
IQALUIT, NUNAVUT

PRODUCED FOR: THE CITY OF IQALUIT
C/O COLLIERS PROJECT LEADERS

PRODUCED BY: CONCENTRIC ASSOCIATES INTERNATIONAL INCORPORATED

CONCENTRIC REFERENCE NUMBER: 21-9162

DATE: JULY 28, 2022

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LIST OF APPENDICES

1. INTRODUCTION AND SCOPE OF WORK

This Dam Safety Inspection (DSI) of the Lake Geraldine Dam (LG Dam) has been prepared for the City of Iqaluit (City). As the owner and operator of the LG Dam, the City of Iqaluit is responsible for its safe management and operation. The intent of this DSI is to assist the City by identifying any visual changes in the condition of the LG Dam, identifying any new concerns, and making recommendations on maintenance, repairs, or further investigations.

1.1 Dam Safety Guidelines

The most recent Dam Safety Guidelines (DSG), published by the Canadian Dam Association, were first released in 2007 and further revised in 2013. The DSG applies, in general, to those structures that are at least 2.5 meters in height, and which have at least 30,000 cubic meters of storage capacity. The LG Dam exceeds these minimum requirements and therefore requires annual DSI's. The DSI is considered to be an Engineering Inspection which is recommended by the DSG to be performed annually or semi-annually by a professional engineer. A Dam Safety Review (DSR) is required, at a minimum, every 5 years. The most recent DSR was performed in April 2022.

This DSI forms part of the dam's permanent record documentation along with other documentation that make up the historical record of the dam (and berms). Section 3.6 "Surveillance" of the DSG recommends more frequent visual inspections be performed. Routine inspections performed by City staff trained in dam surveillance are recommended on a weekly basis to identify any conditions that might indicate a change in the dam's performance.

1.2 Description of Structure

The LG Dam is comprised of a concrete section with an integral concrete spillway, and three earthen berms: the north, center, and south berms. See below for a reference site plan and Appendix A for site photographs.

The 15.3 m wide spillway has an upper elevation of 111.1 m (representing the current maximum operating level of the reservoir), while the concrete dam sections on either side of the spillway have an elevation of 112.3 m. At the maximum operating level of the reservoir, the concrete dam has approximately 0.95 m of freeboard.

The southern section of the concrete dam extends approximately 39.1 m to the south rock abutment. The northern section of the concrete dam extends 13.3 m to the north of the spillway section, where it joins the center earth berm.

The center earth berm extends north approximately 75 m where it meets the access ramp and north access road. The north earth berm is located to the north of the access road ramp and extends 60m to the north rock abutment.

The south earth berm is a separate structure that is located in a valley to the south of the main concrete dam. The south berm is approximately 68.5 m long. The north and center berms incorporate a concrete cutoff wall which is reportedly founded in rock at the base of the berms.

Site Plan

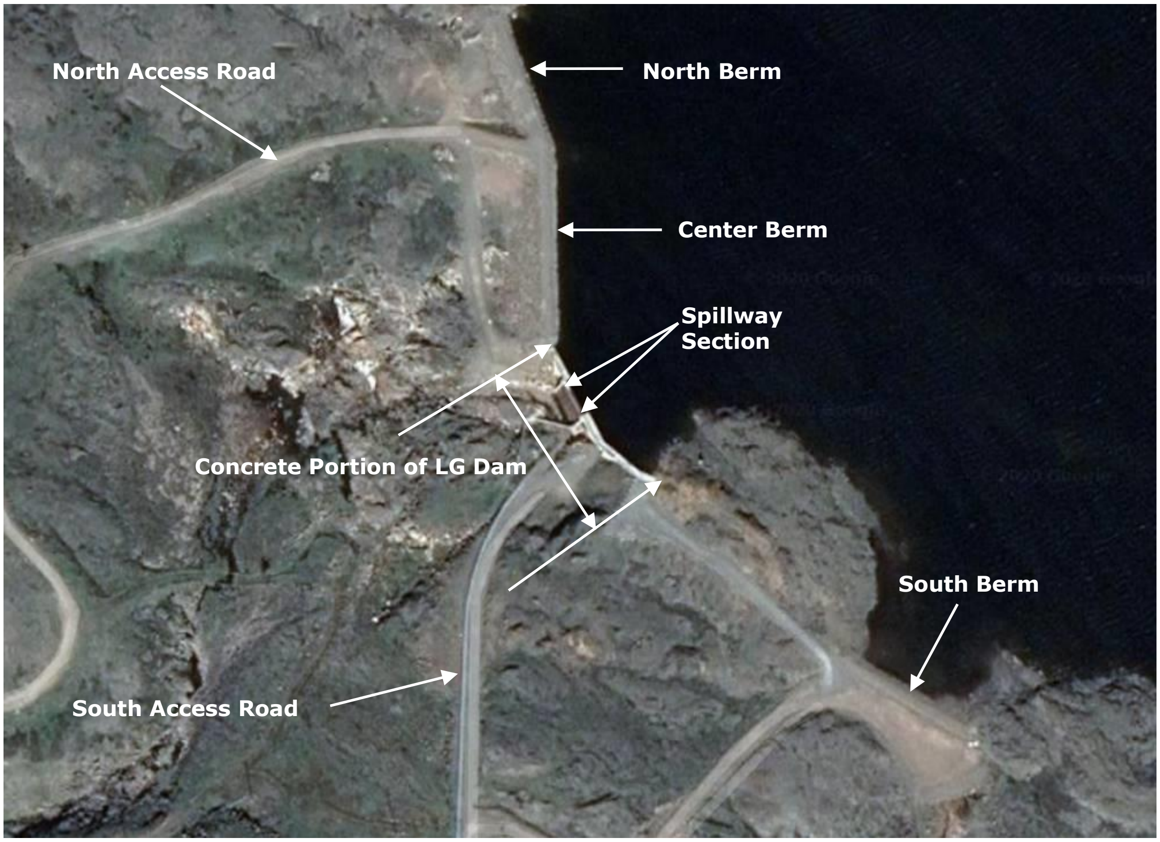

Table 1.1: Lake Geraldine Dam Summary*

Dam/Berm Segment	Length (m)	Crest Elevation	Base Elevation	Bedrock Elevation	Height of Dam/Berm (m)
North Berm	55.5	112.5	108.3	105.0	4.3
Center Berm	78.0	112.5	108.3	97.5	4.5
North Dam	13.3	112.3	102.6	97.5	11.0
Spillway	15.3	111.1	101.6	96	10.0
South Dam	39.1	112.3	102.6	67.5	11.0
South Berm	68.5	112.5	111.5	110.0	1.0

*Tabular data based upon Meco "Dam Safety Management Plan", July 2020

1.3 Scope of Work

As per the requirements of the Dam Safety Guide, the primary task of this DSI is to help identify any significant visual changes in the condition of the concrete dam and earthen berms based on a comparison with the previous inspections and reviews. A visual inspection can identify issues related to dam safety and provides the City of Iqaluit with the opportunity to mitigate any observed concerns or issues. This DSI report is the

primary deliverable and has been prepared in accordance with the Dam Safety Guide document.

The following is a summary of the scope of work for this assignment:

- Conduct a visual on-site assessment of the dam and berms above the water line;
- Prepare a photographic record documenting general and representative conditions;
- Identify, characterize, and risk-assess any significant visual changes in condition;
- Prepare a written report summarizing our observations, items of concern, and recommendations;
- Indicate any recommended repairs and outstanding recommendations from previous inspections and reviews;
- Develop a prioritized list of recommended repairs, upgrades, and improvements with Class D cost estimates;
- Submit final documents in electronic format.

2. HISTORY & BACKGROUND

2.1 Reservoir

The City of Iqaluit derives its water supply from Lake Geraldine, which is retained by a structure consisting of a cast in place concrete section incorporating an integral spillway, and three earthen berms. All concrete structures are reported to be founded on bedrock and engage the rock abutment at the south end of the concrete structure.

Lake Geraldine is a natural body of water in an irregularly shaped basin. It is fed by rainfall and snow/ice melt from a watershed with an area of approximately 385 hectares.

2.2 History

In the late 1950's, the demand for a reliable year-round source of water resulted in the construction of a cast in place concrete gravity dam and a section of earth berm with a central cast in place concrete cut off wall. The project was designed and built by the Department of National Defense. According to the literature, the original construction took place circa 1958.

Since that time, as the City has grown and water demands have risen, the dam has been raised four times to increase the storage capacity. In recent years, the City of Iqaluit has been pumping additional water into the reservoir in the summer and fall of the year from a river located east of the reservoir.

The first height increase of the concrete dam and berms (0.3m) reportedly took place in 1979. This involved a concrete extension, which was dowelled into the existing structure.

The second height increase of the concrete dam and berms took place in 1985 and increased the height of the spillway structure by approximately 1.15m. The berm portion was widened and heightened as well to accommodate the increased storage capacity of the reservoir. The extension of the concrete dam was constructed of concrete dowelled into the existing structure and incorporated a steel formwork frame over the spillway section.

The third extension was undertaken in 1995 and increased the height of the concrete structures by a further 1.5m, with a corresponding increase in berm geometry. Based on analysis done prior to the extension, it was determined that the concrete structures would not have an adequate factor of safety against overturning if the extension was simply "dowelled-in" as before. The 1995 alteration therefore included an extensive rock-anchoring program for the concrete portions to provide the required stability to the structure.

The latest extension was completed in two phases over 2005/06. Additional rock anchors were installed thought the concrete structures in 2005 in preparation for a further height extension of 2 m in 2006. The existing berms were enlarged and the existing cut-of-walls within the north and center berms were extended in height. A new berm (south berm) and cut off wall were installed to the south of the main dam structure. A subsequent technical analysis of the dam and earth berms completed in 2020 indicated that the spillway structure is marginally compliant for stability with relying on rock anchors to resist overturning. CDA guidelines indicate that it is not recommended that passive rock anchors are relied on for stability.

The last major repair program undertaken was completed in the summer of 2021, various repairs were undertaken to maintain the concrete structures, berms, and access roads. These repairs included:

- Placement of additional aggregate material and regrading of the north and south access roads.
- Installation of additional riprap/armor stone on the upstream face of the center and north berms.
- Installation of additional aggregate and regrading of the top of the center and north berms.
- Crack repair and sealing on the downstream face of the concrete structures.
- Concrete repair on the downstream face of the dam.

Replacement of the expansion joint sealant material on the downstream face of the concrete structures was not completed in 2021. This work is currently scheduled to be completed in June 2022.

In August 2019 various repairs were undertaken to repair the upstream face (below the water line) of the dam. These repairs included:

- Repair of the expansion joint.
- Polyurethane crack injection.
- Localized concrete repairs.

3. DAM SAFETY INSPECTION

3.1 Site Inspections and Staff Interviews

A visual site inspection of the LG Dam was performed on June 22-23, 2022 by Randy Scott, of Concentric. The inspection was non-invasive in nature and did not include an underwater survey or assessment.

A summary of observed conditions is as follows:

- Ice remains within Lake Geraldine and snow was present on the downstream face of the north berm.
- The reservoir level (top of ice) was approximately 2.5 m below the top of the spillway at the time of our review. The water level within the reservoir reported by Natural Resources Canada on June 22, 2022 was 109.95 m, approximately 2.4 m below the level of the spillway.
- The temporary road access to the south berm has been blocked with concrete barriers. See Photograph 4.
- The area around the base of the power pole that supplies power to the temporary water treatment facility at the south berm has what appears to be some form of oil / creosote around the base of the pole. See Photograph 5.
- A sink hole was found within the south access road, approximately 40’ south of the access control gate. See Photographs 6 & 7.
- No significant changes were noted in the general condition of the concrete structures. Seepage was observed at two locations within the visible portions of the concrete structures. See Photograph 8.
- The metal enclosures installed atop the piezometer boreholes have been removed and some of the borehole tube designated for the installation of the piezometers have been obstructed with grave and sand. See Photographs 9 & 10.
- Portions of the galvanized metal enclosure that covers the pipe that supplies water from the dam to the water treatment plant have been removed for some unknown reason. See Photographs 12 & 13.
- A metal corner post (used to indicate the edge of the road) has been knocked over by vehicle traffic. See Photograph 11.
- The warning signs installed along the north side of the south access road were removed when the temporary water treatment plant was in operation at the south berm. This signage has not been re-installed now that the treatment plant is no longer in operation.
- The warning signage that is placed at the base of the access ramp to the center/north berms has been pushed over.
- A small rut was observed at the north end of the south berm (presumably from a vehicle).
- Leakage was observed at the base of the interface between the bedrock and the concrete dam. Leakage of water has been observed at this location during previous inspections; however, there appears to be a minor increase in the flow observed at this location.

- Several depressions within the rip-rap stone of the berm on the upstream face of the north and center berms were noted. This area of the berms is generally below the water line and is not visible.
- With the exception of the above noted, no significant changes, such as sloughing, slides, bulging or displacement, were noted in the earthen berms. No active seepage/leakage was observed within the visible portions of the berms; however, based upon our previous inspections and experience, water leakage/seepage may be present within the center berm that is being masked by melt water from the snow and ice.
- The aggregate stockpiles located on the downstream side of the north berm have been used, it is our understanding that this material was used when the temporary water purification plant was operating. These stockpiles are scheduled to be replaced in the summer of 2022.
- Members of the public continue to access the Dam structures and Lake Geraldine.

Minor leakage at the base of the concrete dam at the interface with the bedrock has been consistent over the last 10+ years however, during our most recent site review we noted a minor increase in the flow of water at this location. Leakage at this location is believed to be caused by water moving through the fractured bedrock below the dam and seepage of water between the base of the concrete dam and bedrock. We did not observe any changes or displacement of the bedrock at the base of the dam. As such, we do not believe that the underlying bedrock has changed or been disturbed.

3.2 Dam Safety Analysis

A dam safety analysis was not completed as part of this inspection; however, there were no obvious indicators that the concrete structures have had significant changes since the last DSI.

3.3 Operation, Maintenance, and Surveillance

This DSI falls under the requirements of a visual inspection by an engineer as stated in Section 3.6 "Surveillance" of the Dam Safety Guide. The lack of a centralized repository of operational and maintenance records has been an ongoing issue. This, along with other issues regarding the operation and maintenance of the dam and reservoir, is noted within both the "Dam Safety Management Plan" dated July 16, 2020 prepared by MECO and the 2021 Dam Safety Review dated May 31, 2022 prepared by Concentric.

3.4 Recommendations and Required Action

Based on our inspection and review, we recommend the following:

1. Items deemed to be of an urgent need include:
   a. Repair the sink hole in the south access road.
   b. The contaminated soil around the base of the hydro pole adjacent to the south berm should be removed.
2. Updating of the permanent record file and its storage in a central location with an index that documents the date and contents of all records. The permanent record file needs to include:

a) As-built drawings and specification for work undertaken at the dam.

b) Weekly/monthly inspections completed by City staff.

c) Dam Safety Inspections and Dam Safety Reviews generated by third parties on behalf of the City of Iqaluit.

d) All maintenance records.

e) Correspondence with regulatory agencies.

f) Dam operation, maintenance, and surveillance documents.

g) Reports and documentation generated by third parties on behalf of the City of Iqaluit.

3. Implement a public awareness program to educate and inform the public that:

   a) The dam and earthen berms are a *no trespass* area.

   b) Dog walkers should not allow their pets to travel atop and across the earthen berms due to the risk of (dog) fecal matter contamination of the potable water supply.

   c) ATV and skidoos should not be traveling atop the berms and across Lake Geraldine.

4. The protective galvanized metal enclosure installed over the pipeline from the dam to the water treatment plant should be re-instated.

5. The metal posts / markers that were installed along the north side of the south access road to should be re-instated.

6. The warning signage at the base of the access ramp to the center – north berms should be repaired.

7. The aggregate stockpiles maintained at the west side of the north berm should be replenished.

8. Implementation of a monitoring program to record data from the installed network of piezometers and thermistors used to monitor hydrogeologic and thermal environments within the backfill and foundations. This work is tentatively scheduled for implementation in summer of 2022.

9. The installation of video surveillance is tentatively scheduled for implementation in the fall of 2022 - summer of 2023.

10. Exercising and testing of the valves within the valve chamber is required as part of preventative measures. The condition of the valves within the valve chamber at the base of the dam was previously identified as being in an advanced state of corrosion. To our knowledge no maintenance or testing has been completed on the controls valve in the last 5+ years. There is a significant potential for the valves to fail and not operate correctly when needed in an emergency.

11. Underwater survey of the concrete dam and spillway in 2023.

12. Undertake a test opening on the downstream side of the concrete dam and center berm in late January – early February 2023 to ascertain the source of the water that forms large ice sheets within the valley in the winter months.

13. Repair of cracks within the concrete dam, this work is tentatively scheduled for summer 2022.
14. Repair of spalled concrete within the concrete dam, this work is tentatively scheduled for summer 2022.

4. LIMITATIONS

This report was prepared for the sole use of the City of Iqaluit.

This report was prepared exclusively for the purposed project and site locations outlined in this report. The report is based on information provided to, or obtained by Concentric as indicated in the report, and applies solely to site conditions existing at the time of the site investigations.

The conditions of the site may change over time or may have already changed due to natural forces or human intervention, and Concentric takes no responsibility for the impact that such changes may have on the accuracy or validity of the observations, conclusions and recommendations set out in this report.

The report does not extend to any latent defect or other deficiency which could not have been reasonably discoverable or discovered within the scope of the report. Information supplied by the City of Iqaluit or third parties for use in this report has not been verified by Concentric unless stated otherwise.

Concentric's report represents a review of available information with an established work scope, schedule, and budget. The material in the report reflects Concentric's judgement in light of the information available to it at the time of preparation. Any uses that a third party makes of this report, or any reliance on decisions made based on it, are the responsibilities of such third parties.

Concentric accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made based on this report.

Should there be any questions, please contact the undersigned.

Yours sincerely,

CONCENTRIC

Randy Scott
Designer

Steve Parker, P.Eng.
Lead Project Manager

APPENDIX A
Site Photographs

Photograph 1 – Overview of concrete structure.

Photograph 2 – Typical south berm condition at the time of our review.

Photograph 3 – Typical north and center berm condition at the time of our review.

Photograph 4 – The temporary road to south berm has been blocked with a concrete barrier to limit public access to the dam and reservoir.

Photograph 5 – Oil residue on the ground around the base of the hydro pole, south berm.

Photograph 6 –Sink hole within the south access road, approximately 40' south of the access gate.

Photograph 7 –Sink hole within the south access road, approximately 40' south of the access gate.

Photograph 8 – Typical expansion joint seepage (concrete dam).

Photograph 9 – Borehole tube for piezometer (open).

Photograph 10 – Borehole tube for piezometer blocked with aggregate material.

Photograph 11 – Corner marker at the junction of the south access road and the road to the south berm has been knocked over.

Photograph 12 – Section of the supply pipe from the dam with the corrugates metal enclosure removed.

Photograph 13 – Section of the supply pipe from the dam with the corrugates metal enclosure removed.

APPENDIX B

Lake Geraldine Dam Inspection Checklist

Lake Geraldine Dam Inspection Check List

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Inspector Name: Randy Scott
Inspection Date: June 22/23, 2022
Weather: Clear & Sunny
Reviewer:
Review Date:
Action Required:

Sketch the deficiency, and note its important characteristics.
Measure the deficiency.
Photograph the deficiency or describe its characteristics in writing.
Locate the deficiency relative to a recognizable reference point.
https://wateroffice.ec.gc.ca/report/real_time_e.html?stn=10UH013

General Observations

Description	Yes	No	Observations	Action Required
Snow and ice present on dam & berms	✓		- Snow present on the down stream face of the north berm.	
Snow and ice present on the lake	✓		- Ice present within the reservoir.	
North access road, gate secured (Any visible damage)	✓			
South access road, gate secured (Any visible damage)		✓	- Sink hole found approx. 40' from gate - Warning signage along side of road damaged/missing	✓ Repair
Gates on the concrete dam locked (north and south ends on top of dam)	✓		- Sink hole observed approx. 40' south of gate, recommend that it is repaired as soon as possible.	✓ Repair
Gates and fencing on top of dam intact or damaged		✓	- Minor damage to fence, no action required.	

Lake Geraldine Dam Inspection Check List

CONCENTRIC | Iqaluit

Description	Yes	No	Observations	Action Required
Vandalism		✓		
Debris on site or in the lake		✓	- NONE OBSERVED	
Dam signage intact or damaged		✓	- SIGNAGE AT BASE OF RAMP ACCESS TO BERMS PUSHED OVER	✓
Valve chamber condition and damage (Indicate if there is any cracking, displacement, physical damage, cover is in place, etc)	/	/	- NO DAMAGE OBSERVED	
Uncontrolled breach in the concrete dam or earthen berms (embankments)		✓		
Animal Activity:		✓		

Additional Comments, Sketches or Observations

- SIGNAGE AT BASE OF RAMP ACCESS TO BERMS TO BE REPAIRED
- A SINK HOLE WAS NOTED APPROX. 40' SOUTH OF GATE IN THE SOUTH ACCESS ROAD, RECOMMEND THIS IS REPAIRED AS SOON AS POSSIBLE.
- THE TEMPORARY ROAD TO THE SOUTH BERM HAS BEEN CLOSED OFF WITH THE INSTALLATION OF A CONCRETE BARRIER
- WARNING SIGNAGE ALONG SIDE OF SOUTH ACCESS ROAD MISSING AND DAMAGED.

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Lake Geraldine Dam Inspection Check List

Iqaluit

Concrete Dam and Spillway

Description	Yes	No	Observations	Action Required
Water level relative to sill of spillway (measure from top of the concrete dam) Is there flow over the spillway			- WATER LEVEL IS APPROX. 1.4M BELOW SPILLWAY	
Cracking / spalling present on top (surface) of the concrete dam (Indicate if new, existing, expanded, length, width, depth)		✓		
Cracking / spalling present on upstream face (surface) of the concrete dam (Indicate if new, existing, expanded, length, width, depth)		✓		
Cracking / Spalling present on Downstream face (surface) of the concrete dam (Indicate if new, existing, expanded, length, width, depth)	✓		- NO NEW CRACKING - MINOR SEEPAGE NOTED AT TWO LOCATIONS	✓ MONITOR
Active seepage / leakage through dam Is there silt / sand within the leaking water (Indicate location and rate of leakage in liters per minute)	✓		- MINOR SEEPAGE NOTED AT TWO LOCATIONS, SEE SKETCH	✓ MONITOR
Sealant Condition – Top of Dam	/	/	- POOR, TO BE REPLACED IN 2022	
Sealant Condition – Up stream face of Dam	/	/	- GOOD	
Sealant Condition – Downstream face of Dam	/	/	- POOR, TO BE REPLACED IN 2022	
Active seepage / leakage at: - Interface between concrete and ground (bedrock) - Sealant joints	✓		- LEAKAGE NOTE AT BASE OF CONCRETE DAM ALONG INTERFACE WITH BEDROCK, SEE SKETCH	✓ MONITOR

Description	Yes	No	Observations	Action Required
Displacement, settlement or misalignment of sections of the dam		✓		
Debris / blockage within the spillway and or drainage channel at base of dam		✓		
Erosion at the base of the spillway		✓	- RIP-RAP IN SPILLWAY NEED TO BE SPREAD OUT EVENLY	✓
Monitoring stations (condition, damage, other)	—	—	- NOT INSTALLED AT THIS TIME, SOME OF THE BOREHOLES FOR THE PIEZOMETERS HAVE GRAVEL IN THE TUBES.	

Additional Comments, Sketches or Observations

- LEAKAGE AT BASE OF CONCRETE DAM (SOUTH END) NEEDS TO BE MONITORED

- THE BOREHOLE CAPS AT THE PIEZOMETER LOCATIONS HAVE BEEN REMOVED (BY PERSONS UNKNOWN) AND GRAVEL HAS ENTERED INTO THE BOREHOLES, THIS MAY OBST

North Berm

Description	Yes	No	Observations	Action Required
Sloughing, slides, bulging, collapse or displacement within the earthen berm – Top of Berm		✓		
Sloughing, slides, bulging, collapse or displacement within the earthen berm - Upstream Face	✓		- THE LOW WATER LEVELS HAVE REVEALED SEVERAL POCKETS (FROM WAVE ACTION) IN THE RIP-RAP. RECOMMEND THIS IS REPAIRED ASAP.	✓
Sloughing, slides, bulging, collapse or displacement within the earthen berm - Downstream Face		✓		
Depressions or sink holes within the top (crest) of the berm		✓		
Depressions or sink holes within the upstream face of the berm	✓		- SEE ABOVE	
Depressions or sink holes within the downstream face of the berm		✓		
Rock, gravel or aggregate displacement or washout (erosion) with the top of the berm		✓		
Rock, gravel or aggregate displacement or washout (erosion) within the upstream face of berm	✓		- SEE ABOVE	
Rock, gravel or aggregate displacement or washout (erosion) within the downstream face of berm		✓		

CONCENTRIC

Lake Geraldine Dam
Inspection Check List

Iqaluit

Description	Yes	No	Observations	Action Required
Displaced rip-rap /armor stone on the upstream face of berm	✓		- Low water levels revealed several areas where the rip-rap has been displaced and depressions are present	✓ Repair
Displaced rip-rap /armor stone on the downstream face of berm		✓		
Transverse / longitudinal cracking, within the Top / crest of the berm (Indicate if new, existing, expanded, length, width)		✓		
Transverse / longitudinal cracking, within the Upstream face of the berm (Indicate if new, existing, expanded, length, width)		✓		
Transverse / longitudinal cracking, within the Downstream face of the berm (Indicate if new, existing, expanded, length, width)		✓		
Wet area or active leakage / seepage within the downstream side face of berm Is there silt / sand within the leaking water		✓	- Snow melt still underway	
Ponding water at base of the berm (downstream), is there sand or silt suspended within the water	✓		- Large ponding area on the north side of the access ramp to berms, likely melt water	

Additional Comments, Sketches or Observations

Center Berm

Description	Yes	No	Observations	Action Required
Sloughing, slides, bulging, collapse or displacement within the earthen berm – Top of Berm		✓		
Sloughing, slides, bulging, collapse or displacement within the earthen berm - Upstream Face		✓		
Sloughing, slides, bulging, collapse or displacement within the earthen berm - Downstream Face		✓		
Depressions or sink holes within the top (crest) of the berm		✓		
Depressions or sink holes within the upstream face of the berm	✓		- DEPRESSIONS NOTED AT BASE OF BERM WITHIN THE RIP-RAP	
Depressions or sink holes within the downstream face of the berm		✓		
Rock, gravel or aggregate displacement or washout (erosion) with the top of the berm		✓		
Rock, gravel or aggregate displacement or washout (erosion) within the upstream face of berm		✓		
Rock, gravel or aggregate displacement or washout (erosion) within the downstream face of berm		✓		

Description	Yes	No	Observations	Action Required
Displaced rip-rap /armor stone on the upstream face of berm		✓		
Displaced rip-rap /armor stone on the downstream face of berm	✓		- LOW WATER LEVEL IN RESERVOIR REVEALED SEVERAL DEPRESSIONS IN RIP-RAP, LIKELY FROM EROSION/WAVE ACTION	✓
Transverse / longitudinal cracking, within the Top / crest of the berm (Indicate if new, existing, expanded, length, width)		✓		
Transverse / longitudinal cracking, within the Upstream face of the berm (Indicate if new, existing, expanded, length, width)		✓		
Transverse / longitudinal cracking, within the Downstream face of the berm (Indicate if new, existing, expanded, length, width)		✓		
Wet area or active leakage / seepage within the downstream side face of berm Is there silt / sand within the leaking water	✓		- LIKELY MELT WATER	
Ponding water at base of the berm (downstream), is there sand or silt suspended within the water	✓		- LIKELY MELT WATER	

Additional Comments, Sketches or Observations

- DEPRESSIONS IN RIP-RAP ON UPSTREAM FACE OF BERM SHOULD BE REPAIRED BEFORE WATER LEVEL IS RESTORED IN RESERVOIR.

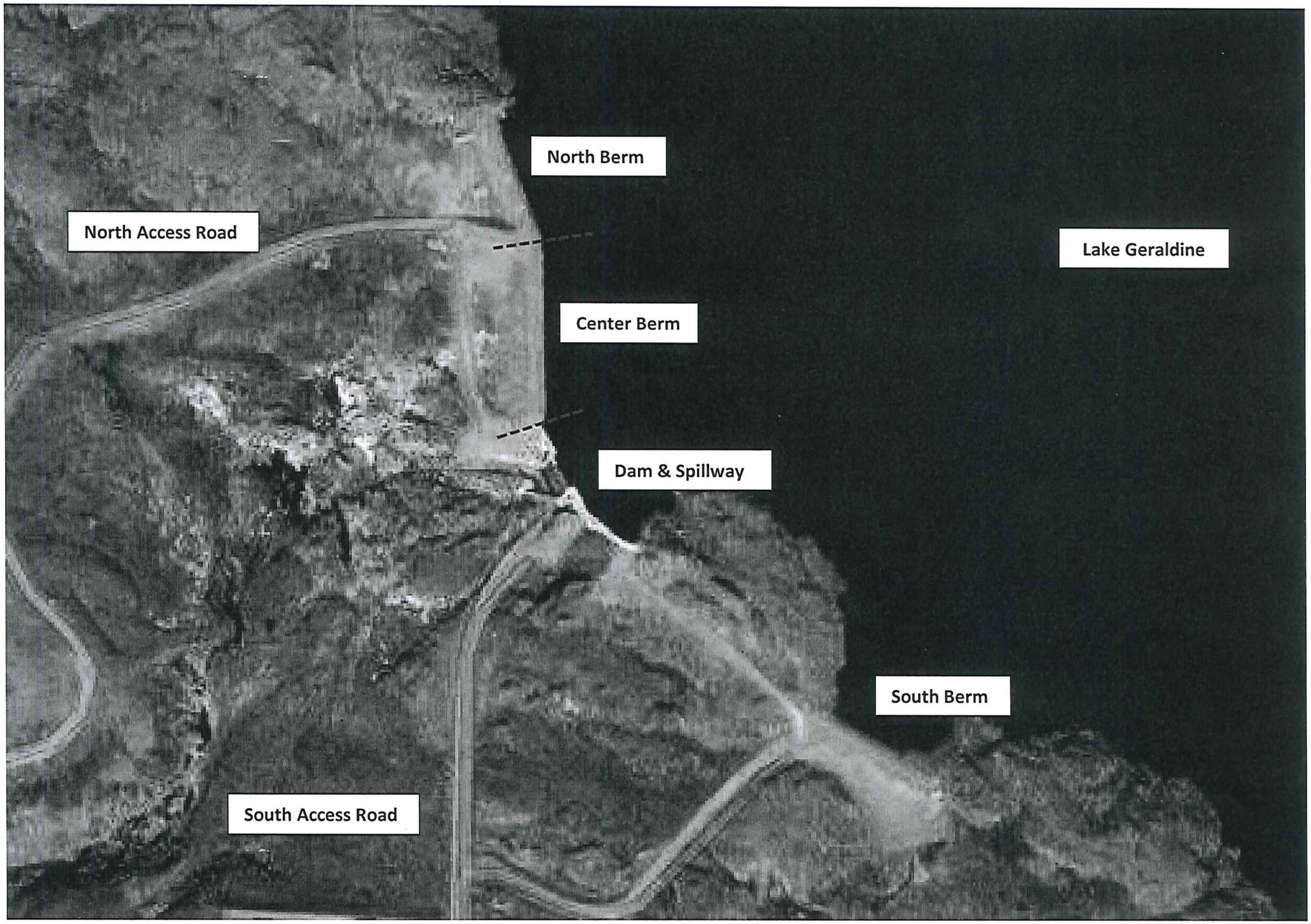
South Berm

Description	Yes	No	Observations	Action Required
Sloughing, slides, bulging, collapse or displacement within the earthen berm – Top of Berm		✓		
Sloughing, slides, bulging, collapse or displacement within the earthen berm - Upstream Face		✓		
Sloughing, slides, bulging, collapse or displacement within the earthen berm - Downstream Face		✓		
Depressions or sink holes within the top (crest) of the berm		✓		
Depressions or sink holes within the upstream face of the berm		✓		
Depressions or sink holes within the downstream face of the berm		✓		
Rock, gravel or aggregate displacement or washout (erosion) with the top of the berm	✓		– RUT IN TOP OF BERM, LIKELY FROM A VEHICLE ↑ SMALL	
Rock, gravel or aggregate displacement or washout (erosion) within the upstream face of berm		✓		
Rock, gravel or aggregate displacement or washout (erosion) within the downstream face of berm		✓		

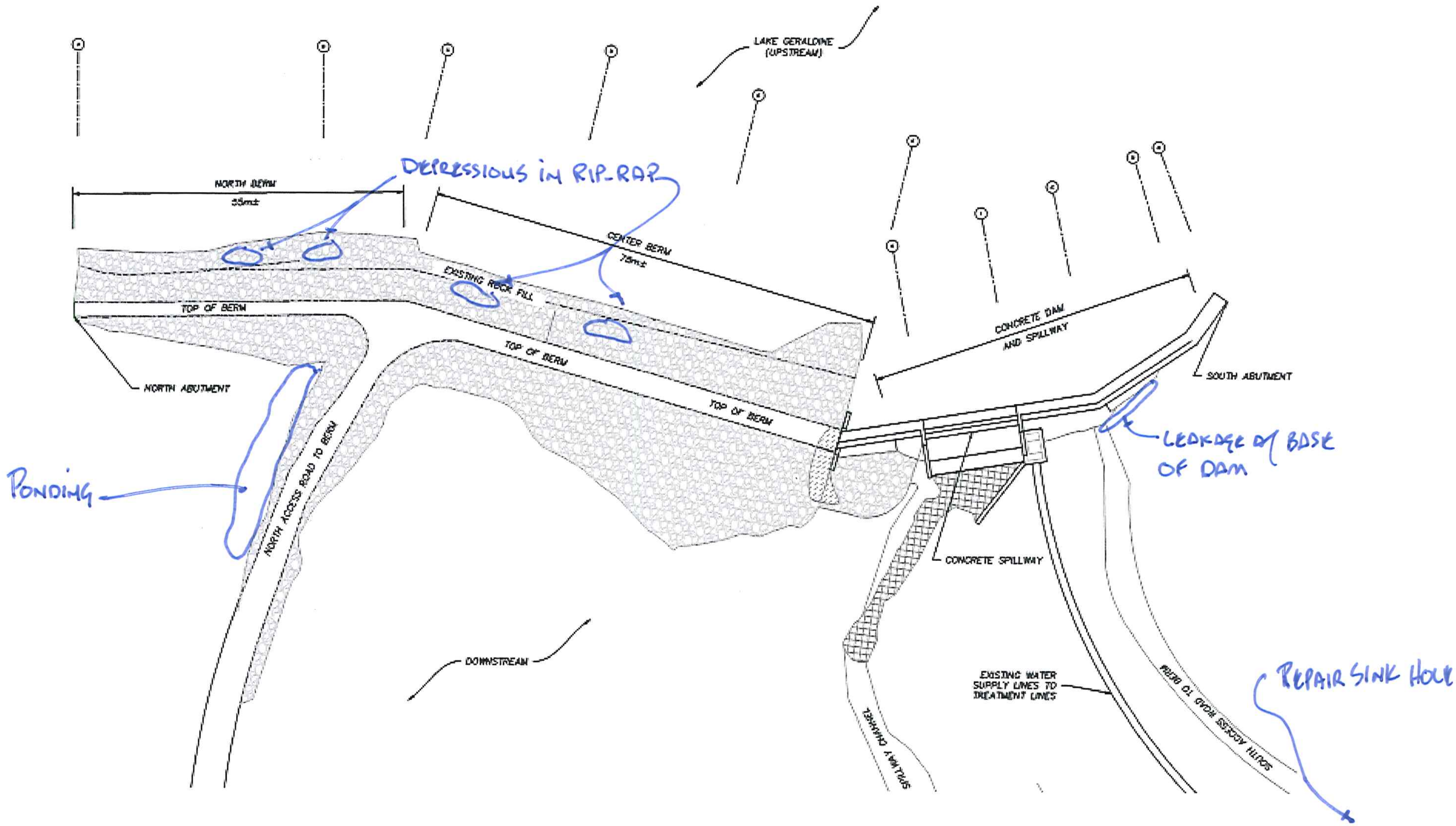
Description	Yes	No	Observations	Action Required
Displaced rip-rap /armor stone on the upstream face of berm		✓		
Displaced rip-rap /armor stone on the downstream face of berm		✓		
Transverse / longitudinal cracking, within the Top / crest of the berm (Indicate if new, existing, expanded, length, width)		✓		
Transverse / longitudinal cracking, within the Upstream face of the berm (Indicate if new, existing, expanded, length, width)		✓		
Transverse / longitudinal cracking, within the Downstream face of the berm (Indicate if new, existing, expanded, length, width)		✓		
Wet area or active leakage / seepage within the downstream side face of berm Is there silt / sand within the leaking water		✓		
Ponding water at base of the berm (downstream), is there sand or silt suspended within the water		✓		

Additional Comments, Sketches or Observations

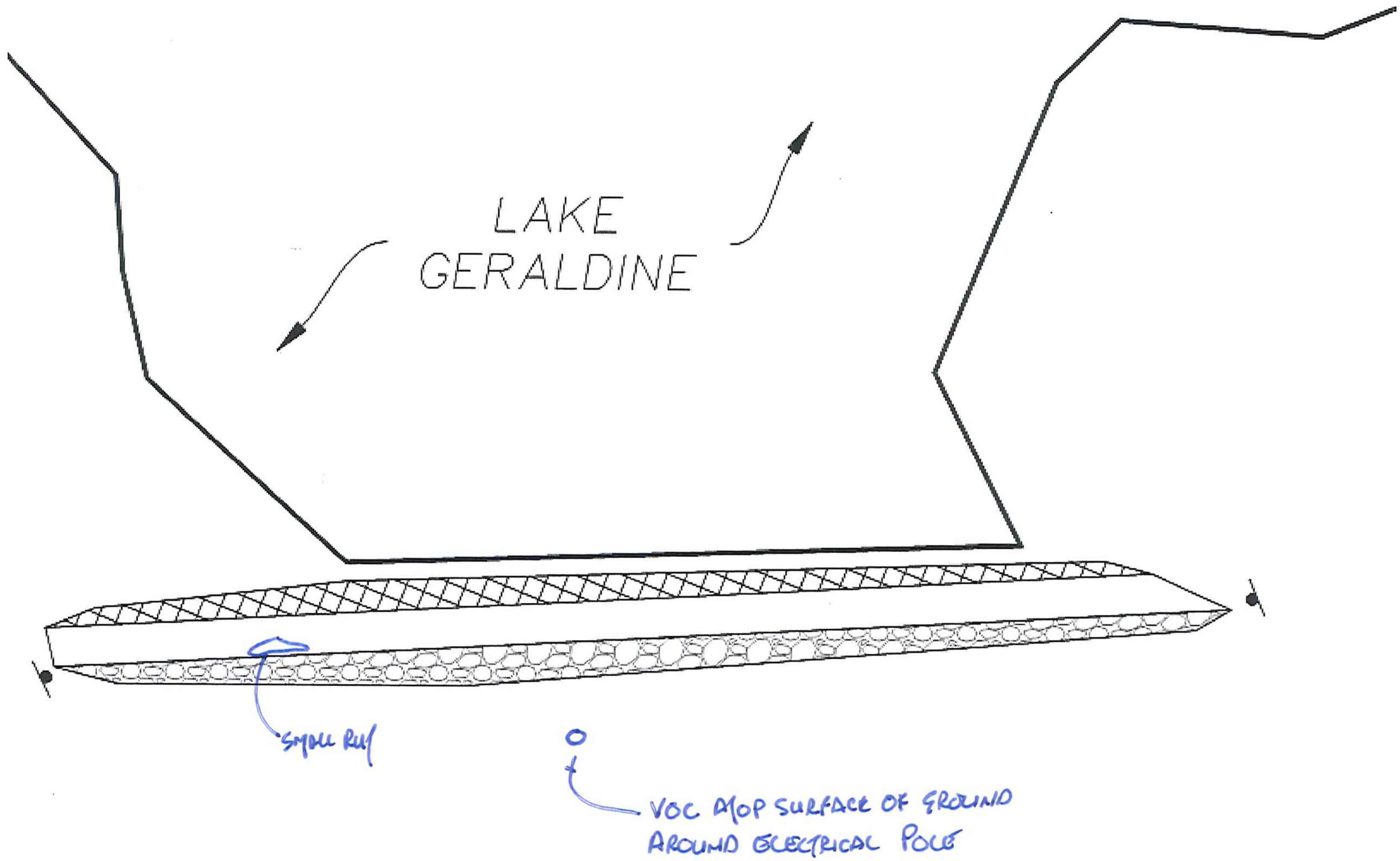
Lake Geraldine Dam Location Plan



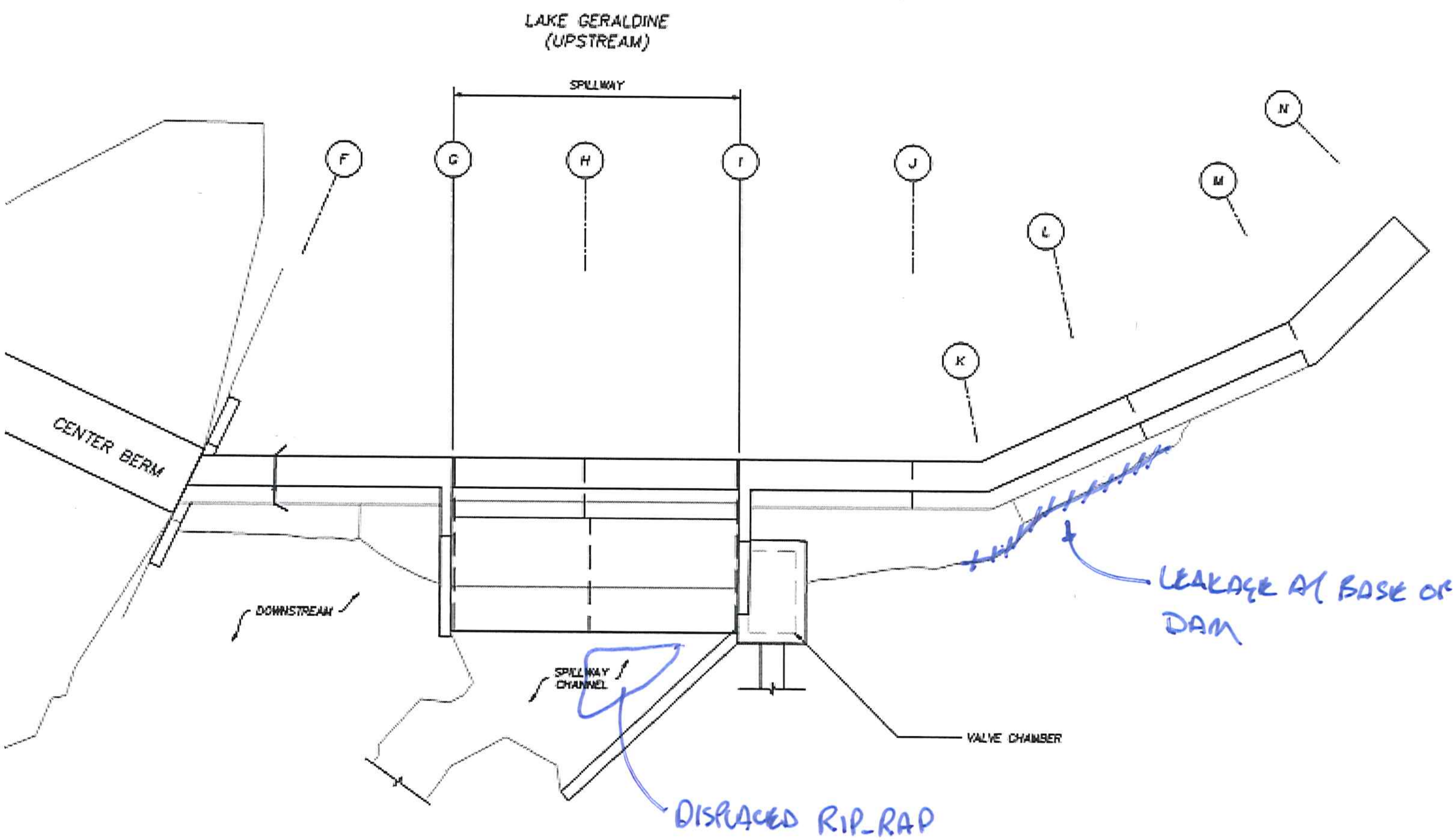
Site Plan – Concrete Dam, Center and North Berms



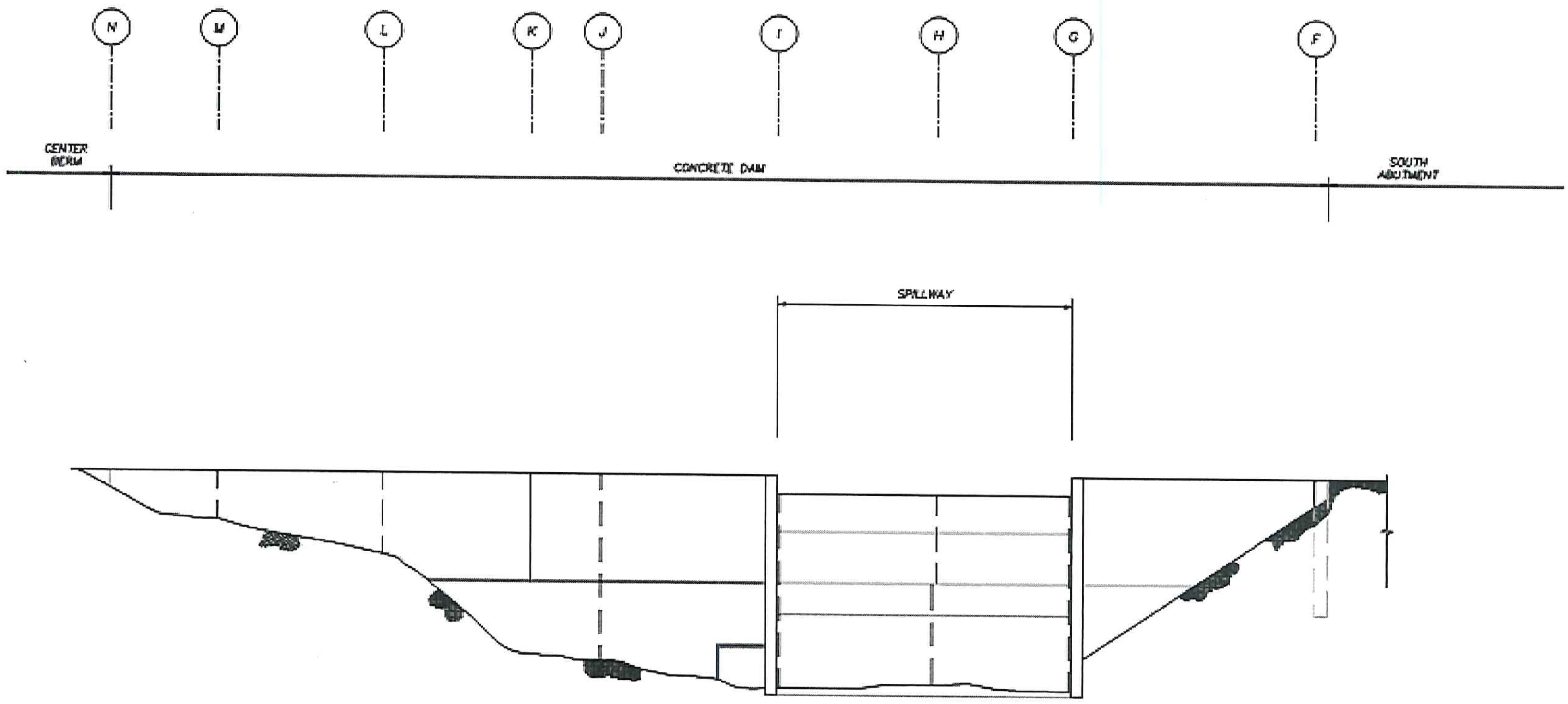
Site Plan – South Berm



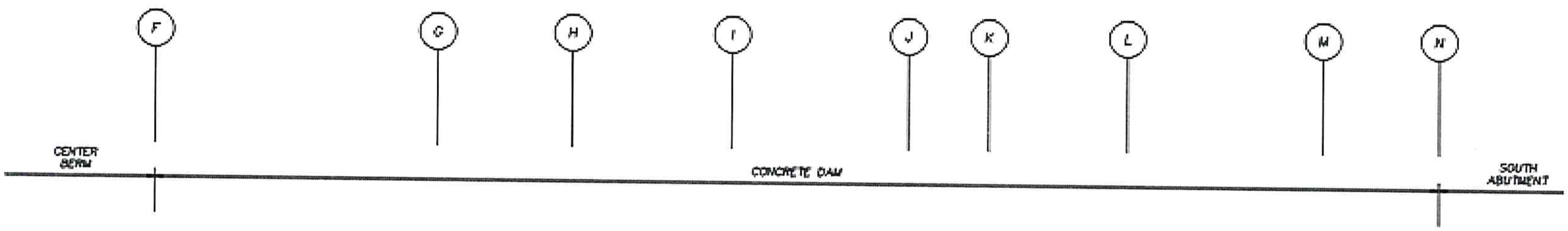
Plan View – Concrete Dam and Spillway

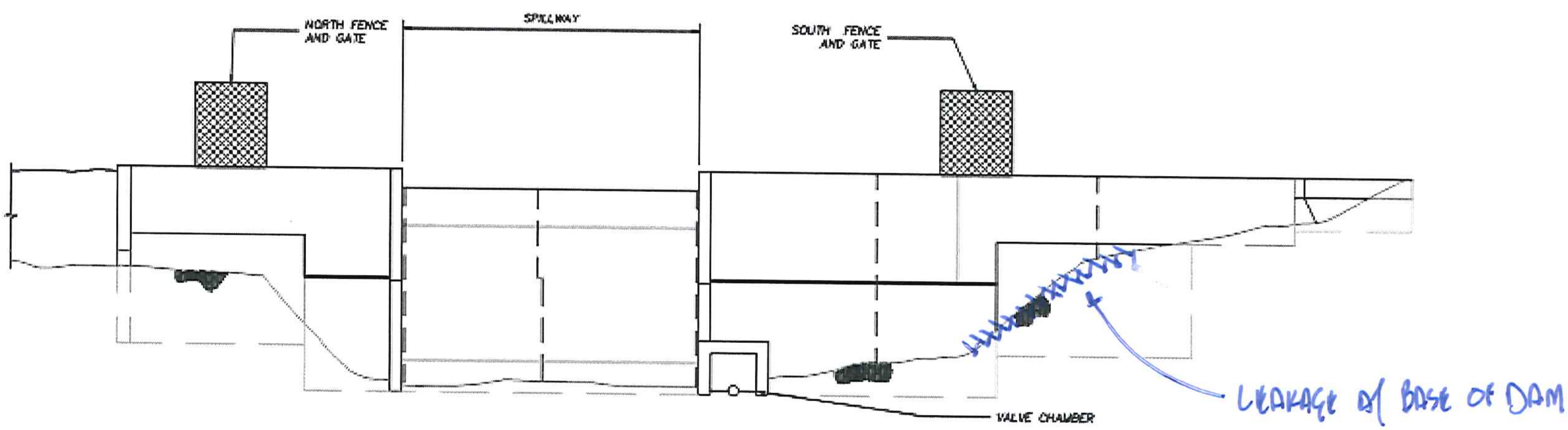


Elevation – Upstream Face, Concrete Dam and Spillway



Elevation – Downstream Face, Concrete Dam and Spillway





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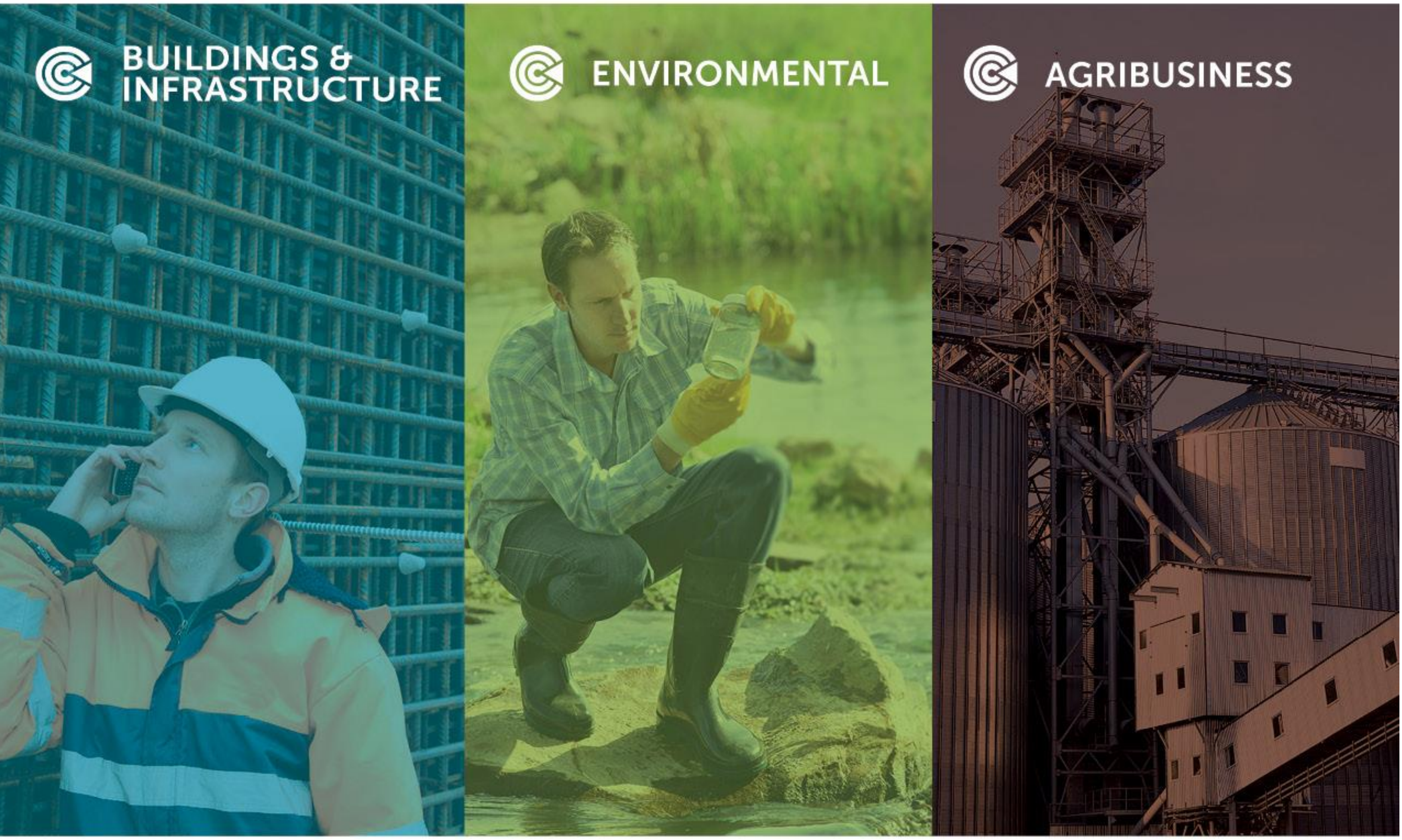

LAKE GERALDINE DAM
DAM SAFETY INSPECTION 2022 #3
IQALUIT, NUNAVUT

PRODUCED FOR: THE CITY OF IQALUIT
C/O COLLIERS PROJECT LEADERS

PRODUCED BY: CONCENTRIC ASSOCIATES INTERNATIONAL INCORPORATED

CONCENTRIC REFERENCE NUMBER: 21-9162

DATE: AUGUST 4TH, 2022

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LIST OF APPENDICES

1. INTRODUCTION AND SCOPE OF WORK

This Dam Safety Inspection (DSI) of the Lake Geraldine Dam (LG Dam) has been prepared for the City of Iqaluit (City). As the owner and operator of the LG Dam, the City of Iqaluit is responsible for its safe management and operation. The intent of this DSI is to assist the City by identifying any visual changes in the condition of the LG Dam, identifying any new concerns, and making recommendations on maintenance, repairs, or further investigations.

1.1 Dam Safety Guidelines

The most recent Dam Safety Guidelines (DSG), published by the Canadian Dam Association, were first released in 2007 and further revised in 2013. The DSG applies, in general, to those structures that are at least 2.5 meters in height, and which have at least 30,000 cubic meters of storage capacity. The LG Dam exceeds these minimum requirements and therefore requires annual DSI's. The DSI is considered to be an Engineering Inspection which is recommended by the DSG to be performed annually or semi-annually by a professional engineer. A Dam Safety Review (DSR) is required, at a minimum, every 5 years. The most recent DSR was performed in April 2022.

This DSI forms part of the dam's permanent record documentation along with other documentation that make up the historical record of the dam (and berms). Section 3.6 "Surveillance" of the DSG recommends more frequent visual inspections be performed. Routine inspections performed by City staff trained in dam surveillance are recommended on a weekly basis to identify any conditions that might indicate a change in the dam's performance.

1.2 Description of Structure

The LG Dam is comprised of a concrete section with an integral concrete spillway, and three earthen berms: the north, center, and south berms. See below for a reference site plan and Appendix A for site photographs.

The 15.3 m wide spillway has an upper elevation of 111.3 m (representing the current maximum operating level of the reservoir), while the concrete dam sections on either side of the spillway have an elevation of 112.3 m. At the maximum operating level of the reservoir, the concrete dam has approximately 0.95 m of freeboard.

The southern section of the concrete dam extends approximately 39.1 m to the south rock abutment. The northern section of the concrete dam extends 13.3 m to the north of the spillway section, where it joins the center earth berm.

The center earth berm extends north approximately 75 m where it meets the access ramp and north access road. The north earth berm is located to the north of the access road ramp and extends 60m to the north rock abutment.

The south earth berm is a separate structure that is located in a valley to the south of the main concrete dam. The south berm is approximately 68.5 m long. The north and center berms incorporate a concrete cutoff wall which is reportedly founded in rock at the base of the berms.

Site Plan

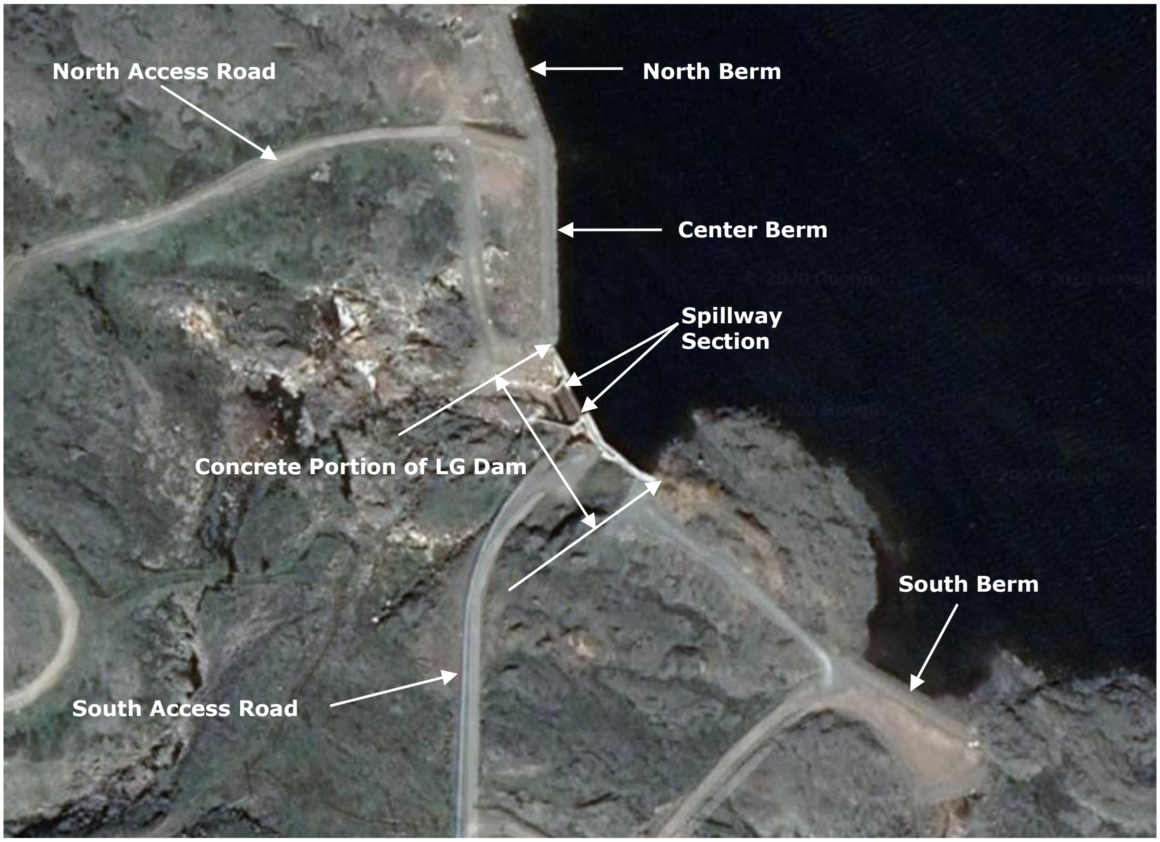


Table 1.1: Lake Geraldine Dam Summary*

Dam/Berm Segment	Length (m)	Crest Elevation	Base Elevation	Bedrock Elevation	Height of Dam/Berm (m)
North Berm	55.5	112.5	108.3	105.0	4.3
Center Berm	78.0	112.5	108.3	97.5	4.5
North Dam	13.3	112.3	102.6	97.5	11.0
Spillway	15.3	111.3	101.6	96	10.0
South Dam	39.1	112.3	102.6	67.5	11.0
South Berm	68.5	112.5	111.5	110.0	1.0

*Tabular data based upon Meco "Dam Safety Management Plan", July 2020

1.3 Scope of Work

As per the requirements of the Dam Safety Guide, the primary task of this DSI is to help identify any significant visual changes in the condition of the concrete dam and earthen berms based on a comparison with the previous inspections and reviews. A visual inspection can identify issues related to dam safety and provides the City of Iqaluit with the opportunity to mitigate any observed concerns or issues. This DSI report is the

primary deliverable and has been prepared in accordance with the Dam Safety Guide document.

The following is a summary of the scope of work for this assignment:

- Conduct a visual on-site assessment of the dam and berms above the water line;
- Prepare a photographic record documenting general and representative conditions;
- Identify, characterize, and risk-assess any significant visual changes in condition;
- Prepare a written report summarizing our observations, items of concern, and recommendations;
- Indicate any recommended repairs and outstanding recommendations from previous inspections and reviews;
- Develop a prioritized list of recommended repairs, upgrades, and improvements with Class D cost estimates;
- Submit final documents in electronic format.

2. HISTORY & BACKGROUND

2.1 Reservoir

The City of Iqaluit derives its water supply from Lake Geraldine, which is retained by a structure consisting of a cast in place concrete section incorporating an integral spillway, and three earthen berms. All concrete structures are reported to be founded on bedrock and engage the rock abutment at the south end of the concrete structure.

Lake Geraldine is a natural body of water in an irregularly shaped basin. It is fed by rainfall and snow/ice melt from a watershed with an area of approximately 385 hectares.

2.2 History

In the late 1950's, the demand for a reliable year-round source of water resulted in the construction of a cast in place concrete gravity dam and a section of earth berm with a central cast in place concrete cut off wall. The project was designed and built by the Department of National Defense. According to the literature, the original construction took place circa 1958.

Since that time, as the City has grown and water demands have risen, the dam has been raised four times to increase the storage capacity. In recent years, the City of Iqaluit has been pumping additional water into the reservoir in the summer and fall of the year from a river located east of the reservoir.

The first height increase of the concrete dam and berms (0.3m) reportedly took place in 1979. This involved a concrete extension, which was dowelled into the existing structure.

The second height increase of the concrete dam and berms took place in 1985 and increased the height of the spillway structure by approximately 1.15m. The berm portion was widened and heightened as well to accommodate the increased storage capacity of the reservoir. The extension of the concrete dam was constructed of concrete dowelled into the existing structure and incorporated a steel formwork frame over the spillway section.

The third extension was undertaken in 1995 and increased the height of the concrete structures by a further 1.5m, with a corresponding increase in berm geometry. Based on analysis done prior to the extension, it was determined that the concrete structures would not have an adequate factor of safety against overturning if the extension was simply "dowelled-in" as before. The 1995 alteration therefore included an extensive rock-anchoring program for the concrete portions to provide the required stability to the structure.

The latest extension was completed in two phases over 2005/06. Additional rock anchors were installed thought the concrete structures in 2005 in preparation for a further height extension of 2 m in 2006. The existing berms were enlarged and the existing cut-of-walls within the north and center berms were extended in height. A new berm (south berm) and cut off wall were installed to the south of the main dam structure. A subsequent technical analysis of the dam and earth berms completed in 2020 indicated that the spillway structure is marginally compliant for stability with relying on rock anchors to resist overturning. CDA guidelines indicate that it is not recommended that passive rock anchors are relied on for stability.

The last major repair program undertaken was completed in the summer of 2021, various repairs were undertaken to maintain the concrete structures, berms, and access roads. These repairs included:

- Placement of additional aggregate material and regrading of the north and south access roads.
- Installation of additional riprap/armor stone on the upstream face of the center and north berms.
- Installation of additional aggregate and regrading of the top of the center and north berms.
- Crack repair and sealing on the downstream face of the concrete structures.
- Concrete repair on the downstream face of the dam.

Replacement of the expansion joint sealant material on the downstream face of the concrete structures was started in 2021 but unable to be completed due to local weather and site conditions. This work was completed in July 2022.

In August 2019 various repairs were undertaken to repair the upstream face (below the water line) of the dam. These repairs included:

- Repair of the expansion joint.
- Polyurethane crack injection.
- Localized concrete repairs.

3. DAM SAFETY INSPECTION

3.1 Site Inspections and Staff Interviews

A visual site inspection of the LG Dam was performed on August 4, 2022 by Cameron McDonald, of Concentric. The inspection was non-invasive in nature and did not include an underwater survey or assessment. For general overview photographs see photograph 1-3 in Appendix A.

A summary of observed conditions is as follows:

- Ice was observed in the spillway approximately 200m downstream of the Dam. No ice present in Lake Geraldine.
- The water level within the reservoir reported by Natural Resources Canada on August 4, 2022 was 110.m, the level of the spillway is 111.3m.
- The temporary road access to the south berm is still blocked with concrete barriers.
- The area around the base of the power pole that supplies power to the temporary water treatment facility at the south berm has what appears to be some form of oil / creosote around the base of the pole. See Photograph 4. This was reported in the last DSI report, no corrective measures have been taken to address this issue.
- The sink hole identified in the previous report, located within the south access road, approximately 40’ south of the access control gate has been repaired.
- No significant changes were noted in the general condition of the concrete structures.
- The metal enclosures installed atop the piezometer boreholes have been removed and some of the borehole tube designated for the installation of the piezometers have been obstructed with gravel and sand. See Photographs 6 & 7.
- No change in condition to the metal corner post (used to indicate the edge of the road) identified to have been knocked over by vehicle traffic in the previous report. See Photograph 8.
- Portions of the galvanized metal enclosure that covers the pipe that supplies water from the dam to the water treatment plant are still missing. See Photograph 9.
- No change in condition to the blizzard markers installed along the north side of the south access road identified in the previous report. See Photograph 10.
- The warning signage that is placed at the base of the access ramp to the center/north berms has been corrected. Signage was noted to have been bent in previous report.
- The warning signage at the south end of the south berm has not yet been installed. This item is part of a capital project that Tower Arctic Limited was engaged to install.
- No change in condition to the small rut identified in the previous report at the north end of the south berm (presumably from a vehicle).
- Leakage was observed at the base of the interface between the bedrock and the concrete dam. Leakage of water has been observed at this location during previous inspections. This leakage is steady and constant.

- A steady flow of water was observed at the toe of the road which leads from the North access road to the base of the concrete Dam. The source of this water is difficult to identify since this is the low point for the entire North and Centre earthen berms.
- A number of depressions within the rip-rap stone of the berm on the upstream face of the north and center berms were identified. This area of the berms is generally below the water line and is not always visible.
- The rip rap at the base of the concrete dam, within the spillway, needs to be adjusted. The rip rap has been displaced and is no longer covering all portions of the base of the dam. Miscellaneous deleterious materials were observed in the spillway.
- Depression noted in the rip rap lip on the south berm in line with the GN's mobile water treatment plant units. It appears rip rap may have been displaced to accommodate intake hoses. This should be corrected. See photograph 12.
- With the exception of the above noted, no significant changes, such as sloughing, slides, bulging or displacement, were noted in the earthen berms. No active seepage/leakage was observed within the visible portions of the berms; however, based upon our previous inspections and experience, water leakage/seepage may be present within the center berm that is being masked by melt water from the snow and ice.
- The aggregate stockpiles located on the downstream side of the north berm have been used, it is our understanding that this material was used when the temporary water purification plant was operating. These stockpiles are scheduled to be replaced in the summer of 2022.
- Members of the public continue to access the Dam structures and Lake Geraldine. Bungee cords were installed to suppress the barbed wire on top of the fence on the North Side of the Concrete Dam. See photograph 11.

Minor leakage at the base of the concrete dam at the interface with the bedrock has been consistent over the last 10+ years however, during our most recent site review we noted a minor increase in the flow of water at this location. Leakage at this location is believed to be caused by water moving through the fractured bedrock below the dam and seepage of water between the base of the concrete dam and bedrock. We did not observe any changes or displacement of the bedrock at the base of the dam. As such, we do not believe that the underlying bedrock has changed or been disturbed.

3.2 Dam Safety Analysis

A dam safety analysis was not completed as part of this inspection; however, there were no obvious indicators that the concrete structures have had significant changes since the last DSI.

3.3 Operation, Maintenance, and Surveillance

This DSI falls under the requirements of a visual inspection by an engineer as stated in Section 3.6 "Surveillance" of the Dam Safety Guide. The lack of a centralized repository of operational and maintenance records has been an ongoing issue. This, along with other issues regarding the operation and maintenance of the dam and reservoir, is noted within both the "Dam Safety Management Plan" dated July 16, 2020 prepared by MECO and the 2021 Dam Safety Review dated May 31, 2022 prepared by Concentric.

3.4 Recommendations and Required Action

Based on our inspection and review, we recommend the following:

1. Items deemed to be of an urgent need include:
   a. Repair the sink hole in the south access road.
   b. The contaminated soil around the base of the hydro pole adjacent to the south berm should be removed.
2. Updating of the permanent record file and its storage in a central location with an index that documents the date and contents of all records. The permanent record file needs to include:
   a) As-built drawings and specification for work undertaken at the dam.
   b) Weekly/monthly inspections completed by City staff.
   c) Dam Safety Inspections and Dam Safety Reviews generated by third parties on behalf of the City of Iqaluit.
   d) All maintenance records.
   e) Correspondence with regulatory agencies.
   f) Dam operation, maintenance, and surveillance documents.
   g) Reports and documentation generated by third parties on behalf of the City of Iqaluit.
3. Implement a public awareness program to educate and inform the public that:
   a) The dam and earthen berms are a *no trespass* area.
   b) Dog walkers should not allow their pets to travel atop and across the earthen berms due to the risk of (dog) fecal matter contamination of the potable water supply.
   c) ATV and skidoos should not be traveling atop the berms and across Lake Geraldine.
4. The protective galvanized metal enclosure installed over the pipeline from the dam to the water treatment plant should be re-instated.
5. The metal posts / markers that were installed along the north side of the south access road to should be re-instated.
6. The warning signage at the base of the access ramp to the center – north berms should be repaired.
7. The aggregate stockpiles maintained at the west side of the north berm should be replenished.
8. Implementation of a monitoring program to record data from the installed network of piezometers and thermistors used to monitor hydrogeologic and thermal environments within the backfill and foundations. This work is tentatively scheduled for implementation in summer of 2022.

9. The installation of video surveillance is tentatively scheduled for implementation in the fall of 2022 - summer of 2023.
10. Exercising and testing of the valves within the valve chamber is required as part of preventative measures. The condition of the valves within the valve chamber at the base of the dam was previously identified as being in an advanced state of corrosion. To our knowledge no maintenance or testing has been completed on the controls valve in the last 5+ years. There is a significant potential for the valves to fail and not operate correctly when needed in an emergency.
11. Underwater survey of the concrete dam and spillway in 2023.
12. Undertake a test opening on the downstream side of the concrete dam and center berm in late January – early February 2023 to ascertain the source of the water that forms large ice sheets within the valley in the winter months.
13. Repair of cracks within the concrete dam, this work is tentatively scheduled for summer 2022.
14. Repair of spalled concrete within the concrete dam, this work is tentatively scheduled for summer 2022.

4. LIMITATIONS

This report was prepared for the sole use of the City of Iqaluit.

This report was prepared exclusively for the purposed project and site locations outlined in this report. The report is based on information provided to, or obtained by Concentric as indicated in the report, and applies solely to site conditions existing at the time of the site investigations.

The conditions of the site may change over time or may have already changed due to natural forces or human intervention, and Concentric takes no responsibility for the impact that such changes may have on the accuracy or validity of the observations, conclusions and recommendations set out in this report.

The report does not extend to any latent defect or other deficiency which could not have been reasonably discoverable or discovered within the scope of the report. Information supplied by the City of Iqaluit or third parties for use in this report has not been verified by Concentric unless stated otherwise.

Concentric's report represents a review of available information with an established work scope, schedule, and budget. The material in the report reflects Concentric's judgement in light of the information available to it at the time of preparation. Any uses that a third party makes of this report, or any reliance on decisions made based on it, are the responsibilities of such third parties.

Concentric accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made based on this report.

Should there be any questions, please contact the undersigned.

Yours sincerely,

CONCENTRIC

Cameron McDonald
Designer

Steve Parker, P.Eng.
Lead Project Manager

APPENDIX A
Site Photographs

Photograph 1 – Overview of concrete structure.

Photograph 2 – Typical south berm condition at the time of our review.

Photograph 3 – Typical north and center berm condition at the time of our review.

Photograph 4 – Oil residue on the ground around the base of the hydro pole, south berm.

Photograph 5 – Typical expansion joint (concrete dam).

Photograph 6 – Borehole tube for piezometer (open).

Photograph 7 – Borehole tube for piezometer blocked with aggregate material.

Photograph 8 – Corner marker at the junction of the south access road and the road to the south berm has been knocked over.

Photograph 9 – Section of the supply pipe from the dam with the corrugates metal enclosure removed.

Photograph 10 – Blizzard markers knocked over

Photograph 11 – Bungee cord suppressing barbed wire

Photograph 12 – Displaced rip rap in South Berm

APPENDIX B

Lake Geraldine Dam Inspection Checklist

CONCENTRIC

Lake Geraldine Dam Inspection Check List

Iqaluit

Inspector Name: Cameron McDonald

Inspection Date: August 4, 2022

Weather: Sunny 10° (Rained in the morning)

Reviewer:

Review Date:

Action Required:

Sketch the deficiency, and note its important characteristics.
Measure the deficiency.
Photograph the deficiency or describe its characteristics in writing.
Locate the deficiency relative to a recognizable reference point.

General Observations

Description	Yes	No	Observations	Action Required
Snow and ice present on dam & berms		X	Snow & Ice in the spillway downstream	
Snow and ice present on the lake		X		
North access road, gate secured (Any visible damage)	X			
South access road, gate secured (Any visible damage)	X			
Gates on the concrete dam locked (north and south ends on top of dam)	X			
Gates and fencing on top of dam intact or damaged	X		Bungee chord supressing barbed wire was in place on the North Gate. Bungee chord was removed	

Description	Yes	No	Observations	Action Required
Vandalism		X		
Debris on site or in the lake		X		
Dam signage intact or damaged	X		Dam signage intact, still missing sign on south end of south berm	
Valve chamber condition and damage (Indicate if there is any cracking, displacement, physical damage, cover is in place, etc)	—		No damage	
Uncontrolled breach in the concrete dam or earthen berms (embankments)	—		None	
Animal Activity:	—		None	

Additional Comments, Sketches or Observations

Concrete Dam and Spillway				
Description	Yes	No	Observations	Action Required
Water level relative to sill of spillway (measure from top of the concrete dam) Is there flow over the spillway	—	—	1.5m freeboard on spillway, no flow over spillway	
Cracking / spalling present on top (surface) of the concrete dam (Indicate if new, existing, expanded, length, width, depth)		X		
Cracking / spalling present on upstream face (surface) of the concrete dam (Indicate if new, existing, expanded, length, width, depth)		X		
Cracking / Spalling present on Downstream face (surface) of the concrete dam (Indicate if new, existing, expanded, length, width, depth)	X		Regular cracking & spalling, Same places as previous reports, not noticeably larger	
Active seepage / leakage through dam Is there silt / sand within the leaking water (Indicate location and rate of leakage in liters per minute)		X		
Sealant Condition – Top of Dam	—	—	Good	
Sealant Condition – Up stream face of Dam	—	—	Good	
Sealant Condition – Downstream face of Dam	—		Good - Recently Replaced	
Active seepage / leakage at: - Interface between concrete and ground (bedrock) - Sealant joints	X		Interface at Gridline L	

Description	Yes	No	Observations	Action Required
Displacement, settlement or misalignment of sections of the dam		X		
Debris / blockage within the spillway and or drainage channel at base of dam		X	Some garbage / deleterious materials in drainage channel	
Erosion at the base of the spillway	X		Rip rap needs to be adjusted	
Monitoring stations (condition, damage, other)	—		No damage	

Additional Comments, Sketches or Observations

North Berm

Description	Yes	No	Observations	Action Required
Sloughing, slides, bulging, collapse or displacement within the earthen berm – Top of Berm		X		
Sloughing, slides, bulging, collapse or displacement within the earthen berm - Upstream Face		X		
Sloughing, slides, bulging, collapse or displacement within the earthen berm - Downstream Face		X		
Depressions or sink holes within the top (crest) of the berm		X		
Depressions or sink holes within the upstream face of the berm		X		
Depressions or sink holes within the downstream face of the berm		X		
Rock, gravel or aggregate displacement or washout (erosion) with the top of the berm		X		
Rock, gravel or aggregate displacement or washout (erosion) within the upstream face of berm		X		
Rock, gravel or aggregate displacement or washout (erosion) within the downstream face of berm		X		

CONCENTRIC

Lake Geraldine Dam Inspection Check List

Iqaluit

Description	Yes	No	Observations	Action Required
Displaced rip-rap /armor stone on the upstream face of berm	X		Same locations as previously identified, see markups on site layout plan	
Displaced rip-rap /armor stone on the downstream face of berm		X		
Transverse / longitudinal cracking, within the Top / crest of the berm (Indicate if new, existing, expanded, length, width)		X		
Transverse / longitudinal cracking, within the Upstream face of the berm (Indicate if new, existing, expanded, length, width)		X		
Transverse / longitudinal cracking, within the Downstream face of the berm (Indicate if new, existing, expanded, length, width)		X		
Wet area or active leakage / seepage within the downstream side face of berm Is there silt / sand within the leaking water		X		
Ponding water at base of the berm (downstream), is there sand or silt suspended within the water		X		

Additional Comments, Sketches or Observations

Center Berm

Description	Yes	No	Observations	Action Required
Sloughing, slides, bulging, collapse or displacement within the earthen berm – Top of Berm		X		
Sloughing, slides, bulging, collapse or displacement within the earthen berm - Upstream Face		X		
Sloughing, slides, bulging, collapse or displacement within the earthen berm - Downstream Face		X		
Depressions or sink holes within the top (crest) of the berm		X		
Depressions or sink holes within the upstream face of the berm		X		
Depressions or sink holes within the downstream face of the berm		X		
Rock, gravel or aggregate displacement or washout (erosion) with the top of the berm		X		
Rock, gravel or aggregate displacement or washout (erosion) within the upstream face of berm		X		
Rock, gravel or aggregate displacement or washout (erosion) within the downstream face of berm		X		

CONCENTRIC

Lake Geraldine Dam Inspection Check List

Iqaluit

Description	Yes	No	Observations	Action Required
Displaced rip-rap /armor stone on the upstream face of berm	X		See site plan	
Displaced rip-rap /armor stone on the downstream face of berm		X		
Transverse / longitudinal cracking, within the Top / crest of the berm (Indicate if new, existing, expanded, length, width)		X		
Transverse / longitudinal cracking, within the Upstream face of the berm (Indicate if new, existing, expanded, length, width)		X		
Transverse / longitudinal cracking, within the Downstream face of the berm (Indicate if new, existing, expanded, length, width)		X		
Wet area or active leakage / seepage within the downstream side face of berm Is there silt / sand within the leaking water	X		Leakage noticed near the access road to the concrete Dam, see site plan, no silt in water	
Ponding water at base of the berm (downstream), is there sand or silt suspended within the water		X		

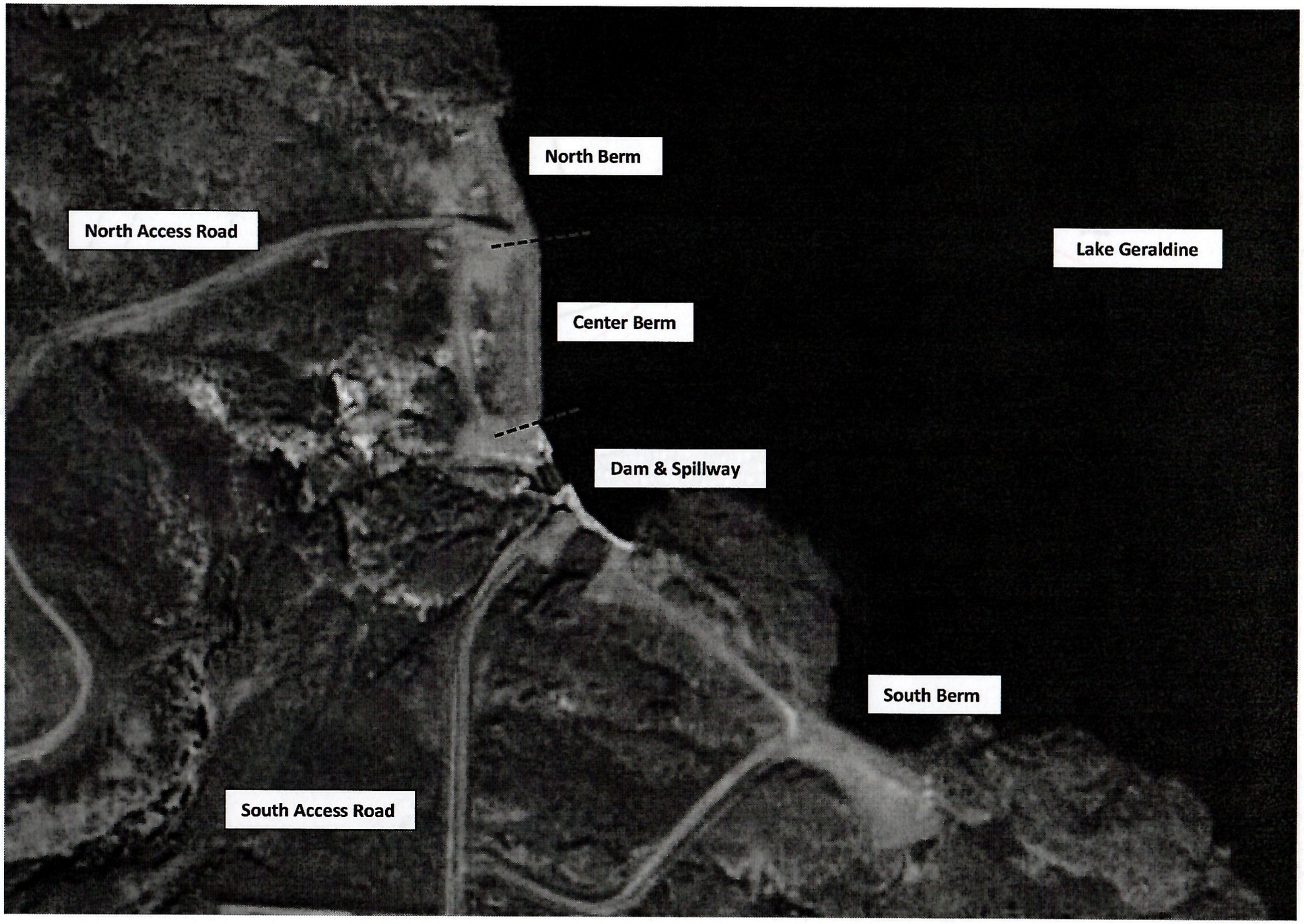
Additional Comments, Sketches or Observations

South Berm				
Description	Yes	No	Observations	Action Required
Sloughing, slides, bulging, collapse or displacement within the earthen berm – Top of Berm		X		
Sloughing, slides, bulging, collapse or displacement within the earthen berm - Upstream Face	X		In line with the GN mobile water treatment Unit, rip rap lip is depressed. Was likely to allow their hoses to lie flat accross the berm.	X
Sloughing, slides, bulging, collapse or displacement within the earthen berm - Downstream Face		X		
Depressions or sink holes within the top (crest) of the berm		X		
Depressions or sink holes within the upstream face of the berm		X		
Depressions or sink holes within the downstream face of the berm		X		
Rock, gravel or aggregate displacement or washout (erosion) with the top of the berm		X		
Rock, gravel or aggregate displacement or washout (erosion) within the upstream face of berm		X		
Rock, gravel or aggregate displacement or washout (erosion) within the downstream face of berm		X		

Description	Yes	No	Observations	Action Required
Displaced rip-rap /armor stone on the upstream face of berm	X		See note above	
Displaced rip-rap /armor stone on the downstream face of berm		X		
Transverse / longitudinal cracking, within the Top / crest of the berm (Indicate if new, existing, expanded, length, width)		X		
Transverse / longitudinal cracking, within the Upstream face of the berm (Indicate if new, existing, expanded, length, width)		X		
Transverse / longitudinal cracking, within the Downstream face of the berm (Indicate if new, existing, expanded, length, width)		X		
Wet area or active leakage / seepage within the downstream side face of berm Is there silt / sand within the leaking water		X		
Ponding water at base of the berm (downstream), is there sand or silt suspended within the water		X		

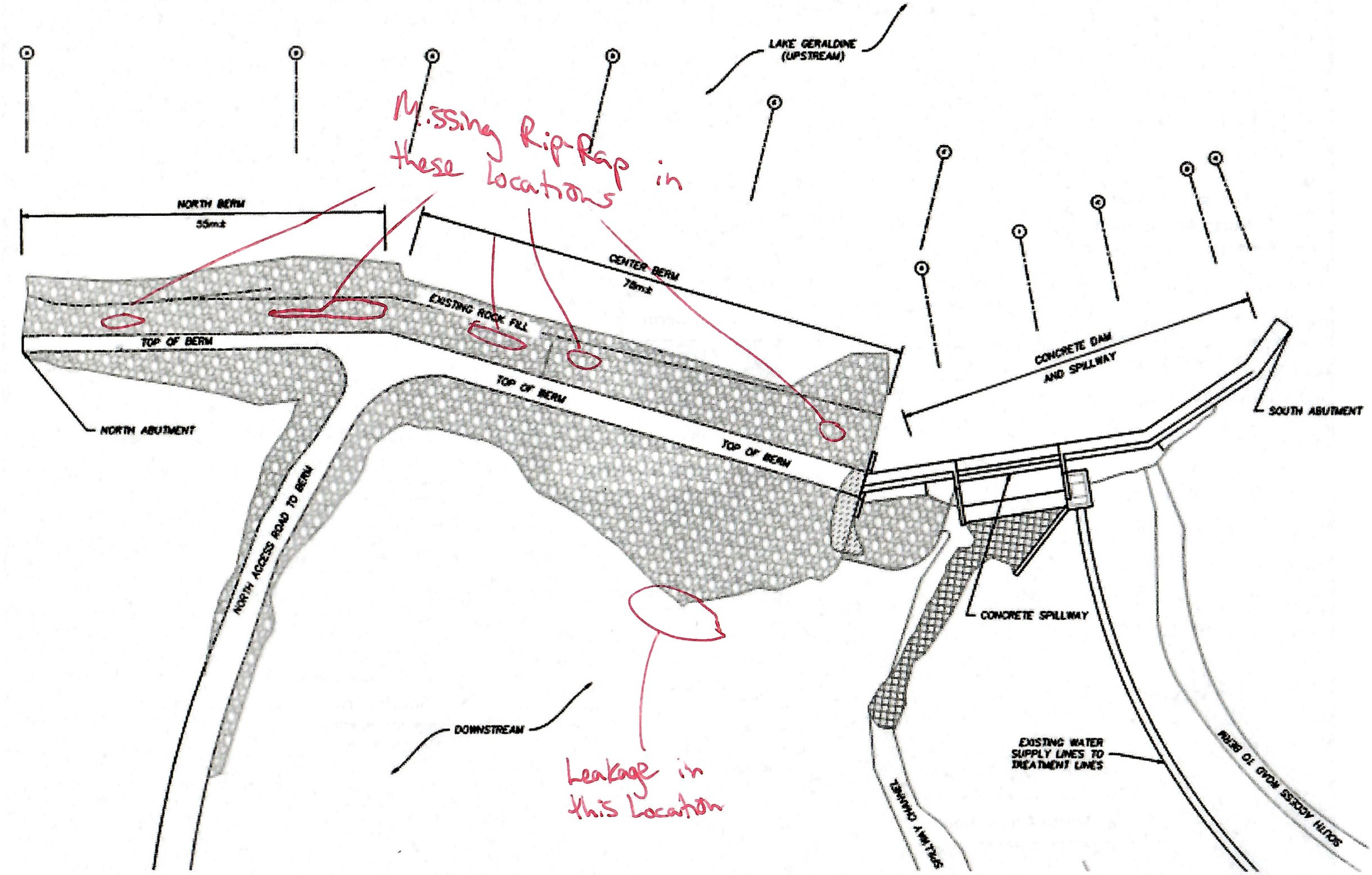
Additional Comments, Sketches or Observations

Lake Geraldine Dam Location Plan

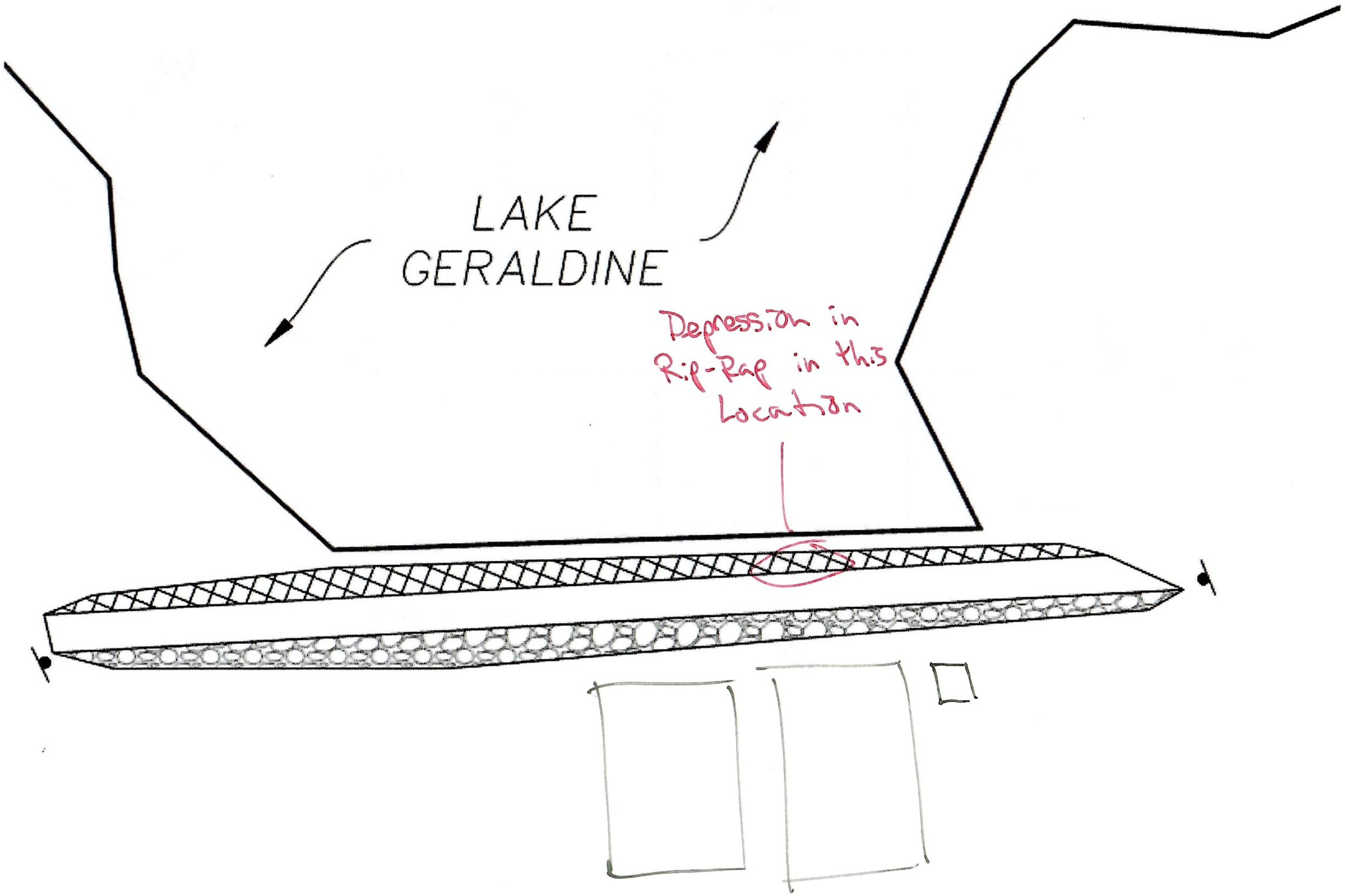


Lake Geraldine Dam
Inspection Check List

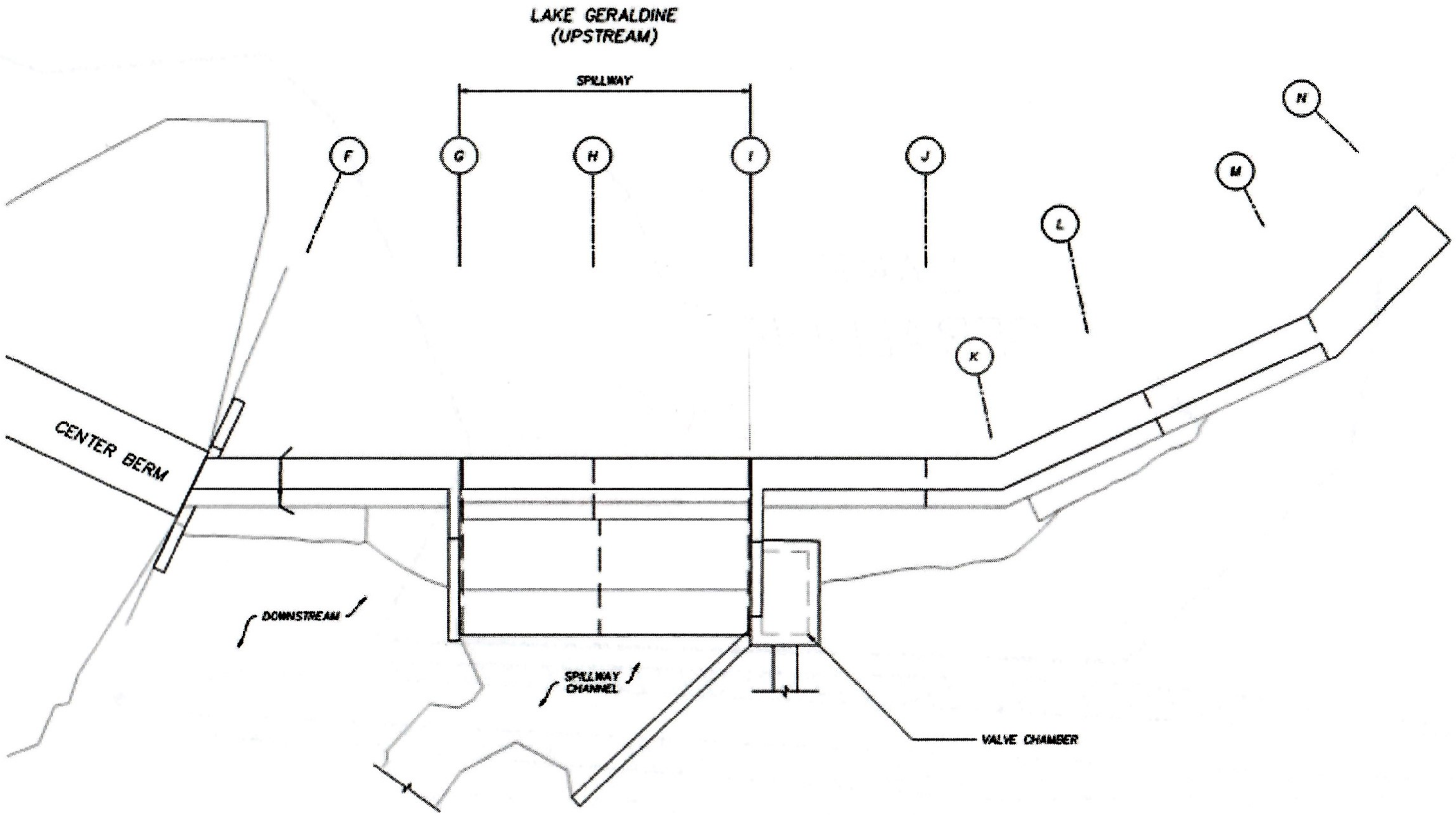
Site Plan – Concrete Dam, Center and North Berms



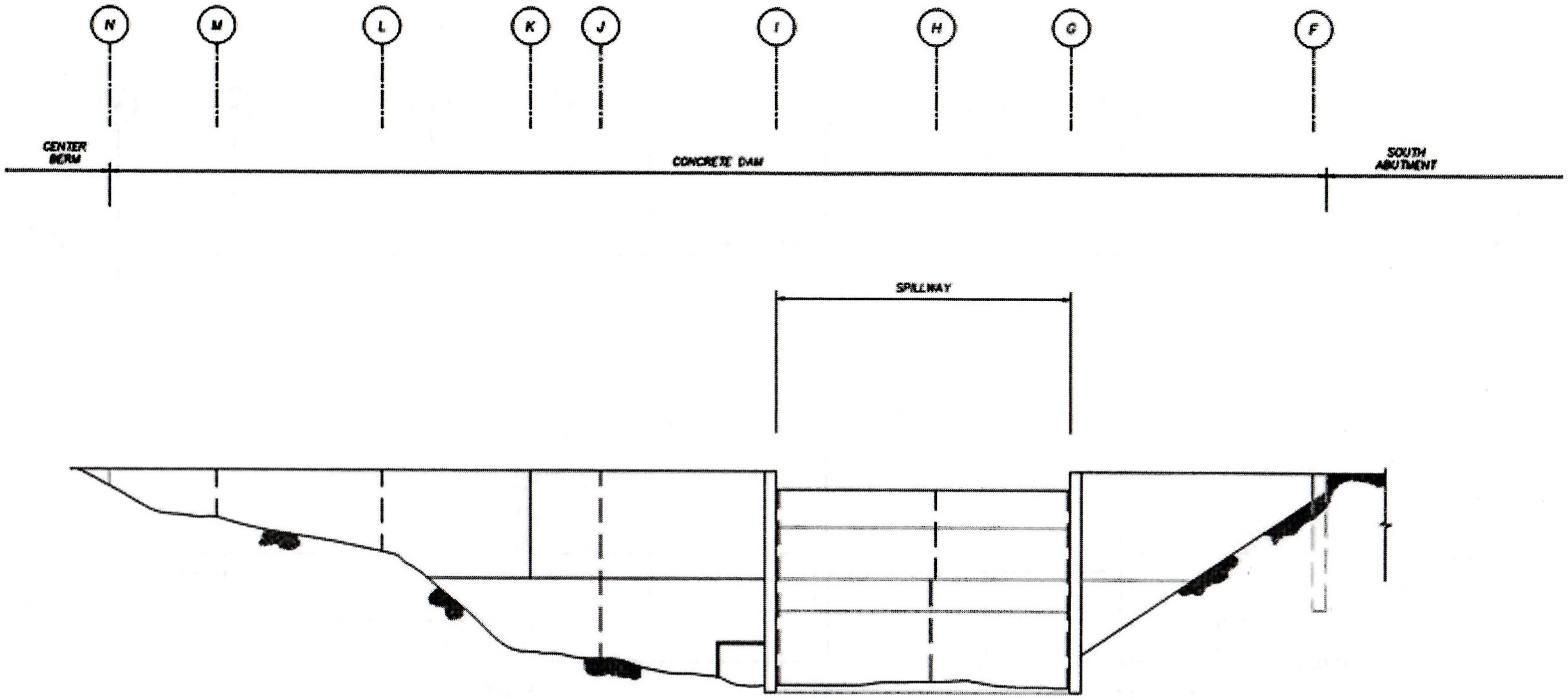
Site Plan – South Berm



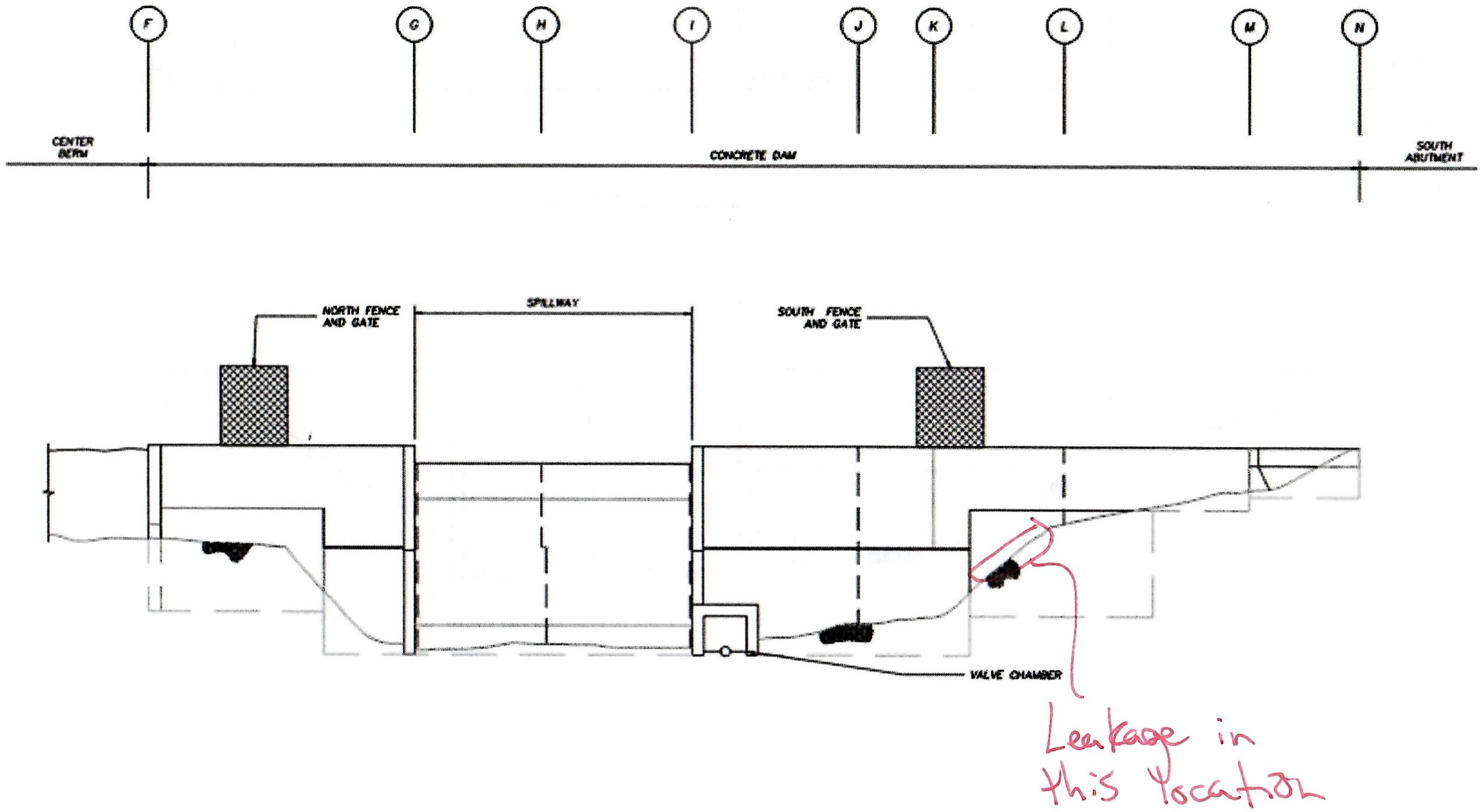
Plan View – Concrete Dam and Spillway



Elevation – Upstream Face, Concrete Dam and Spillway



Elevation – Downstream Face, Concrete Dam and Spillway



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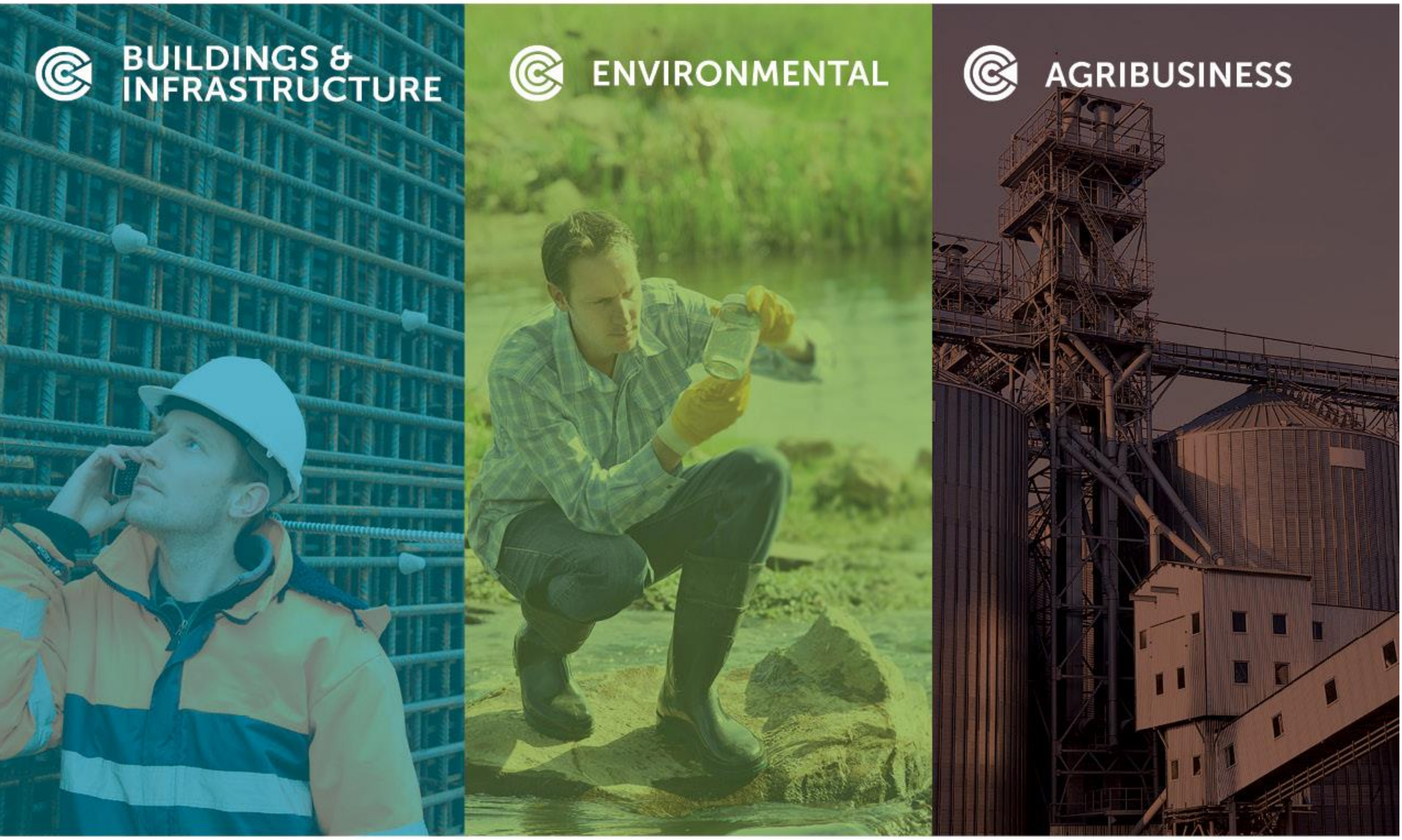

LAKE GERALDINE DAM
DAM SAFETY INSPECTION 2022 #4
IQALUIT, NUNAVUT

PRODUCED FOR: THE CITY OF IQALUIT
C/O COLLIERS PROJECT LEADERS

PRODUCED BY: CONCENTRIC ASSOCIATES INTERNATIONAL INCORPORATED

CONCENTRIC REFERENCE NUMBER: 21-9162

DATE: SEPTEMBER 29TH, 2022

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LIST OF APPENDICES

1. INTRODUCTION AND SCOPE OF WORK

This Dam Safety Inspection (DSI) of the Lake Geraldine Dam (LG Dam) has been prepared for the City of Iqaluit (City). As the owner and operator of the LG Dam, the City of Iqaluit is responsible for its safe management and operation. The intent of this DSI is to assist the City by identifying any visual changes in the condition of the LG Dam, identifying any new concerns, and making recommendations on maintenance, repairs, or further investigations.

1.1 Dam Safety Guidelines

The most recent Dam Safety Guidelines (DSG), published by the Canadian Dam Association, were first released in 2007 and further revised in 2013. The DSG applies, in general, to those structures that are at least 2.5 meters in height, and which have at least 30,000 cubic meters of storage capacity. The LG Dam exceeds these minimum requirements and therefore requires annual DSI's. The DSI is considered to be an Engineering Inspection which is recommended by the DSG to be performed annually or semi-annually by a professional engineer. A Dam Safety Review (DSR) is required, at a minimum, every 5 years. The most recent DSR was performed in April 2022.

This DSI forms part of the dam's permanent record documentation along with other documentation that make up the historical record of the dam (and berms). Section 3.6 "Surveillance" of the DSG recommends more frequent visual inspections be performed. Routine inspections performed by City staff trained in dam surveillance are recommended on a weekly basis to identify any conditions that might indicate a change in the dam's performance.

1.2 Description of Structure

The LG Dam is comprised of a concrete section with an integral concrete spillway, and three earthen berms: the north, center, and south berms. See below for a reference site plan and Appendix A for site photographs.

The 15.3 m wide spillway has an upper elevation of 111.3 m (representing the current maximum operating level of the reservoir), while the concrete dam sections on either side of the spillway have an elevation of 112.3 m. At the maximum operating level of the reservoir, the concrete dam has approximately 0.95 m of freeboard.

The southern section of the concrete dam extends approximately 39.1 m to the south rock abutment. The northern section of the concrete dam extends 13.3 m to the north of the spillway section, where it joins the center earth berm.

The center earth berm extends north approximately 75 m where it meets the access ramp and north access road. The north earth berm is located to the north of the access road ramp and extends 60m to the north rock abutment.

The south earth berm is a separate structure that is located in a valley to the south of the main concrete dam. The south berm is approximately 68.5 m long. The north and center berms incorporate a concrete cutoff wall which is reportedly founded in rock at the base of the berms.

Site Plan

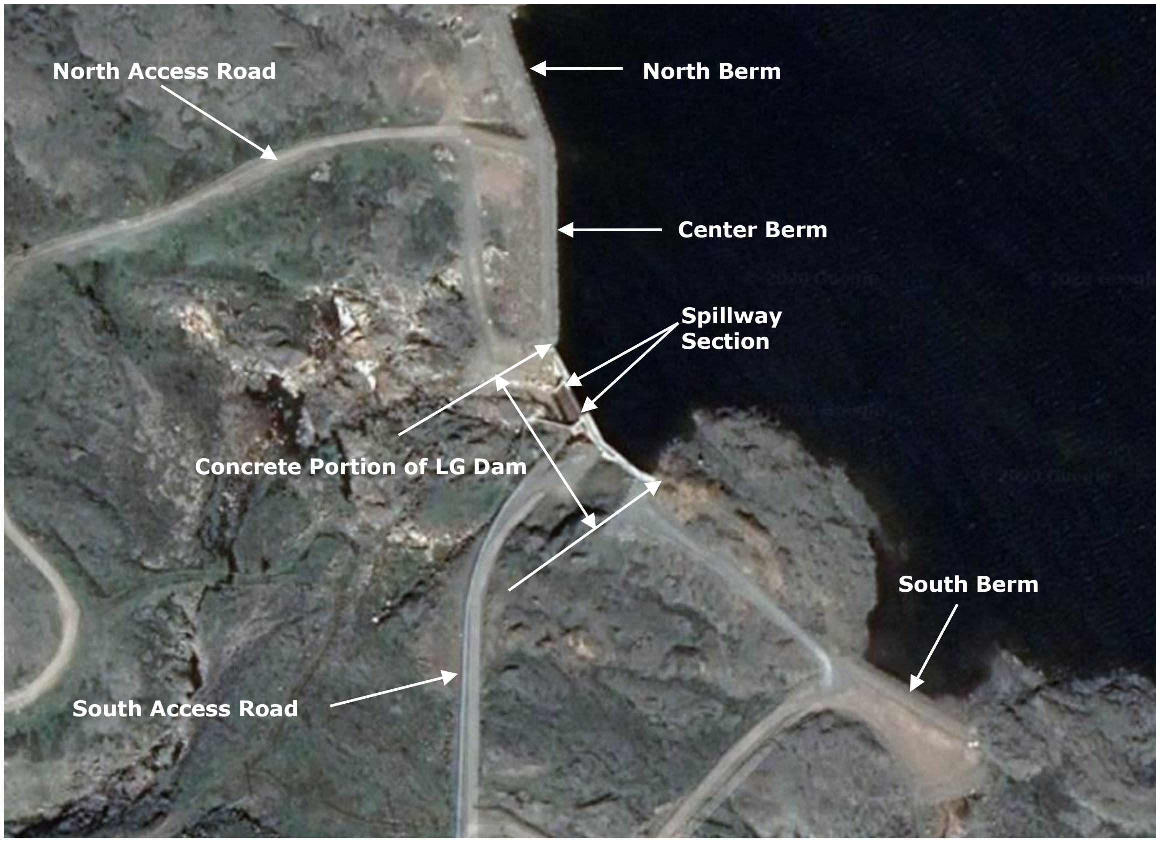


Table 1.1: Lake Geraldine Dam Summary*

Dam/Berm Segment	Length (m)	Crest Elevation	Base Elevation	Bedrock Elevation	Height of Dam/Berm (m)
North Berm	55.5	112.5	108.3	105.0	4.3
Center Berm	78.0	112.5	108.3	97.5	4.5
North Dam	13.3	112.3	102.6	97.5	11.0
Spillway	15.3	111.3	101.6	96	10.0
South Dam	39.1	112.3	102.6	97.5	11.0
South Berm	68.5	112.5	111.5	110.0	1.0

*Tabular data based upon Meco "Dam Safety Management Plan", July 2020

1.3 Scope of Work

As per the requirements of the Dam Safety Guide, the primary task of this DSI is to help identify any significant visual changes in the condition of the concrete dam and earthen berms based on a comparison with the previous inspections and reviews. A visual inspection can identify issues related to dam safety and provides the City of Iqaluit with the opportunity to mitigate any observed concerns or issues. This DSI report is the

primary deliverable and has been prepared in accordance with the Dam Safety Guide document.

The following is a summary of the scope of work for this assignment:

- Conduct a visual on-site assessment of the dam and berms above the water line;
- Prepare a photographic record documenting general and representative conditions;
- Identify, characterize, and risk-assess any significant visual changes in condition;
- Prepare a written report summarizing our observations, items of concern, and recommendations;
- Indicate any recommended repairs and outstanding recommendations from previous inspections and reviews;
- Develop a prioritized list of recommended repairs, upgrades, and improvements with Class D cost estimates;
- Submit final documents in electronic format.

2. HISTORY & BACKGROUND

2.1 Reservoir

The City of Iqaluit derives its water supply from Lake Geraldine, which is retained by a structure consisting of a cast in place concrete section incorporating an integral spillway, and three earthen berms. All concrete structures are reported to be founded on bedrock and engage the rock abutment at the south end of the concrete structure.

Lake Geraldine is a natural body of water in an irregularly shaped basin. It is fed by rainfall and snow/ice melt from a watershed with an area of approximately 385 hectares.

2.2 History

In the late 1950's, the demand for a reliable year-round source of water resulted in the construction of a cast in place concrete gravity dam and a section of earth berm with a central cast in place concrete cut off wall. The project was designed and built by the Department of National Defense. According to the literature, the original construction took place circa 1958.

Since that time, as the City has grown and water demands have risen, the dam has been raised four times to increase the storage capacity. In recent years, the City of Iqaluit has been pumping additional water into the reservoir in the summer and fall of the year from a river located east of the reservoir.

The first height increase of the concrete dam and berms (0.3m) reportedly took place in 1979. This involved a concrete extension, which was dowelled into the existing structure.

The second height increase of the concrete dam and berms took place in 1985 and increased the height of the spillway structure by approximately 1.15m. The berm portion was widened and heightened as well to accommodate the increased storage capacity of the reservoir. The extension of the concrete dam was constructed with concrete and steel reinforcement, dowelled into the existing structure and incorporated a steel formwork frame over the spillway section.

The third extension was undertaken in 1995 and increased the height of the concrete structures by a further 1.5m, with a corresponding increase in berm geometry. Based on analysis done prior to the extension, it was determined that the concrete structures would not have an adequate factor of safety against overturning if the extension was simply "dowelled-in" as before. The 1995 alteration therefore included an extensive rock-anchoring program for the concrete portions to provide the required stability to the structure.

The latest extension was completed in two phases over 2005/06. Additional rock anchors were installed thought the concrete structures in 2005 in preparation for a further height extension of 2 m in 2006. The existing berms were enlarged and the existing cut-of-walls within the north and center berms were extended in height. A new berm (south berm) and cut off wall were installed to the south of the main dam structure. A subsequent technical analysis of the dam and earth berms completed in 2020 indicated that the spillway structure is marginally compliant for stability with relying on rock anchors to resist overturning. CDA guidelines indicate that it is not recommended that passive rock anchors are relied on for stability. The geotechnical investigation completed in 2019 concluded that the bedrock below the concrete dam appeared to be fractured and that the loading capacity of the rock bolts (installed in 2006) would not meet the design expectations. Additional information on this investigation is available within the report produced by Meco and titled, "Technical Analysis & Risk Assessment, Lake Geraldine DSMP", dated 16 July 2020.

In August 2019 various repairs were undertaken to repair the upstream face (below the water line) of the dam. These repairs included:

- Repair of the expansion joint.
- Polyurethane crack injection.
- Localized concrete repairs.

The last major repair program undertaken was completed in the summer of 2021, various repairs were undertaken to maintain the concrete structures, berms, and access roads. These repairs included:

- Placement of additional aggregate material and regrading of the north and south access roads.
- Installation of additional riprap/armor stone on the upstream face of the center and north berms.
- Installation of additional aggregate and regrading of the top of the center and north berms.
- Crack repair and sealing on the downstream face of the concrete structures.
- Concrete repair on the downstream face of the dam.

Replacement of the expansion joint sealant material on the downstream face of the concrete structures was started in 2021 however, the work could not be completed due to local weather and site conditions. This work was completed in July 2022.

Additional improvements were undertaken in the summer of 2022. These repairs included:

- Installation of eight survey monuments.
- Installation of water pressure (piezometer) and temperature data monitoring stations.
- Re-establishment of aggregate stock piles on site.

This work was currently underway at the time this report was prepared.

3. DAM SAFETY INSPECTION

3.1 Site Inspections and Staff Interviews

A visual site inspection of the LG Dam was performed on September 29, 2022 by Cameron McDonald, of Concentric. The inspection was non-invasive in nature and did not include an underwater survey or assessment. For general overview photographs see photograph 1-3 in Appendix A.

A summary of observed conditions is as follows:

- No ice present surrounding the concrete portion of the dam. Snow began to fall midway through the inspection. No ice present in Lake Geraldine.
- The water level within the reservoir reported by Natural Resources Canada on September 29, 2022 was 111.108m.
- Concrete barriers remain in place to block access to the bypass road to the southern berm.
- The area around the base of the power pole that supplies power to the temporary water treatment facility at the south berm has what appears to be some form of oil / creosote around the base of the pole. See Photograph 4. This was reported in the previous DSI report, no corrective measures have been taken to address this potential issue.
- No significant changes were noted in the general condition of the concrete structures.
- Nunavut Excavating has completed the installation of the monitoring stations along the downstream face of the North and South Berms. The metal enclosures installed atop the piezometer boreholes have been removed and some of the borehole tube designated for the installation of the piezometers are obstructed with gravel and sand. See Photographs 3, 6 & 7.
- No change in condition to the metal corner post (used to indicate the edge of the road) identified to have been knocked over by vehicle traffic in the previous report. See Photograph 8.
- Portions of the galvanized metal enclosure that covers the pipe that supplies water from the dam to the water treatment plant are still missing. See Photograph 9.
- No change in condition to the blizzard markers installed along the north side of the south access road identified in the previous report. See Photograph 10.

- The warning signage at the south end of the south berm has been installed. Signage is not installed in a suitable manner. See Photograph 13.
- No change in condition to the small rut identified in the previous report at the north end of the south berm (presumably from a vehicle).
- Leakage was observed at the base of the interface between the bedrock and the concrete dam. Leakage of water has been observed at this location during previous inspections. This leakage is steady and constant.
- The rip rap at the base of the concrete dam, within the spillway, needs to be adjusted. The rip rap has been displaced and is no longer covering all portions of the base of the dam. Miscellaneous materials were observed in the spillway.
- Depression noted in the rip rap lip on the south berm in line with the GN's mobile water treatment plant units. It appears rip rap may have been displaced to accommodate intake hoses. This should be corrected. See photograph 12.
- With the exception of the above noted, no significant changes, such as sloughing, slides, bulging or displacement, were noted in the earthen berms. No active seepage/leakage was observed within the visible portions of the berms; however, based upon our previous inspections and experience, water leakage/seepage may be present within the center berm that is being masked by melt water from the snow and ice.
- The aggregate stockpiles located on the downstream side of the north berm were replenished in early September, however Nunavut Excavating used some of the material to replace aggregate when they installed the monitoring stations.
- Members of the public continue to access the Dam structures and Lake Geraldine.
- Minor leakage at the base of the concrete dam at the interface with the bedrock has been consistent over the last 10+ years however, during our most recent site review we noted a minor increase in the flow of water at this location. Leakage at this location is believed to be caused by water moving through the fractured bedrock below the dam and seepage of water between the base of the concrete dam and bedrock. We did not observe any changes or displacement of the bedrock at the base of the dam. As such, we do not believe that the underlying bedrock has changed or been disturbed.
- Several depressions within the upstream face of the dam were noted when the water level was low in June 2022, these depressions should be corrected in the spring – summer of 2023 when the water level is low in the dam.

3.2 Dam Safety Analysis

A dam safety analysis was not completed as part of this inspection; however, there were no obvious indicators that the concrete structures have had significant changes since the last DSI.

3.3 Operation, Maintenance, and Surveillance

This DSI falls under the requirements of a visual inspection by an engineer as stated in Section 3.6 "Surveillance" of the Dam Safety Guide. The lack of a centralized repository of operational and maintenance records has been an ongoing issue. This, along with other issues regarding the operation and maintenance of the dam and reservoir, is noted within both the "Dam Safety Management Plan" dated July 16, 2020 prepared by MECO and the 2021 Dam Safety Review dated May 31, 2022 prepared by Concentric.

3.4 Recommendations and Required Action

Based on our inspection and review, we recommend the following:

1. Items deemed to be of an urgent need include:
   a. The contaminated soil around the base of the hydro pole adjacent to the south berm should be removed.
   b. Replace stockpile material that Nunavut Excavating used.
2. Updating of the permanent record file and its storage in a central location with an index that documents the date and contents of all records. The permanent record file needs to include:
   a) As-built drawings and specification for work undertaken at the dam.
   b) Weekly/monthly inspections completed by City staff.
   c) Dam Safety Inspections and Dam Safety Reviews generated by third parties on behalf of the City of Iqaluit.
   d) All maintenance records.
   e) Correspondence with regulatory agencies.
   f) Dam operation, maintenance, and surveillance documents.
   g) Reports and documentation generated by third parties on behalf of the City of Iqaluit.
3. Implement a public awareness program to educate and inform the public that:
   a) The dam and earthen berms are a *no trespass* area.
   b) Dog walkers should not allow their pets to travel atop and across the earthen berms due to the risk of (dog) fecal matter contamination of the potable water supply.
   c) ATV and skidoos should not be traveling atop the berms and across Lake Geraldine.
4. The protective galvanized metal enclosure installed over the pipeline from the dam to the water treatment plant should be re-instated.
5. The metal posts / markers that were installed along the north side of the south access road to should be re-instated.
6. The aggregate stockpiles maintained at the west side of the north berm should be replenished by Nunavut Excavation.
7. The installation of video surveillance should be considered with a scheduled implementation in the summer of 2023.
8. Exercising and testing of the valves within the valve chamber is required as part of preventative measures. The condition of the valves within the valve chamber at the base of the dam was previously identified as being in an advanced state of corrosion. To our knowledge no maintenance or testing has been completed on the

controls valve in the last 5+ years. There is a significant potential for the valves to fail and not operate correctly when needed in an emergency. A study to address this issue is currently underway.

9. Underwater survey of the concrete dam and spillway in 2023.
10. Undertake a test opening on the downstream side of the concrete dam and center berm in late January – early February 2023 to ascertain the source of the water that forms large ice sheets within the valley in the winter months.
11. Repair of cracks within the concrete dam, this work is tentatively scheduled for summer 2023.
12. Repair of spalled concrete within the concrete dam, this work is tentatively scheduled for summer 2023.

4. LIMITATIONS

This report was prepared for the sole use of the City of Iqaluit.

This report was prepared exclusively for the purposed project and site locations outlined in this report. The report is based on information provided to, or obtained by Concentric as indicated in the report, and applies solely to site conditions existing at the time of the site investigations.

The conditions of the site may change over time or may have already changed due to natural forces or human intervention, and Concentric takes no responsibility for the impact that such changes may have on the accuracy or validity of the observations, conclusions and recommendations set out in this report.

The report does not extend to any latent defect or other deficiency which could not have been reasonably discoverable or discovered within the scope of the report. Information supplied by the City of Iqaluit or third parties for use in this report has not been verified by Concentric unless stated otherwise.

Concentric's report represents a review of available information with an established work scope, schedule, and budget. The material in the report reflects Concentric's judgement in light of the information available to it at the time of preparation. Any uses that a third party makes of this report, or any reliance on decisions made based on it, are the responsibilities of such third parties.

Concentric accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made based on this report.

Should there be any questions, please contact the undersigned.

Yours sincerely,

CONCENTRIC

Cameron McDonald
Designer

Steve Parker, P.Eng.
Lead Project Manager

APPENDIX A
Site Photographs

Photograph 1 – Overview of concrete structure.

Photograph 2 – Typical south berm condition at the time of our review.

Photograph 3 – Typical north and center berm condition at the time of our review. New monitoring stations installed.

Photograph 4 – Oil residue on the ground around the base of the hydro pole, south berm.

Photograph 5 – Typical expansion joint (concrete dam).

Photograph 6 – Borehole tube for piezometer (open).

Photograph 7 – Borehole tube for piezometer blocked with aggregate material.

Photograph 8 – Corner marker at the junction of the south access road and the road to the south berm has been knocked over.

Photograph 9 – Section of the supply pipe from the dam with the corrugates metal enclosure removed.

Photograph 10 – Blizzard markers knocked over.

Photograph 12 – Displaced rip rap in South Berm.

Photograph 13 – Warning signage installed in the wrong location at the South end of the South Berm.

APPENDIX B

Lake Geraldine Dam Inspection Checklist

Lake Geraldine Dam Inspection Check List

Inspector Name:	Cameron McDonald	Reviewer:	
Inspection Date:	September 29, 2022	Review Date:	
Weather:	-1°C, Overcast with periods of snow	Action Required:	

Sketch the deficiency, and note its important characteristics.
Measure the deficiency.
Photograph the deficiency or describe its characteristics in writing.
Locate the deficiency relative to a recognizable reference point.
https://wateroffice.ec.gc.ca/report/real_time_e.html?stn=10UH013

General Observations

Description	Yes	No	Observations	Action Required
Snow and ice present on dam & berms	X		Snowfall began during DSI. Some photos in the report will show snow on the berms and concrete dam, and others will not. Water on the downstream face of the concrete dam was not from snow melt.	
Snow and ice present on the lake		X		
North access road, gate secured (Any visible damage)	X			
South access road, gate secured (Any visible damage)		X	Gate was not locked and secured.	
Gates on the concrete dam locked (north and south ends on top of dam)	X			
Gates and fencing on top of dam intact or damaged	X		Fencing is intact, however there are areas that appear to be bent out of shape due to trespassers climbing around the fence and over top of the barbed wire.	

Description	Yes	No	Observations	Action Required
Vandalism		X		
Debris on site or in the lake		X		
Dam signage intact or damaged	——	——	Dam signage in place, signage at the North Berm is knocked over. Signage for the South Berm is installed in the wrong location.	
Valve chamber condition and damage (Indicate if there is any cracking, displacement, physical damage, cover is in place, etc)	——	——	No visible change.	
Uncontrolled breach in the concrete dam or earthen berms (embankments)		X		
Animal Activity:		X		

Additional Comments, Sketches or Observations

Concrete Dam and Spillway				
Description	Yes	No	Observations	Action Required
Water level relative to sill of spillway (measure from top of the concrete dam) Is there flow over the spillway		X	6-8" of freeboard.	
Cracking / spalling present on top (surface) of the concrete dam (Indicate if new, existing, expanded, length, width, depth)		X		
Cracking / spalling present on upstream face (surface) of the concrete dam (Indicate if new, existing, expanded, length, width, depth)		X		
Cracking / Spalling present on Downstream face (surface) of the concrete dam (Indicate if new, existing, expanded, length, width, depth)	X		Pre existing spalling. Surface level, spalling does not appear to be expanding.	
Active seepage / leakage through dam Is there silt / sand within the leaking water (Indicate location and rate of leakage in liters per minute)	X		See diagram	
Sealant Condition – Top of Dam	—	—	Sealant has been picked out of expansion joints.	
Sealant Condition – Up stream face of Dam	—	—	Good.	
Sealant Condition – Downstream face of Dam	—	—	Good.	
Active seepage / leakage at: - Interface between concrete and ground (bedrock) - Sealant joints	X		See diagram.	

CONCENTRIC

Lake Geraldine Dam Inspection Check List

Iqaluit

Description	Yes	No	Observations	Action Required
Displacement, settlement or misalignment of sections of the dam		X		
Debris / blockage within the spillway and or drainage channel at base of dam		X		
Erosion at the base of the spillway	—	—	Rip rap needs to be adjusted to be uniformly distributed along the toe of the dam.	
Monitoring stations (condition, damage, other)	—	—	Monitoring stations have been installed. South berm monitoring station was installed in the wrong location. Nunavut Excavating to correct this.	X

Additional Comments, Sketches or Observations

North Berm

Description	Yes	No	Observations	Action Required
Sloughing, slides, bulging, collapse or displacement within the earthen berm – Top of Berm		X		
Sloughing, slides, bulging, collapse or displacement within the earthen berm - Upstream Face		X		
Sloughing, slides, bulging, collapse or displacement within the earthen berm - Downstream Face		X		
Depressions or sink holes within the top (crest) of the berm	X		Tire marks along top of berm from construction activities related to monitoring station installation.	
Depressions or sink holes within the upstream face of the berm		X		
Depressions or sink holes within the downstream face of the berm		X		
Rock, gravel or aggregate displacement or washout (erosion) with the top of the berm		X		
Rock, gravel or aggregate displacement or washout (erosion) within the upstream face of berm		X		
Rock, gravel or aggregate displacement or washout (erosion) within the downstream face of berm		X		

Description	Yes	No	Observations	Action Required
Displaced rip-rap /armor stone on the upstream face of berm	X		Locations previously identified. New material was not placed this year.	
Displaced rip-rap /armor stone on the downstream face of berm		X		
Transverse / longitudinal cracking, within the Top / crest of the berm (Indicate if new, existing, expanded, length, width)		X		
Transverse / longitudinal cracking, within the Upstream face of the berm (Indicate if new, existing, expanded, length, width)		X		
Transverse / longitudinal cracking, within the Downstream face of the berm (Indicate if new, existing, expanded, length, width)		X		
Wet area or active leakage / seepage within the downstream side face of berm Is there silt / sand within the leaking water		X		
Ponding water at base of the berm (downstream), is there sand or silt suspended within the water		X		

Additional Comments, Sketches or Observations

Center Berm

Description	Yes	No	Observations	Action Required
Sloughing, slides, bulging, collapse or displacement within the earthen berm – Top of Berm		X		
Sloughing, slides, bulging, collapse or displacement within the earthen berm - Upstream Face		X		
Sloughing, slides, bulging, collapse or displacement within the earthen berm - Downstream Face		X		
Depressions or sink holes within the top (crest) of the berm	X		Tire marks along top of berm from construction activities related to monitoring station installation.	
Depressions or sink holes within the upstream face of the berm		X		
Depressions or sink holes within the downstream face of the berm		X		
Rock, gravel or aggregate displacement or washout (erosion) with the top of the berm		X		
Rock, gravel or aggregate displacement or washout (erosion) within the upstream face of berm		X		
Rock, gravel or aggregate displacement or washout (erosion) within the downstream face of berm		X		

Description	Yes	No	Observations	Action Required
Displaced rip-rap /armor stone on the upstream face of berm	X		Locations previously identified. New material was not placed this year.	
Displaced rip-rap /armor stone on the downstream face of berm		X		
Transverse / longitudinal cracking, within the Top / crest of the berm (Indicate if new, existing, expanded, length, width)		X		
Transverse / longitudinal cracking, within the Upstream face of the berm (Indicate if new, existing, expanded, length, width)		X		
Transverse / longitudinal cracking, within the Downstream face of the berm (Indicate if new, existing, expanded, length, width)		X		
Wet area or active leakage / seepage within the downstream side face of berm Is there silt / sand within the leaking water	X		Slow stream of water at the low point of the berm. No silt or sediment being scoured. See diagram.	
Ponding water at base of the berm (downstream), is there sand or silt suspended within the water	X		See diagram.	

Additional Comments, Sketches or Observations

South Berm

Description	Yes	No	Observations	Action Required
Sloughing, slides, bulging, collapse or displacement within the earthen berm – Top of Berm		X		
Sloughing, slides, bulging, collapse or displacement within the earthen berm - Upstream Face		X		
Sloughing, slides, bulging, collapse or displacement within the earthen berm - Downstream Face		X		
Depressions or sink holes within the top (crest) of the berm		X		
Depressions or sink holes within the upstream face of the berm		X		
Depressions or sink holes within the downstream face of the berm		X		
Rock, gravel or aggregate displacement or washout (erosion) with the top of the berm		X		
Rock, gravel or aggregate displacement or washout (erosion) within the upstream face of berm		X		
Rock, gravel or aggregate displacement or washout (erosion) within the downstream face of berm		X		

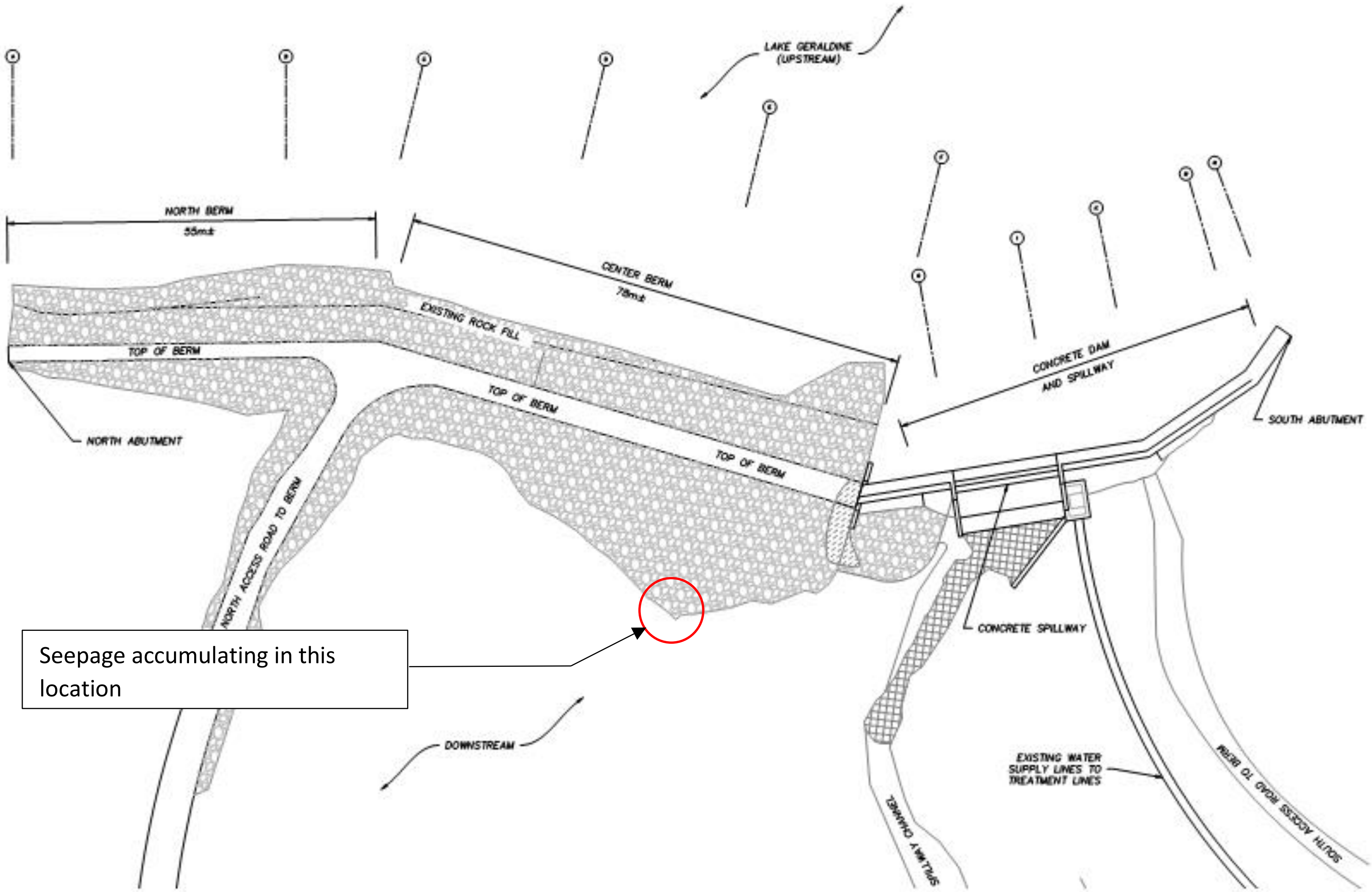
Lake Geraldine Dam Inspection Check List

Description	Yes	No	Observations	Action Required
Displaced rip-rap /armor stone on the upstream face of berm	X		Rip rap lip has been displaced where the GN's mobile water treatment plant was located. See diagram.	X
Displaced rip-rap /armor stone on the downstream face of berm		X		
Transverse / longitudinal cracking, within the Top / crest of the berm (Indicate if new, existing, expanded, length, width)		X		
Transverse / longitudinal cracking, within the Upstream face of the berm (Indicate if new, existing, expanded, length, width)		X		
Transverse / longitudinal cracking, within the Downstream face of the berm (Indicate if new, existing, expanded, length, width)		X		
Wet area or active leakage / seepage within the downstream side face of berm Is there silt / sand within the leaking water		X		
Ponding water at base of the berm (downstream), is there sand or silt suspended within the water		X		

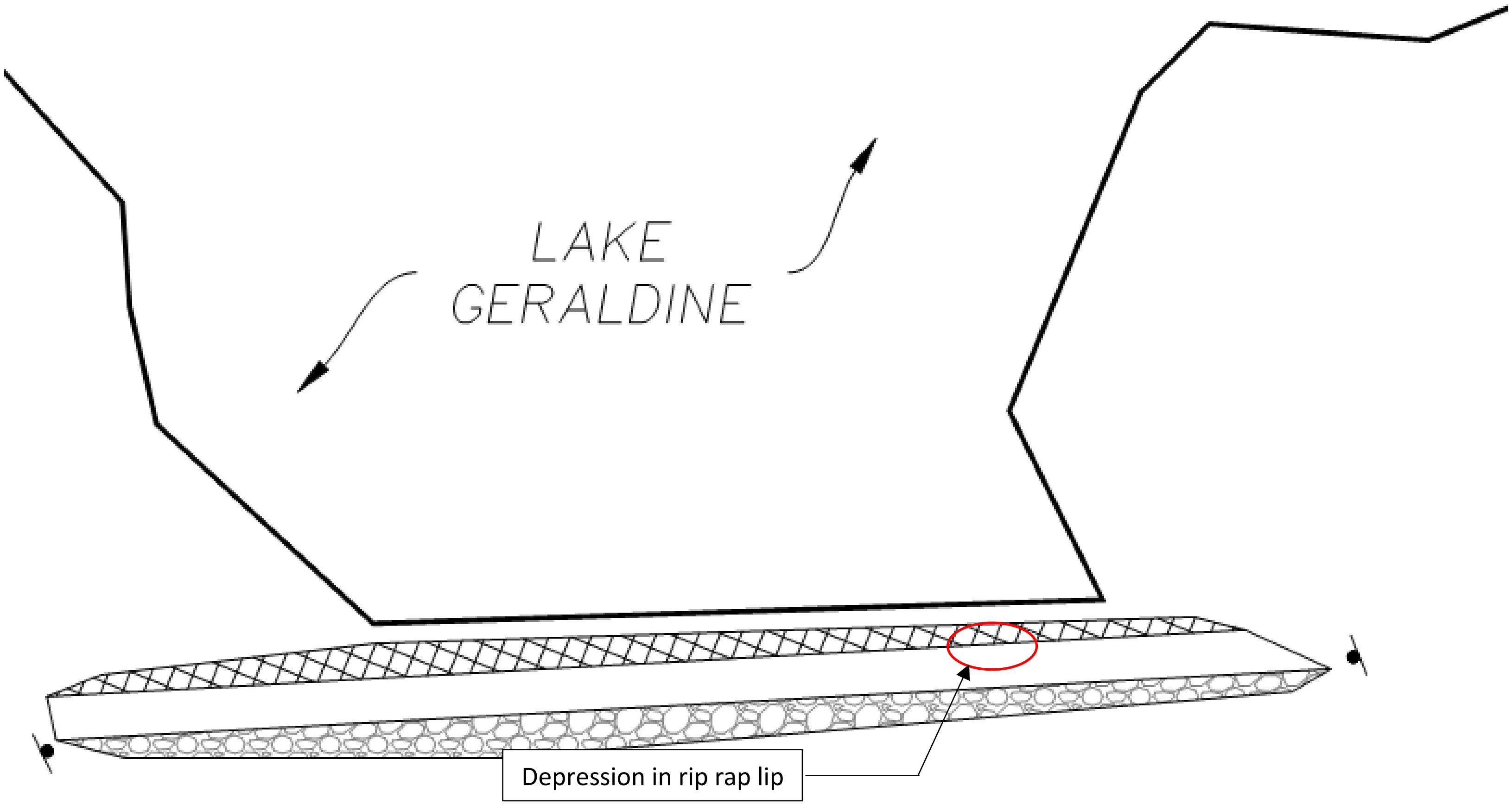
Additional Comments, Sketches or Observations

Lake Geraldine Dam Location Plan

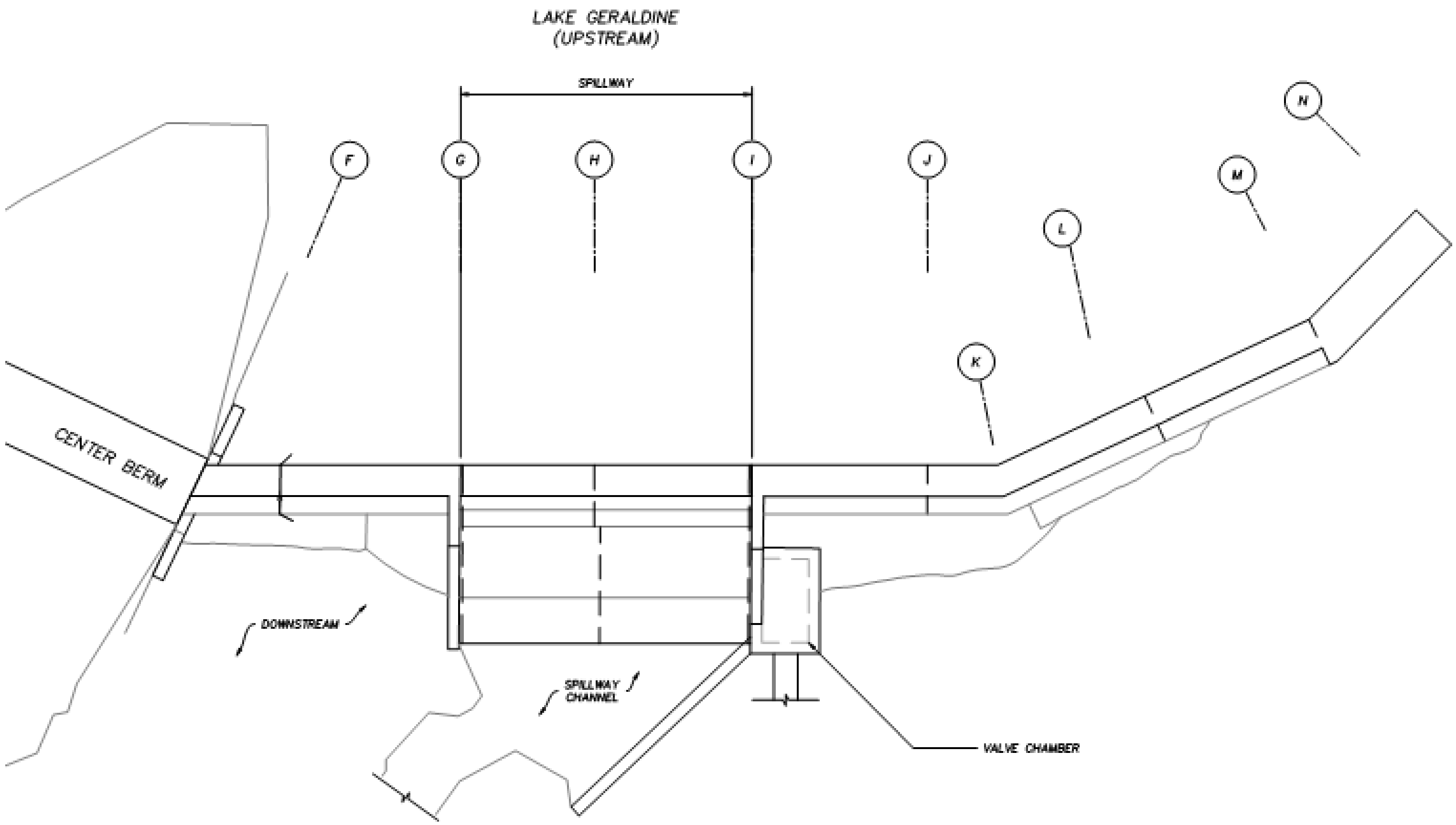
Site Plan – Concrete Dam, Center and North Berms



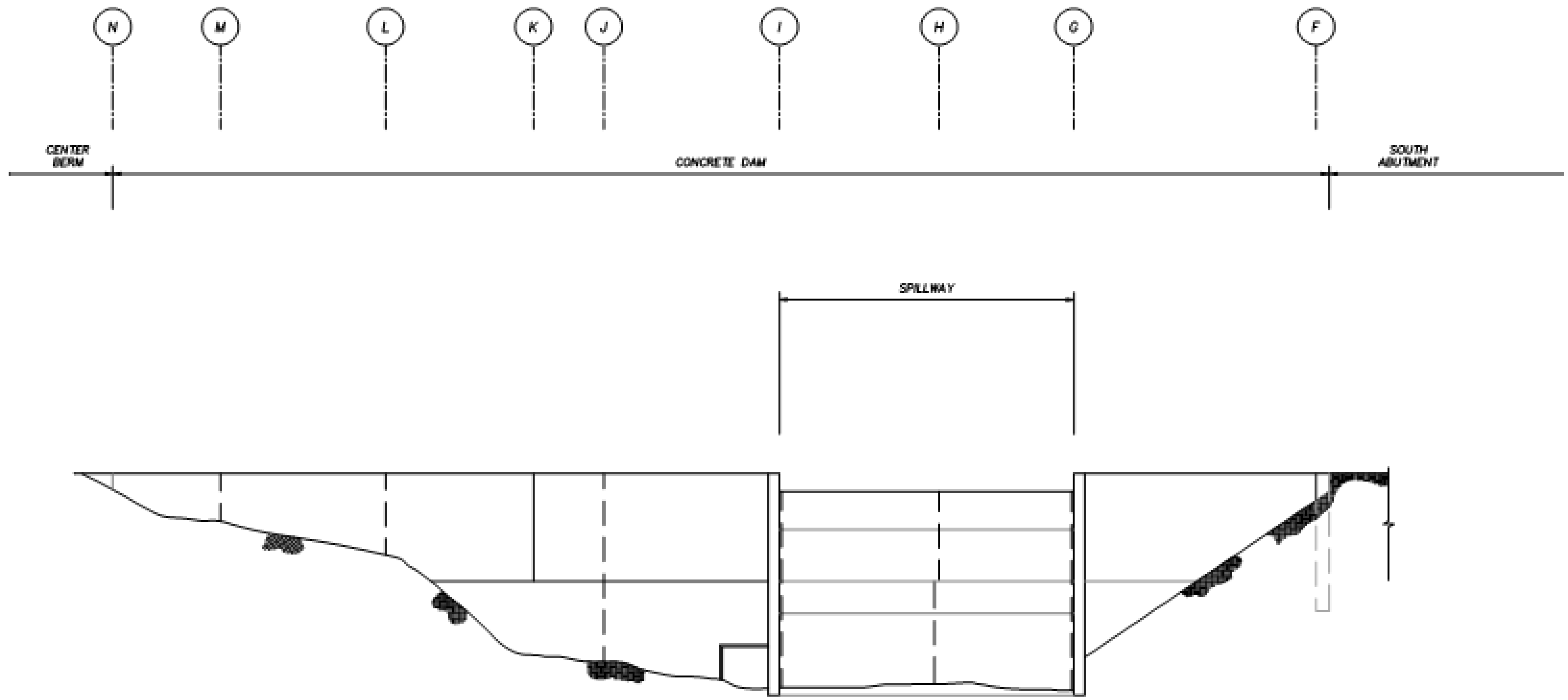
Site Plan – South Berm



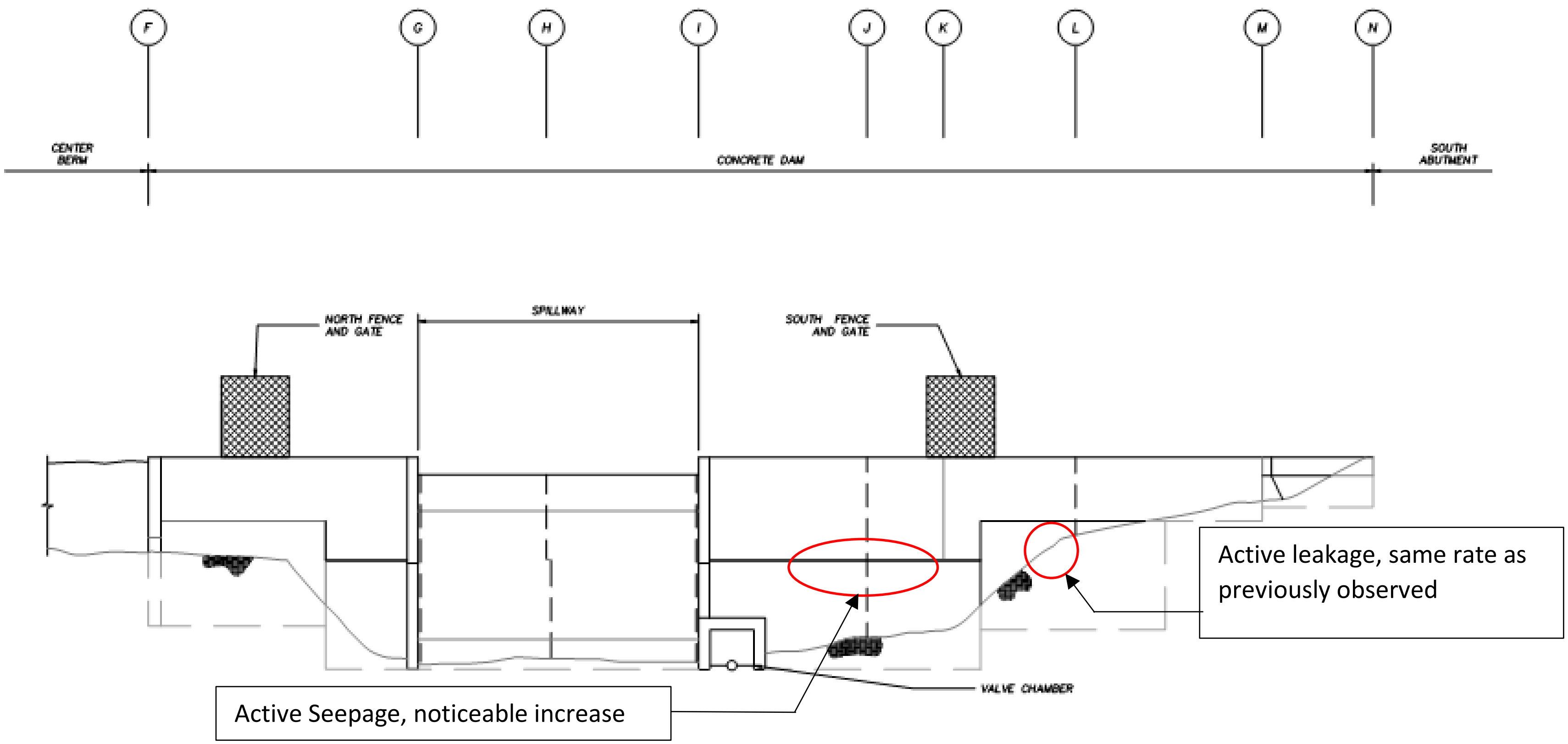
Plan View – Concrete Dam and Spillway



Elevation – Upstream Face, Concrete Dam and Spillway



Elevation – Downstream Face, Concrete Dam and Spillway



APPENDIX B

WATER QUALITY SAMPLING RESULTS

CADUCEON ENVIRONMENTAL LABORATORIES
Client committed. Quality assured.

CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: G100690 **REPORT No. B22-00715**

Report To:

City of Iqaluit
PO Box 460,
Iqaluit NU X0A 0H0
Attention: Emmanuel Kayode

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 10-Jan-22
DATE REPORTED: 24-Jan-22
SAMPLE MATRIX: Drinking Water

JOB/PROJECT NO.: Test A (WTP)
P.O. NUMBER:
WATERWORKS NO.

				Client I.D.	Test A-WTP Raw	Test A-WTP Raw	Test A-WTP Potable	Test A- WTP Potable (Total)
				Sample I.D.	B22-00715-1	B22-00715-2	B22-00715-3	B22-00715-4
				Date Collected	07-Jan-22	07-Jan-22	07-Jan-22	07-Jan-22
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
Hardness (as CaCO3)	mg/L	1	SM 3120	12-Jan-22/O	17		18	
Hardness (as CaCO3)	mg/L	1	SM 3120	13-Jan-22/O		19		18
Alkalinity(CaCO3) to pH4.5	mg/L	5	SM 2320B	10-Jan-22/O	16		12	
Bicarbonate(as CaCO3)	mg/L	5	SM 2320B	10-Jan-22/O	16		12	
Carbonate (as CaCO3)	mg/L	5	SM 2320B	10-Jan-22/O	< 5		< 5	
Hydroxide	mg/L	5	EPA 310.2	10-Jan-22/O	< 5		< 5	
Acidity (as CaCO3)	mg/L	5	Subcontract	14-Jan-22	< 5 [1]		< 5 [1]	
pH @25°C	pH Units		SM 4500H	10-Jan-22/O	6.49		6.19	
Conductivity @25°C	µmho/cm	1	SM 2510B	10-Jan-22/O	40		42	
TDS(ion sum calc.)	mg/L	1	Calc.	13-Jan-22/O	20		20	
Total Suspended Solids	mg/L	3	SM2540D	12-Jan-22/K	< 3		< 3	
Turbidity	NTU	0.1	SM 2130	12-Jan-22/O	0.3		0.2	
REDOX potential	mV		In-House	12-Jan-22/R	390		682	
Chloride	mg/L	0.5	SM4110C	10-Jan-22/O	1.2		2.9	
Sulphate	mg/L	1	SM4110C	10-Jan-22/O	2		2	
Aluminum	mg/L	0.01	SM 3120	12-Jan-22/O	< 0.01		< 0.01	
Aluminum	mg/L	0.01	SM 3120	13-Jan-22/O		< 0.01		< 0.01
Antimony	mg/L	0.0001	EPA 200.8	10-Jan-22/O	< 0.0001		< 0.0001	
Antimony	mg/L	0.0001	EPA 200.8	11-Jan-22/O		0.0004		0.0003
Arsenic	mg/L	0.0001	EPA 200.8	10-Jan-22/O	< 0.0001		< 0.0001	
Arsenic	mg/L	0.0001	EPA 200.8	11-Jan-22/O		< 0.0001		< 0.0001
Barium	mg/L	0.001	SM 3120	12-Jan-22/O	0.002		0.002	
Barium	mg/L	0.001	SM 3120	13-Jan-22/O		0.002		0.002
Beryllium	mg/L	0.002	SM 3120	12-Jan-22/O	< 0.002		< 0.002	
Beryllium	mg/L	0.002	SM 3120	13-Jan-22/O		< 0.002		< 0.002
Cadmium	mg/L	).000015	EPA 200.8	10-Jan-22/O	< 0.000015		< 0.000015	

R.L. = Reporting Limit
Test methods may be modified from specified reference method unless indicated by an *
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill,B-Barrie

Greg Clarkin , BSc., C. Chem
Lab Manager - Ottawa District

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CERTIFICATE OF ANALYSIS

Final Report

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SAMPLE MATRIX: Drinking Water

JOB/PROJECT NO.: Test A (WTP)
P.O. NUMBER:
WATERWORKS NO.

				Client I.D.	Test A- WTP Raw	Test A- WTP Raw	Test A- WTP Potable	Test A- WTP Potable (Total)
				Sample I.D.	B22-00715-1	B22-00715-2	B22-00715-3	B22-00715-4
				Date Collected	07-Jan-22	07-Jan-22	07-Jan-22	07-Jan-22
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
Cadmium	mg/L	).000015	EPA 200.8	11-Jan-22/O		< 0.000015		< 0.000015
Chromium	mg/L	0.002	SM 3120	12-Jan-22/O	< 0.002		< 0.002	
Chromium	mg/L	0.002	SM 3120	13-Jan-22/O		< 0.002		< 0.002
Cobalt	mg/L	0.005	SM 3120	12-Jan-22/O	< 0.005		< 0.005	
Cobalt	mg/L	0.005	SM 3120	13-Jan-22/O		< 0.005		< 0.005
Copper	mg/L	0.002	SM 3120	12-Jan-22/O	0.023		0.023	
Copper	mg/L	0.002	SM 3120	13-Jan-22/O		0.023		0.023
Iron	mg/L	0.005	SM 3120	21-Jan-22/O	0.015		0.017	
Iron	mg/L	0.005	SM 3120	13-Jan-22/O		0.023		0.023
Lead	mg/L	0.00002	EPA 200.8	10-Jan-22/O	0.00003		0.00009	
Lead	mg/L	0.00002	EPA 200.8	11-Jan-22/O		0.00003		0.00009
Lithium	mg/L	0.01	SM 3120	12-Jan-22/O	< 0.01		< 0.01	
Lithium	mg/L	0.01	SM 3120	13-Jan-22/O		< 0.01		< 0.01
Manganese	mg/L	0.001	SM 3120	12-Jan-22/O	0.005		0.003	
Manganese	mg/L	0.001	SM 3120	13-Jan-22/O		0.005		0.004
Mercury	mg/L	0.00002	SM 3112 B	11-Jan-22/O	< 0.00002	< 0.00002	< 0.00002	< 0.00002
Molybdenum	mg/L	0.01	SM 3120	12-Jan-22/O	< 0.01		< 0.01	
Molybdenum	mg/L	0.01	SM 3120	13-Jan-22/O		< 0.01		< 0.01
Nickel	mg/L	0.01	SM 3120	12-Jan-22/O	< 0.01		< 0.01	
Nickel	mg/L	0.01	SM 3120	13-Jan-22/O		< 0.01		< 0.01
Selenium	mg/L	0.001	EPA 200.8	10-Jan-22/O	< 0.001		< 0.001	
Selenium	mg/L	0.001	EPA 200.8	11-Jan-22/O		< 0.001		< 0.001
Silver	mg/L	0.0001	EPA 200.8	10-Jan-22/O	< 0.0001		< 0.0001	
Silver	mg/L	0.0001	EPA 200.8	11-Jan-22/O		< 0.0001		< 0.0001
Strontium	mg/L	0.001	SM 3120	12-Jan-22/O	0.013		0.013	
Strontium	mg/L	0.001	SM 3120	13-Jan-22/O		0.014		0.013

R.L. = Reporting Limit
Test methods may be modified from specified reference method unless indicated by an *
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill,B-Barrie

Greg Clarkin , BSc., C. Chem
Lab Manager - Ottawa District

CADUCEON ENVIRONMENTAL LABORATORIES
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CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: G100690 **REPORT No. B22-00715**

Report To:
City of Iqaluit
PO Box 460,
Iqaluit NU X0A 0H0
Attention: Emmanuel Kayode

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 10-Jan-22
DATE REPORTED: 24-Jan-22
SAMPLE MATRIX: Drinking Water

JOB/PROJECT NO.: Test A (WTP)
P.O. NUMBER:
WATERWORKS NO.

			Client I.D.		Test A- WTP Raw	Test A- WTP Raw	Test A- WTP Potable	Test A- WTP Potable (Total)
			Sample I.D.		B22-00715-1	B22-00715-2	B22-00715-3	B22-00715-4
			Date Collected		07-Jan-22	07-Jan-22	07-Jan-22	07-Jan-22
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
Thallium	mg/L	0.00005	EPA 200.8	10-Jan-22/O	< 0.00005		< 0.00005	
Thallium	mg/L	0.00005	EPA 200.8	11-Jan-22/O		< 0.00005		< 0.00005
Tin	mg/L	0.05	SM 3120	12-Jan-22/O	< 0.05		< 0.05	
Tin	mg/L	0.05	SM 3120	13-Jan-22/O		< 0.05		< 0.05
Titanium	mg/L	0.005	SM 3120	12-Jan-22/O	< 0.005		< 0.005	
Titanium	mg/L	0.005	SM 3120	13-Jan-22/O		< 0.005		< 0.005
Uranium	mg/L	0.00005	EPA 200.8	10-Jan-22/O	< 0.00005		< 0.00005	
Uranium	mg/L	0.00005	EPA 200.8	11-Jan-22/O		< 0.00005		< 0.00005
Vanadium	mg/L	0.005	SM 3120	12-Jan-22/O	< 0.005		< 0.005	
Vanadium	mg/L	0.005	SM 3120	13-Jan-22/O		< 0.005		< 0.005
Zinc	mg/L	0.005	SM 3120	12-Jan-22/O	< 0.005		< 0.005	
Zinc	mg/L	0.005	SM 3120	13-Jan-22/O		0.011		0.010
Total Organic Carbon	mg/L	0.2	EPA 415.2	10-Jan-22/O	1.7		2.1	
TIC	mg/L	0.5	EPA 415.1	10-Jan-22/O	6.6		7.0	
Fecal Coliform	cfu/100mL	1	MOE	10-Jan-22/O	0		0	
Anion Sum	meq/L		Calc.	13-Jan-22/O	0.397		0.383	
Cation Sum	meq/L		Calc.	13-Jan-22/O	0.386		0.391	
% Difference	%		Calc.	13-Jan-22/O	1.43		0.951	
Ion Ratio	AS/CS		Calc.	13-Jan-22/O	1.03		0.981	
Sodium Adsorption Ratio	-		Calc.	13-Jan-22/O	0.0850		0.0833	
Conductivity (calc.)	µmho/cm		Calc.	13-Jan-22/O	41		42	
EC(calc.)/EC(actual)	-		Calc.	13-Jan-22/O	1.02		1.01	
TDS(calc.)/EC(actual)	-		Calc.	13-Jan-22/O	0.501		0.487	
Langelier Index(25°C)	S.I.		Calc.	13-Jan-22/O	-2.89		-3.29	

1 . Subcontracted to Testmark Labs

Greg Clarkin , BSc., C. Chem
Lab Manager - Ottawa District

R.L. = Reporting Limit
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Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill,B-Barrie

CADUCEON ENVIRONMENTAL LABORATORIES
Client committed. Quality assured.

CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: G100690 **REPORT No. B22-00719**

Report To:

City of Iqaluit
PO Box 460,
Iqaluit NU X0A 0H0
Attention: Emmanuel Kayode

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 10-Jan-22
DATE REPORTED: 20-Jan-22
SAMPLE MATRIX: Waste Water

JOB/PROJECT NO.: Test F
P.O. NUMBER:
WATERWORKS NO.

			Client I.D.		WWTP Influent	WWTP Effluent		
			Sample I.D.		B22-00719-1	B22-00719-2		
			Date Collected		07-Jan-22	07-Jan-22		
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
BOD(5 day)	mg/L	3	SM 5210B	10-Jan-22/K	245	155		
Total Suspended Solids	mg/L	3	SM2540D	12-Jan-22/K	300	180		
Conductivity @25°C	µmho/cm	1	SM 2510B	10-Jan-22/O	644	330		
pH @25°C	pH Units		SM 4500H	10-Jan-22/O	7.46	7.18		
Nitrite (N)	mg/L	0.1	SM4110C	11-Jan-22/O	< 0.1	< 0.1		
Nitrate (N)	mg/L	0.1	SM4110C	11-Jan-22/O	0.1	< 0.1		
Ammonia (N)-Total	mg/L	0.01	SM4500-NH3-H	12-Jan-22/K	66.2	22.3		
o-Phosphate (P)	mg/L	0.002	PE4500-S	12-Jan-22/K	4.38	1.71		
Phosphorus-Total	mg/L	0.01	E3199A.1	11-Jan-22/K	6.84	4.08		
Aluminum	mg/L	0.01	SM 3120	13-Jan-22/O	0.41	0.13		
Antimony	mg/L	0.0005	EPA 200.8	10-Jan-22/O	0.0006	0.0006		
Arsenic	mg/L	0.0005	EPA 200.8	10-Jan-22/O	< 0.0005	< 0.0005		
Barium	mg/L	0.001	SM 3120	13-Jan-22/O	0.016	0.006		
Beryllium	mg/L	0.002	SM 3120	13-Jan-22/O	< 0.002	< 0.002		
Cadmium	mg/L	).00007(	EPA 200.8	10-Jan-22/O	0.000215	0.000080		
Chromium	mg/L	0.002	SM 3120	13-Jan-22/O	0.002	< 0.002		
Cobalt	mg/L	0.005	SM 3120	13-Jan-22/O	< 0.005	< 0.005		
Copper	mg/L	0.002	SM 3120	13-Jan-22/O	0.336	0.257		
Iron	mg/L	0.005	SM 3120	13-Jan-22/O	1.04	0.696		
Lead	mg/L	0.0001	EPA 200.8	10-Jan-22/O	0.0062	0.0016		
Lithium	mg/L	0.01	SM 3120	13-Jan-22/O	< 0.01	< 0.01		
Manganese	mg/L	0.001	SM 3120	13-Jan-22/O	0.053	0.041		
Mercury	mg/L	0.00002	SM 3112 B	13-Jan-22/O	0.00062	< 0.00002		
Molybdenum	mg/L	0.01	SM 3120	13-Jan-22/O	< 0.01	< 0.01		
Nickel	mg/L	0.01	SM 3120	13-Jan-22/O	< 0.01	< 0.01		
Selenium	mg/L	0.005	EPA 200.8	10-Jan-22/O	< 0.005	< 0.005		

NOTE: The acceptable holding time of 48 hrs for Total & Fecal Coliform was exceeded upon arrival at the Lab.

R.L. = Reporting Limit
Test methods may be modified from specified reference method unless indicated by an *
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill,B-Barrie

Greg Clarkin , BSc., C. Chem
Lab Manager - Ottawa District

CADUCEON ENVIRONMENTAL LABORATORIES
Client committed. Quality assured.

CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: G100690 **REPORT No. B22-00719**

Report To:

City of Iqaluit
PO Box 460,
Iqaluit NU X0A 0H0
Attention: Emmanuel Kayode

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 10-Jan-22
DATE REPORTED: 20-Jan-22
SAMPLE MATRIX: Waste Water

JOB/PROJECT NO.: Test F
P.O. NUMBER:
WATERWORKS NO.

			Client I.D.		WWTP Influent	WWTP Effluent		
			Sample I.D.		B22-00719-1	B22-00719-2		
			Date Collected		07-Jan-22	07-Jan-22		
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
Silver	mg/L	0.0001	EPA 200.8	10-Jan-22/O	0.0009	0.0001		
Strontium	mg/L	0.001	SM 3120	13-Jan-22/O	0.027	0.023		
Thallium	mg/L	0.0003	EPA 200.8	10-Jan-22/O	< 0.0003	< 0.0003		
Tin	mg/L	0.05	SM 3120	13-Jan-22/O	< 0.05	< 0.05		
Titanium	mg/L	0.005	SM 3120	13-Jan-22/O	0.008	< 0.005		
Uranium	mg/L	0.0003	EPA 200.8	10-Jan-22/O	< 0.0003	< 0.0003		
Vanadium	mg/L	0.005	SM 3120	13-Jan-22/O	< 0.005	< 0.005		
Zinc	mg/L	0.005	SM 3120	13-Jan-22/O	0.227	0.103		
Total Coliform	cfu/100mL	1	MOE	10-Jan-22/O	70000000	19000000		
Fecal Coliform	cfu/100mL	1	MOE	10-Jan-22/O	2300000	100000		

NOTE: The acceptable holding time of 48 hrs for Total & Fecal Coliform was exceeded upon arrival at the Lab.

Greg Clarkin , BSc., C. Chem
Lab Manager - Ottawa District

R.L. = Reporting Limit
Test methods may be modified from specified reference method unless indicated by an *
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill,B-Barrie

CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: G095643 **REPORT No. B22-03737**

Report To:

City of Iqaluit
PO Box 460,
Iqaluit NU X0A 0H0
Attention: Emmanuel Kayode

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 08-Feb-22
DATE REPORTED: 14-Feb-22
SAMPLE MATRIX: Waste Water

JOB/PROJECT NO.: Test F
P.O. NUMBER:
WATERWORKS NO.

				Client I.D.	WWTP Influent	WWTP Effluent		
				Sample I.D.	B22-03737-1	B22-03737-2		
				Date Collected	07-Feb-22	07-Feb-22		
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
BOD(5 day)	mg/L	3	SM 5210B	09-Feb-22/K	209	152		
Total Suspended Solids	mg/L	3	SM2540D	10-Feb-22/K	168	144		
Conductivity @25°C	µmho/cm	1	SM 2510B	09-Feb-22/O	396	309		
pH @25°C	pH Units		SM 4500H	09-Feb-22/O	7.74	7.50		
Nitrite (N)	mg/L	0.1	SM4110C	08-Feb-22/O	< 0.1	< 0.1		
Nitrate (N)	mg/L	0.1	SM4110C	08-Feb-22/O	0.1	0.1		
Ammonia (N)-Total	mg/L	0.01	SM4500-NH3-H	10-Feb-22/K	36.7	25.1		
o-Phosphate (P)	mg/L	0.002	PE4500-S	10-Feb-22/K	3.35	2.04		
Phosphorus-Total	mg/L	0.01	E3516.2	14-Feb-22/K	4.65	3.94		
Aluminum	mg/L	0.01	SM 3120	09-Feb-22/O	0.11	0.10		
Antimony	mg/L	0.0005	EPA 200.8	11-Feb-22/O	< 0.0005	< 0.0005		
Arsenic	mg/L	0.0005	EPA 200.8	11-Feb-22/O	< 0.0005	< 0.0005		
Barium	mg/L	0.001	SM 3120	09-Feb-22/O	0.006	0.005		
Beryllium	mg/L	0.002	SM 3120	09-Feb-22/O	< 0.002	< 0.002		
Cadmium	mg/L	).000070	EPA 200.8	11-Feb-22/O	0.000114	0.000110		
Chromium	mg/L	0.002	SM 3120	09-Feb-22/O	< 0.002	0.009		
Cobalt	mg/L	0.005	SM 3120	09-Feb-22/O	< 0.005	< 0.005		
Copper	mg/L	0.002	SM 3120	09-Feb-22/O	0.324	0.270		
Iron	mg/L	0.005	SM 3120	09-Feb-22/O	0.318	0.259		
Lead	mg/L	0.0001	EPA 200.8	11-Feb-22/O	0.0021	0.0013		
Lithium	mg/L	0.01	SM 3120	09-Feb-22/O	< 0.01	< 0.01		
Manganese	mg/L	0.001	SM 3120	09-Feb-22/O	0.026	0.025		
Mercury	mg/L	0.00002	SM 3112 B	10-Feb-22/O	0.00003	< 0.00002		
Molybdenum	mg/L	0.01	SM 3120	09-Feb-22/O	< 0.01	< 0.01		
Nickel	mg/L	0.01	SM 3120	09-Feb-22/O	< 0.01	< 0.01		
Selenium	mg/L	0.005	EPA 200.8	11-Feb-22/O	< 0.005	< 0.005		

R.L. = Reporting Limit
Test methods may be modified from specified reference method unless indicated by an *
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill,B-Barrie

Greg Clarkin , BSc., C. Chem
Lab Manager - Ottawa District

CADUCEON ENVIRONMENTAL LABORATORIES
Client committed. Quality assured.

CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: G095643 **REPORT No. B22-03737**

Report To:
City of Iqaluit
PO Box 460,
Iqaluit NU X0A 0H0
Attention: Emmanuel Kayode

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 08-Feb-22
DATE REPORTED: 14-Feb-22
SAMPLE MATRIX: Waste Water

JOB/PROJECT NO.: Test F
P.O. NUMBER:
WATERWORKS NO.

				Client I.D.	WWTP Influent	WWTP Effluent		
				Sample I.D.	B22-03737-1	B22-03737-2		
				Date Collected	07-Feb-22	07-Feb-22		
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
Silver	mg/L	0.0001	EPA 200.8	11-Feb-22/O	< 0.0001	< 0.0001		
Strontium	mg/L	0.001	SM 3120	09-Feb-22/O	0.022	0.020		
Thallium	mg/L	0.0003	EPA 200.8	11-Feb-22/O	< 0.0003	< 0.0003		
Tin	mg/L	0.05	SM 3120	09-Feb-22/O	< 0.05	< 0.05		
Titanium	mg/L	0.005	SM 3120	09-Feb-22/O	< 0.005	< 0.005		
Uranium	mg/L	0.0003	EPA 200.8	11-Feb-22/O	< 0.0003	< 0.0003		
Vanadium	mg/L	0.005	SM 3120	09-Feb-22/O	< 0.005	< 0.005		
Zinc	mg/L	0.005	SM 3120	09-Feb-22/O	0.130	0.102		
Total Coliform	cfu/100mL	1	MOE	08-Feb-22/O	35000000	21000000		
Fecal Coliform	cfu/100mL	1	MOE	08-Feb-22/O	7000000	5000000		

R.L. = Reporting Limit
Test methods may be modified from specified reference method unless indicated by an *
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill,B-Barrie

Greg Clarkin , BSc., C. Chem
Lab Manager - Ottawa District

CADUCEON ENVIRONMENTAL LABORATORIES

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CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: DW 04569 **REPORT No. B22-04569**

Report To:

City of Iqaluit
PO Box 460,
Iqaluit NU X0A 0H0
Attention: Emmanuel Kayode

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 16-Feb-22
DATE REPORTED: 23-Feb-22
SAMPLE MATRIX: Drinking Water

JOB/PROJECT NO.: Test A (WTP)
P.O. NUMBER:
WATERWORKS NO.

			Client I.D.		WTP Raw	WTP Raw (Total)	WTP Potable	WTP Potable (Total)
			Sample I.D.		B22-04569-1	B22-04569-2	B22-04569-3	B22-04569-4
			Date Collected		14-Feb-22	14-Feb-22	14-Feb-22	14-Feb-22
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
Hardness (as CaCO3)	mg/L	1	SM 3120	18-Feb-22/O	20		21	
Hardness (as CaCO3)	mg/L	1	SM 3120	18-Feb-22/O		20		21
Alkalinity(CaCO3) to pH4.5	mg/L	5	SM 2320B	17-Feb-22/O	35		18	
Bicarbonate(as CaCO3)	mg/L	5	SM 2320B	17-Feb-22/O	35		18	
Carbonate (as CaCO3)	mg/L	5	SM 2320B	17-Feb-22/O	< 5		< 5	
Hydroxide	mg/L	5	EPA 310.2	17-Feb-22/O	< 5		< 5	
Acidity (as CaCO3)	mg/L	5	Subcontract	22-Feb-22	< 5 [1]		< 5 [1]	
pH @25°C	pH Units		SM 4500H	17-Feb-22/O	6.52		6.44	
Conductivity @25°C	µmho/cm	1	SM 2510B	17-Feb-22/O	44		46	
TDS(ion sum calc.)	mg/L	1	Calc.	22-Feb-22/O	34		25	
Total Suspended Solids	mg/L	3	SM2540D	17-Feb-22/K	< 3		< 3	
Turbidity	NTU	0.1	SM 2130	17-Feb-22/O	0.2		0.2	
REDOX potential	mV		In-House	17-Feb-22/R	350		773	
Chloride	mg/L	0.5	SM4110C	16-Feb-22/O	1.6		3.6	
Sulphate	mg/L	1	SM4110C	16-Feb-22/O	2		2	
Aluminum	mg/L	0.01	SM 3120	18-Feb-22/O	< 0.01		< 0.01	
Aluminum	mg/L	0.01	SM 3120	18-Feb-22/O		< 0.01		< 0.01
Antimony	mg/L	0.0001	EPA 200.8	18-Feb-22/O	< 0.0001		< 0.0001	
Antimony	mg/L	0.0001	EPA 200.8	18-Feb-22/O		0.0003		0.0003
Arsenic	mg/L	0.0001	EPA 200.8	18-Feb-22/O	< 0.0001		< 0.0001	
Arsenic	mg/L	0.0001	EPA 200.8	18-Feb-22/O		< 0.0001		< 0.0001
Barium	mg/L	0.001	SM 3120	18-Feb-22/O	0.001		0.002	
Barium	mg/L	0.001	SM 3120	18-Feb-22/O		0.002		0.002
Beryllium	mg/L	0.002	SM 3120	18-Feb-22/O	< 0.002		< 0.002	
Beryllium	mg/L	0.002	SM 3120	18-Feb-22/O		< 0.002		< 0.002
Cadmium	mg/L	).000015	EPA 200.8	18-Feb-22/O	< 0.000015		< 0.000015	
Cadmium	mg/L	).000015	EPA 200.8	18-Feb-22/O		< 0.000015		< 0.000015

Greg Clarkin , BSc., C. Chem
Lab Manager - Ottawa District

R.L. = Reporting Limit
Test methods may be modified from specified reference method unless indicated by an *
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill,B-Barrie

CERTIFICATE OF ANALYSIS

Final Report

Client committed. Quality assured.

C.O.C.: DW 04569 **REPORT No. B22-04569**

Report To:

City of Iqaluit
PO Box 460,
Iqaluit NU X0A 0H0
Attention: Emmanuel Kayode

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 16-Feb-22
DATE REPORTED: 23-Feb-22
SAMPLE MATRIX: Drinking Water

JOB/PROJECT NO.: Test A (WTP)
P.O. NUMBER:
WATERWORKS NO.

				Client I.D.	WTP Raw	WTP Raw (Total)	WTP Potable	WTP Potable (Total)
				Sample I.D.	B22-04569-1	B22-04569-2	B22-04569-3	B22-04569-4
				Date Collected	14-Feb-22	14-Feb-22	14-Feb-22	14-Feb-22
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
Chromium	mg/L	0.002	SM 3120	18-Feb-22/O	< 0.002		< 0.002	
Chromium	mg/L	0.002	SM 3120	18-Feb-22/O		< 0.002		< 0.002
Cobalt	mg/L	0.005	SM 3120	18-Feb-22/O	< 0.005		< 0.005	
Cobalt	mg/L	0.005	SM 3120	18-Feb-22/O		< 0.005		< 0.005
Copper	mg/L	0.002	SM 3120	18-Feb-22/O	0.002		0.065	
Copper	mg/L	0.002	SM 3120	18-Feb-22/O		0.002		0.066
Iron	mg/L	0.005	SM 3120	18-Feb-22/O	0.019		0.024	
Iron	mg/L	0.005	SM 3120	18-Feb-22/O		0.030		0.027
Lead	mg/L	0.00002	EPA 200.8	18-Feb-22/O	< 0.00002		0.00009	
Lead	mg/L	0.00002	EPA 200.8	18-Feb-22/O		< 0.00002		0.00013
Lithium	mg/L	0.01	SM 3120	18-Feb-22/O	< 0.01		< 0.01	
Lithium	mg/L	0.01	SM 3120	18-Feb-22/O		< 0.01		< 0.01
Manganese	mg/L	0.001	SM 3120	18-Feb-22/O	0.005		0.005	
Manganese	mg/L	0.001	SM 3120	18-Feb-22/O		0.005		0.005
Mercury	mg/L	0.00002	SM 3112 B	17-Feb-22/O	< 0.00002	< 0.00002	< 0.00002	< 0.00002
Molybdenum	mg/L	0.01	SM 3120	18-Feb-22/O	< 0.01		< 0.01	
Molybdenum	mg/L	0.01	SM 3120	18-Feb-22/O		< 0.01		< 0.01
Nickel	mg/L	0.01	SM 3120	18-Feb-22/O	< 0.01		< 0.01	
Nickel	mg/L	0.01	SM 3120	18-Feb-22/O		< 0.01		< 0.01
Selenium	mg/L	0.001	EPA 200.8	18-Feb-22/O	< 0.001		< 0.001	
Selenium	mg/L	0.001	EPA 200.8	18-Feb-22/O		< 0.001		< 0.001
Silver	mg/L	0.0001	EPA 200.8	18-Feb-22/O	< 0.0001		< 0.0001	
Silver	mg/L	0.0001	EPA 200.8	18-Feb-22/O		< 0.0001		< 0.0001
Strontium	mg/L	0.001	SM 3120	18-Feb-22/O	0.014		0.016	
Strontium	mg/L	0.001	SM 3120	18-Feb-22/O		0.014		0.016
Thallium	mg/L	0.00005	EPA 200.8	18-Feb-22/O	< 0.00005		< 0.00005	
Thallium	mg/L	0.00005	EPA 200.8	18-Feb-22/O		< 0.00005		< 0.00005

Greg Clarkin , BSc., C. Chem
Lab Manager - Ottawa District

R.L. = Reporting Limit
Test methods may be modified from specified reference method unless indicated by an *
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill,B-Barrie

CADUCEON ENVIRONMENTAL LABORATORIES
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CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: DW 04569 **REPORT No. B22-04569**

Report To:

City of Iqaluit
PO Box 460,
Iqaluit NU X0A 0H0
Attention: Emmanuel Kayode

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 16-Feb-22
DATE REPORTED: 23-Feb-22
SAMPLE MATRIX: Drinking Water

JOB/PROJECT NO.: Test A (WTP)
P.O. NUMBER:
WATERWORKS NO.

				Client I.D.	WTP Raw	WTP Raw (Total)	WTP Potable	WTP Potable (Total)
				Sample I.D.	B22-04569-1	B22-04569-2	B22-04569-3	B22-04569-4
				Date Collected	14-Feb-22	14-Feb-22	14-Feb-22	14-Feb-22
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
Tin	mg/L	0.05	SM 3120	18-Feb-22/O	< 0.05		< 0.05	
Tin	mg/L	0.05	SM 3120	18-Feb-22/O		< 0.05		< 0.05
Titanium	mg/L	0.005	SM 3120	18-Feb-22/O	< 0.005		< 0.005	
Titanium	mg/L	0.005	SM 3120	18-Feb-22/O		< 0.005		< 0.005
Uranium	mg/L	0.00005	EPA 200.8	18-Feb-22/O	< 0.00005		< 0.00005	
Uranium	mg/L	0.00005	EPA 200.8	18-Feb-22/O		< 0.00005		< 0.00005
Vanadium	mg/L	0.005	SM 3120	18-Feb-22/O	< 0.005		< 0.005	
Vanadium	mg/L	0.005	SM 3120	18-Feb-22/O		< 0.005		< 0.005
Zinc	mg/L	0.005	SM 3120	18-Feb-22/O	< 0.005		0.012	
Zinc	mg/L	0.005	SM 3120	18-Feb-22/O		0.005		0.014
Total Organic Carbon	mg/L	0.2	EPA 415.2	17-Feb-22/O	1.3		1.2	
TIC	mg/L	0.5	EPA 415.1	17-Feb-22/O	14.4		8.1	
Fecal Coliform	cfu/100mL	1	MOE	16-Feb-22/O	0		0	
Anion Sum	meq/L		Calc.	22-Feb-22/O	0.800		0.505	
Cation Sum	meq/L		Calc.	22-Feb-22/O	0.444		0.464	
% Difference	%		Calc.	22-Feb-22/O	28.6		4.23	
Ion Ratio	AS/CS		Calc.	22-Feb-22/O	1.80		1.09	
Sodium Adsorption Ratio	-		Calc.	22-Feb-22/O	0.0890		0.0888	
Conductivity (calc.)	µmho/cm		Calc.	22-Feb-22/O	62		52	
EC(calc.)/EC(actual)	-		Calc.	22-Feb-22/O	1.40		1.15	
TDS(calc.)/EC(actual)	-		Calc.	22-Feb-22/O	0.764		0.559	
Langelier Index(25°C)	S.I.		Calc.	22-Feb-22/O	-2.47		-2.81	

1 Subcontracted to Testmark Labs

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Greg Clarkin , BSc., C. Chem
Lab Manager - Ottawa District

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CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: G095644 **REPORT No. B22-06771**

Report To:

City of Iqaluit
PO Box 460,
Iqaluit NU X0A 0H0
Attention: Emmanuel Kayode

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 11-Mar-22
DATE REPORTED: 21-Mar-22
SAMPLE MATRIX: Waste Water

JOB/PROJECT NO.: Test F
P.O. NUMBER:
WATERWORKS NO.

			Client I.D.		WWTP Influent	WWTP Effluent		
			Sample I.D.		B22-06771-1	B22-06771-2		
			Date Collected		10-Mar-22	10-Mar-22		
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
BOD(5 day)	mg/L	3	SM 5210B	14-Mar-22/K	148	130		
Total Suspended Solids	mg/L	3	SM2540D	14-Mar-22/K	350	116		
Conductivity @25°C	µmho/cm	1	SM 2510B	11-Mar-22/O	393	311		
pH @25°C	pH Units		SM 4500H	11-Mar-22/O	7.57	7.54		
Nitrite (N)	mg/L	0.1	SM4110C	14-Mar-22/O	< 1	< 0.1		
Nitrate (N)	mg/L	0.1	SM4110C	14-Mar-22/O	< 1	< 0.1		
Ammonia (N)-Total	mg/L	0.01	SM4500-NH3-H	14-Mar-22/K	36.9	18.7		
o-Phosphate (P)	mg/L	0.002	PE4500-S	14-Mar-22/K	3.40	0.926		
Phosphorus-Total	mg/L	0.01	E3516.2	15-Mar-22/K	4.92	2.84		
Aluminum	mg/L	0.01	SM 3120	14-Mar-22/O	0.10	0.13		
Antimony	mg/L	0.0005	EPA 200.8	16-Mar-22/O	< 0.0005	< 0.0005		
Arsenic	mg/L	0.0005	EPA 200.8	14-Mar-22/O	< 0.0005	< 0.0005		
Barium	mg/L	0.001	SM 3120	14-Mar-22/O	0.006	0.005		
Beryllium	mg/L	0.002	SM 3120	14-Mar-22/O	< 0.002	< 0.002		
Cadmium	mg/L	).00007(	EPA 200.8	14-Mar-22/O	0.000079	0.000105		
Chromium	mg/L	0.002	SM 3120	14-Mar-22/O	< 0.002	< 0.002		
Cobalt	mg/L	0.005	SM 3120	14-Mar-22/O	< 0.005	< 0.005		
Copper	mg/L	0.002	SM 3120	14-Mar-22/O	0.290	0.253		
Iron	mg/L	0.005	SM 3120	14-Mar-22/O	0.328	0.199		
Lead	mg/L	0.0001	EPA 200.8	14-Mar-22/O	0.0046	0.0016		
Lithium	mg/L	0.01	SM 3120	14-Mar-22/O	< 0.01	< 0.01		
Manganese	mg/L	0.001	SM 3120	14-Mar-22/O	0.019	0.016		
Mercury	mg/L	0.00002	SM 3112 B	15-Mar-22/O	0.00002	< 0.00002		
Molybdenum	mg/L	0.01	SM 3120	14-Mar-22/O	< 0.01	< 0.01		
Nickel	mg/L	0.01	SM 3120	14-Mar-22/O	< 0.01	< 0.01		
Selenium	mg/L	0.005	EPA 200.8	14-Mar-22/O	< 0.005	< 0.005		

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Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill,B-Barrie

Greg Clarkin , BSc., C. Chem
Lab Manager - Ottawa District

CADUCEON ENVIRONMENTAL LABORATORIES
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CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: G095644 **REPORT No. B22-06771**

Report To:

City of Iqaluit
PO Box 460,
Iqaluit NU X0A 0H0
Attention: Emmanuel Kayode

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 11-Mar-22
DATE REPORTED: 21-Mar-22
SAMPLE MATRIX: Waste Water

JOB/PROJECT NO.: Test F
P.O. NUMBER:
WATERWORKS NO.

			Client I.D.		WWTP Influent	WWTP Effluent		
			Sample I.D.		B22-06771-1	B22-06771-2		
			Date Collected		10-Mar-22	10-Mar-22		
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
Silver	mg/L	0.0001	EPA 200.8	14-Mar-22/O	< 0.0001	< 0.0001		
Strontium	mg/L	0.001	SM 3120	14-Mar-22/O	0.020	0.019		
Thallium	mg/L	0.0003	EPA 200.8	14-Mar-22/O	< 0.0003	< 0.0003		
Tin	mg/L	0.05	SM 3120	14-Mar-22/O	< 0.05	< 0.05		
Titanium	mg/L	0.005	SM 3120	14-Mar-22/O	< 0.005	< 0.005		
Uranium	mg/L	0.0003	EPA 200.8	16-Mar-22/O	< 0.0003	< 0.0003		
Vanadium	mg/L	0.005	SM 3120	14-Mar-22/O	< 0.005	< 0.005		
Zinc	mg/L	0.005	SM 3120	14-Mar-22/O	0.118	0.082		
Total Coliform	cfu/100mL	1	MOE	11-Mar-22/O	37000000	11000000		
Fecal Coliform	cfu/100mL	1	MOE	11-Mar-22/O	3800000	1300000		

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Greg Clarkin , BSc., C. Chem
Lab Manager - Ottawa District

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CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: G095644 **REPORT No. B22-06774**

Report To:

City of Iqaluit
PO Box 460,
Iqaluit NU X0A 0H0
Attention: Emmanuel Kayode

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 11-Mar-22
DATE REPORTED: 25-Mar-22
SAMPLE MATRIX: Drinking Water

JOB/PROJECT NO.: Test A (WTP)
P.O. NUMBER:
WATERWORKS NO.

Parameter	Qty	Site Analyzed	Analyst Initials	Date Analyzed	Lab Method	Reference Method
A - Wet Chem	2	Holly Lane	SYL	11-Mar-22	A-ALK-02 O	EPA 310.2
Alkalinity (as CaCO3)	2	Holly Lane	SYL	11-Mar-22	A-ALK-03 (o)	SM 2320B
Conductivity	2	Holly Lane	JGC	11-Mar-22	A-COND-02 (o)	SM 2510B
Anions	2	Holly Lane	VK	11-Mar-22	A-IC-01 (o)	SM4110C
pH	2	Holly Lane	SYL	11-Mar-22	A-PH-01 (o)	SM 4500H
Physical	2	Richmond Hill	nka	21-Mar-22	A-REDOX	In-House
Total Suspended Solids	2	Kingston	bbr	14-Mar-22	A-TSS-001 (k)	SM2540D
Turbidity	2	Holly Lane	ST	14-Mar-22	A-TURB-01 (o)	SM 2130
B - Bacteriological	2	Holly Lane	SLO	11-Mar-22	B-MFFC-01 (o)	MOE E3371
A - Wet Chem	2	Holly Lane	VK	11-Mar-22	C-TC	EPA 415.1
TOC	2	Holly Lane	VK	11-Mar-22	C-TOC-01	EPA 415.2
Mercury	4	Holly Lane	PBK	15-Mar-22	D-HG-02 (o)	SM 3112 B
Metals - ICP-OES	2	Holly Lane	AHM	11-Mar-22	D-ICP-01 (o)	SM 3120
Metals - ICP-OES	2	Holly Lane	NHG	14-Mar-22	D-ICP-01 (o)	SM 3120
Metals-ICP-MS	2	Holly Lane	TPR	17-Mar-22	D-ICPMS Dissolved 7800	EPA 200.8
Metals - ICP-MS	2	Holly Lane	TPR	14-Mar-22	D-ICPMS-01 (o)	EPA 200.8
Calculation	2	Holly Lane	JGC	14-Mar-22	D-Ion Balance	Calc.
Subcontracted	2	Default Site	JGC	24-Mar-22	S-Acidity	Subcontract

Canadian DW Guidelines - Drinking Water
CDWG - Canadian Drinking Water Guidelines

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Greg Clarkin , BSc., C. Chem
Lab Manager - Ottawa District

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CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: G095644 **REPORT No. B22-06774**

Report To:
City of Iqaluit
PO Box 460,
Iqaluit NU X0A 0H0
Attention: Emmanuel Kayode

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 11-Mar-22
DATE REPORTED: 25-Mar-22
SAMPLE MATRIX: Drinking Water

JOB/PROJECT NO.: Test A (WTP)
P.O. NUMBER:
WATERWORKS NO.

	Client I.D.		Test A- Raw WTP	Test A- Raw WTP (Total)	Test A- Potable WTP	Test A- Potable (Total)	**Canadian DW Guidelines**	
	Sample I.D.		B22-06774-1	B22-06774-2	B22-06774-3	B22-06774-4	**CDWG**	
	Date Collected		10-Mar-22	10-Mar-22	10-Mar-22	10-Mar-22		
Parameter	**Units**	**R.L.**						
Hardness (as CaCO3)	mg/L	1	20		20			
Hardness (as CaCO3)	mg/L	1		20		20		
Alkalinity(CaCO3) to pH4.5	mg/L	5	23		16			
Bicarbonate(as CaCO3)	mg/L	5	23		16			
Carbonate (as CaCO3)	mg/L	5	< 5		< 5			
Hydroxide	mg/L	5	< 5		< 5			
Acidity (as CaCO3)	mg/L	5	< 5 [1]		< 5 [1]			
pH @25°C	pH Units		**6.35**		**6.21**		8.5	
Conductivity @25°C	µmho/cm	1	45		46			
TDS(ion sum calc.)	mg/L	1	25		28		500	
Total Suspended Solids	mg/L	3	< 3		< 3			
Turbidity	NTU	0.1	0.2		0.2		1	
REDOX potential	mV		362		400			
Chloride	mg/L	0.5	1.0		2.8		250	
Sulphate	mg/L	1	1		7		500	
Aluminum	mg/L	0.01	< 0.01		< 0.01		2.9	
Aluminum	mg/L	0.01		< 0.01		< 0.01	2.9	
Antimony	mg/L	0.0001	< 0.0001		< 0.0001		0.006	
Antimony	mg/L	0.0001		0.0002		0.0003	0.006	
Arsenic	mg/L	0.0001	< 0.0001		< 0.0001		0.010	
Arsenic	mg/L	0.0001		< 0.0001		< 0.0001	0.010	
Barium	mg/L	0.001	0.002		0.002		2.0	
Barium	mg/L	0.001		0.002		0.002	2.0	
Beryllium	mg/L	0.002	< 0.002		< 0.002			
Beryllium	mg/L	0.002		< 0.002		< 0.002		

Canadian DW Guidelines - Drinking Water
CDWG - Canadian Drinking Water Guidelines

R.L. = Reporting Limit
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Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill,B-Barrie

Greg Clarkin , BSc., C. Chem
Lab Manager - Ottawa District

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CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: G095644 **REPORT No. B22-06774**

Report To:

City of Iqaluit
PO Box 460,
Iqaluit NU X0A 0H0
Attention: Emmanuel Kayode

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 11-Mar-22
DATE REPORTED: 25-Mar-22
SAMPLE MATRIX: Drinking Water

JOB/PROJECT NO.: Test A (WTP)
P.O. NUMBER:
WATERWORKS NO.

	Client I.D.		Test A- Raw WTP	Test A- Raw WTP (Total)	Test A- Potable WTP	Test A- Potable (Total)	**Canadian DW Guidelines CDWG**	
	Sample I.D.		B22-06774-1	B22-06774-2	B22-06774-3	B22-06774-4		
	Date Collected		10-Mar-22	10-Mar-22	10-Mar-22	10-Mar-22		
Parameter	**Units**	**R.L.**						
Cadmium	mg/L	).000015	< 0.000015		< 0.000015		0.007	
Cadmium	mg/L	).000015		< 0.000015		< 0.000015	0.007	
Chromium	mg/L	0.002	< 0.002		< 0.002		0.05	
Chromium	mg/L	0.002		< 0.002		< 0.002	0.05	
Cobalt	mg/L	0.005	< 0.005		< 0.005			
Cobalt	mg/L	0.005		< 0.005		< 0.005		
Copper	mg/L	0.002	< 0.002		0.024		2	
Copper	mg/L	0.002		< 0.002		0.024	2	
Iron	mg/L	0.005	0.016		0.014		0.3	
Iron	mg/L	0.005		0.023		0.058	0.3	
Lead	mg/L	0.00002	< 0.00002		0.00004		0.005	
Lead	mg/L	0.00002		< 0.00002		0.00005	0.005	
Lithium	mg/L	0.01	< 0.01		< 0.01			
Lithium	mg/L	0.01		< 0.01		< 0.01		
Manganese	mg/L	0.001	0.004		0.003		0.12	
Manganese	mg/L	0.001		0.004		0.004	0.12	
Mercury	mg/L	0.00002	< 0.00002	< 0.00002	< 0.00002	< 0.00002	0.001	
Molybdenum	mg/L	0.01	< 0.01		< 0.01			
Molybdenum	mg/L	0.01		< 0.01		< 0.01		
Nickel	mg/L	0.01	< 0.01		< 0.01			
Nickel	mg/L	0.01		< 0.01		< 0.01		
Selenium	mg/L	0.001	< 0.001		< 0.001		0.05	
Selenium	mg/L	0.001		< 0.001		< 0.001	0.05	
Silver	mg/L	0.0001	< 0.0001		< 0.0001			
Silver	mg/L	0.0001		< 0.0001		< 0.0001		
Strontium	mg/L	0.001	0.016		0.014		7.0	

Canadian DW Guidelines - Drinking Water
CDWG - Canadian Drinking Water Guidelines

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Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill,B-Barrie

Greg Clarkin , BSc., C. Chem
Lab Manager - Ottawa District

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Final Report

C.O.C.: G095644 **REPORT No. B22-06774**

Report To:

City of Iqaluit
PO Box 460,
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Attention: Emmanuel Kayode

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 11-Mar-22
DATE REPORTED: 25-Mar-22
SAMPLE MATRIX: Drinking Water

JOB/PROJECT NO.: Test A (WTP)
P.O. NUMBER:
WATERWORKS NO.

	Client I.D.		Test A- Raw WTP	Test A- Raw WTP (Total)	Test A- Potable WTP	Test A- Potable (Total)	**Canadian DW Guidelines**	
	Sample I.D.		B22-06774-1	B22-06774-2	B22-06774-3	B22-06774-4	**CDWG**	
	Date Collected		10-Mar-22	10-Mar-22	10-Mar-22	10-Mar-22		
Parameter	**Units**	**R.L.**						
Strontium	mg/L	0.001		0.016		0.014	7.0	
Thallium	mg/L	0.00005	< 0.00005		< 0.00005			
Thallium	mg/L	0.00005		< 0.00005		< 0.00005		
Tin	mg/L	0.05	< 0.05		< 0.05			
Tin	mg/L	0.05		< 0.05		< 0.05		
Titanium	mg/L	0.005	< 0.005		< 0.005			
Titanium	mg/L	0.005		< 0.005		< 0.005		
Uranium	mg/L	0.00005	< 0.00005		< 0.00005		0.02	
Uranium	mg/L	0.00005		< 0.00005		< 0.00005	0.02	
Vanadium	mg/L	0.005	< 0.005		< 0.005			
Vanadium	mg/L	0.005		< 0.005		< 0.005		
Zinc	mg/L	0.005	< 0.005		< 0.005		5	
Zinc	mg/L	0.005		0.007		0.008	5	
Total Organic Carbon	mg/L	0.2	4.4		2.7			
TIC	mg/L	0.5	10.4		9.3			
Fecal Coliform	cfu/100mL	1	0		0			
Anion Sum	meq/L		0.513		0.549			
Cation Sum	meq/L		0.457		0.436			
% Difference	%		5.81		11.4			
Ion Ratio	AS/CS		1.12		1.26			
Sodium Adsorption Ratio	-		0.0941		0.0943			
Conductivity (calc.)	µmho/cm		49		55			
EC(calc.)/EC(actual)	-		1.10		1.19			
TDS(calc.)/EC(actual)	-		0.551		0.602			
Langelier Index(25°C)	S.I.		-2.81		-3.36			

1 . Subcontracted to Testmark Labs

Canadian DW Guidelines - Drinking Water
CDWG - Canadian Drinking Water Guidelines

Greg Clarkin , BSc., C. Chem
Lab Manager - Ottawa District

R.L. = Reporting Limit
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Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill,B-Barrie

CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: G095644 **REPORT No. B22-06774**

Report To:

City of Iqaluit
PO Box 460,
Iqaluit NU X0A 0H0
Attention: Emmanuel Kayode

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 11-Mar-22
DATE REPORTED: 25-Mar-22
SAMPLE MATRIX: Drinking Water

JOB/PROJECT NO.: Test A (WTP)
P.O. NUMBER:
WATERWORKS NO.

Summary of Exceedances

Canadian Drinking Water Guidelines

Test A- Raw WTP	Found Value	Limit
pH @25°C (pH Units)	6.35	8.5
Test A- Potable WTP	Found Value	Limit
pH @25°C (pH Units)	6.21	8.5

Canadian DW Guidelines - Drinking Water
CDWG - Canadian Drinking Water Guidelines

R.L. = Reporting Limit
Test methods may be modified from specified reference method unless indicated by an *
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill,B-Barrie

Greg Clarkin , BSc., C. Chem
Lab Manager - Ottawa District

CADUCEON ENVIRONMENTAL LABORATORIES

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CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: G095651 **REPORT No. B22-09300**

Report To:

City of Iqaluit
PO Box 460,
Iqaluit NU X0A 0H0
Attention: Emmanuel Kayode

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 05-Apr-22
DATE REPORTED: 12-Apr-22
SAMPLE MATRIX: Waste Water

JOB/PROJECT NO.: Test F
P.O. NUMBER:
WATERWORKS NO.

			Client I.D.		WWTP Influent	WWTP Effluent		
			Sample I.D.		B22-09300-1	B22-09300-2		
			Date Collected		04-Apr-22	04-Apr-22		
Parameter	Units	R.L.	Reference Method	Date/Site Analyzed				
BOD(5 day)	mg/L	3	SM 5210B	07-Apr-22/K	239	255		
Total Suspended Solids	mg/L	3	SM2540D	07-Apr-22/K	880	240		
Conductivity @25°C	µmho/cm	1	SM 2510B	05-Apr-22/O	379	487		
pH @25°C	pH Units		SM 4500H	05-Apr-22/O	7.29	7.64		
Nitrite (N)	mg/L	0.1	SM4110C	06-Apr-22/O	< 0.1	< 0.1		
Nitrate (N)	mg/L	0.1	SM4110C	06-Apr-22/O	0.1	< 0.1		
Ammonia (N)-Total	mg/L	0.01	SM4500-NH3-H	07-Apr-22/K	31.7	31.0		
o-Phosphate (P)	mg/L	0.002	PE4500-S	07-Apr-22/K	3.34	4.51		
Phosphorus-Total	mg/L	0.01	E3516.2	07-Apr-22/K	6.27	7.30		
Aluminum	mg/L	0.01	SM 3120	08-Apr-22/O	0.78	0.19		
Antimony	mg/L	0.0005	EPA 200.8	06-Apr-22/O	< 0.0005	< 0.0005		
Arsenic	mg/L	0.0005	EPA 200.8	06-Apr-22/O	< 0.0005	< 0.0005		
Barium	mg/L	0.001	SM 3120	08-Apr-22/O	0.028	0.008		
Beryllium	mg/L	0.002	SM 3120	08-Apr-22/O	< 0.002	< 0.002		
Cadmium	mg/L	).00007(	EPA 200.8	06-Apr-22/O	0.000257	0.000149		
Chromium	mg/L	0.002	SM 3120	08-Apr-22/O	0.004	< 0.002		
Cobalt	mg/L	0.005	SM 3120	08-Apr-22/O	< 0.005	< 0.005		
Copper	mg/L	0.002	SM 3120	08-Apr-22/O	0.593	0.407		
Iron	mg/L	0.005	SM 3120	08-Apr-22/O	2.35	0.892		
Lead	mg/L	0.0001	EPA 200.8	06-Apr-22/O	0.0202	0.0019		
Lithium	mg/L	0.01	SM 3120	08-Apr-22/O	< 0.01	< 0.01		
Manganese	mg/L	0.001	SM 3120	08-Apr-22/O	0.046	0.036		
Mercury	mg/L	0.00002	SM 3112 B	06-Apr-22/O	0.00024	0.00009		
Molybdenum	mg/L	0.01	SM 3120	08-Apr-22/O	< 0.01	< 0.01		
Nickel	mg/L	0.01	SM 3120	08-Apr-22/O	< 0.01	< 0.01		
Selenium	mg/L	0.005	EPA 200.8	06-Apr-22/O	< 0.005	< 0.005		

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Greg Clarkin , BSc., C. Chem
Lab Manager - Ottawa District

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CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: G095651 **REPORT No. B22-09300**

Report To:

City of Iqaluit
PO Box 460,
Iqaluit NU X0A 0H0
Attention: Emmanuel Kayode

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 05-Apr-22
DATE REPORTED: 12-Apr-22
SAMPLE MATRIX: Waste Water

JOB/PROJECT NO.: Test F
P.O. NUMBER:
WATERWORKS NO.

			Client I.D.		WWTP Influent	WWTP Effluent		
			Sample I.D.		B22-09300-1	B22-09300-2		
			Date Collected		04-Apr-22	04-Apr-22		
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
Silver	mg/L	0.0001	EPA 200.8	06-Apr-22/O	0.0002	< 0.0001		
Strontium	mg/L	0.001	SM 3120	08-Apr-22/O	0.031	0.026		
Thallium	mg/L	0.0003	EPA 200.8	06-Apr-22/O	< 0.0003	< 0.0003		
Tin	mg/L	0.05	SM 3120	08-Apr-22/O	< 0.05	< 0.05		
Titanium	mg/L	0.005	SM 3120	08-Apr-22/O	0.020	< 0.005		
Uranium	mg/L	0.0003	EPA 200.8	06-Apr-22/O	< 0.0003	< 0.0003		
Vanadium	mg/L	0.005	SM 3120	08-Apr-22/O	< 0.005	< 0.005		
Zinc	mg/L	0.005	SM 3120	08-Apr-22/O	0.337	0.177		
Total Coliform	cfu/100mL	1	MOE	05-Apr-22/O	47000000	87000000		
Fecal Coliform	cfu/100mL	1	MOE	05-Apr-22/O	3900000	5400000		

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Greg Clarkin , BSc., C. Chem
Lab Manager - Ottawa District

CERTIFICATE OF ANALYSIS

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Final Report

C.O.C.: DW 105894 **REPORT No. B22-09529**

Report To:
City of Iqaluit
PO Box 460,
Iqaluit NU X0A 0H0
Attention: Emmanuel Kayode

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 06-Apr-22
DATE REPORTED: 12-Apr-22
SAMPLE MATRIX: Drinking Water

JOB/PROJECT NO.: Test A (WTP)
P.O. NUMBER: 460
WATERWORKS NO.

Parameter	Qty	Site Analyzed	Analyst Initials	Date Analyzed	Lab Method	Reference Method
A - Wet Chem	2	Holly Lane	SYL	07-Apr-22	A-ALK-02 O	EPA 310.2
Alkalinity (as CaCO3)	2	Holly Lane	SYL	07-Apr-22	A-ALK-03 (o)	SM 2320B
Conductivity	2	Holly Lane	SYL	07-Apr-22	A-COND-02 (o)	SM 2510B
Anions	2	Holly Lane	VK	06-Apr-22	A-IC-01 (o)	SM4110C
pH	2	Holly Lane	SYL	07-Apr-22	A-PH-01 (o)	SM 4500H
Physical	2	Richmond Hill	nka	08-Apr-22	A-REDOX	In-House
Total Suspended Solids	2	Kingston	IFG	08-Apr-22	A-TSS-001 (k)	SM2540D
Turbidity	2	Holly Lane	ST	07-Apr-22	A-TURB-01 (o)	SM 2130
B - Bacteriological	2	Holly Lane	SLO	06-Apr-22	B-MFFC-01 (o)	MOE E3371
A - Wet Chem	2	Holly Lane	VK	06-Apr-22	C-TC	EPA 415.1
TOC	2	Holly Lane	VK	06-Apr-22	C-TOC-01	EPA 415.2
Mercury	4	Holly Lane	PBK	07-Apr-22	D-HG-02 (o)	SM 3112 B
Metals - ICP-OES	2	Holly Lane	AHM	08-Apr-22	D-ICP-01 (o)	SM 3120
Metals-ICP-MS	2	Holly Lane	TPR	08-Apr-22	D-ICPMS Dissolved 7800	EPA 200.8
Metals - ICP-MS	2	Holly Lane	TPR	08-Apr-22	D-ICPMS-01 (o)	EPA 200.8
Calculation	2	Holly Lane	JGC	11-Apr-22	D-Ion Balance	Calc.
Subcontracted	2	Default Site	TYP	08-Apr-22	S-Acidity	Subcontract

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CDWG - Canadian Drinking Water Guidelines

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Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 06-Apr-22
DATE REPORTED: 12-Apr-22
SAMPLE MATRIX: Drinking Water

JOB/PROJECT NO.: Test A (WTP)
P.O. NUMBER: 460
WATERWORKS NO.

	Client I.D.		Test A- Raw WTP	Test A- Raw WTP (Total)	Test A- Potable WTP	Test A- Potable (Total)	**Canadian DW Guidelines**	
	Sample I.D.		B22-09529-1	B22-09529-2	B22-09529-3	B22-09529-4	**CDWG**	
	Date Collected		05-Apr-22	05-Apr-22	05-Apr-22	05-Apr-22		
Parameter	**Units**	**R.L.**						
Hardness (as CaCO3)	mg/L	1	22		22			
Hardness (as CaCO3)	mg/L	1		22		23		
Alkalinity(CaCO3) to pH4.5	mg/L	5	17		15			
Bicarbonate(as CaCO3)	mg/L	5	17		15			
Carbonate (as CaCO3)	mg/L	5	< 5		< 5			
Hydroxide	mg/L	5	< 5		< 5			
Acidity (as CaCO3)	mg/L	5	< 5 [1]		< 5 [1]			
pH @25°C	pH Units		7.29		6.99		8.5	
Conductivity @25°C	µmho/cm	1	46		48			
TDS(ion sum calc.)	mg/L	1	24		24		500	
Total Suspended Solids	mg/L	3	< 3		< 3			
Turbidity	NTU	0.1	0.3		0.2		1	
REDOX potential	mV		428		599			
Chloride	mg/L	0.5	1.7		3.2		250	
Sulphate	mg/L	1	3		3		500	
Aluminum	mg/L	0.01	< 0.01		< 0.01		2.9	
Aluminum	mg/L	0.01		0.01		< 0.01	2.9	
Antimony	mg/L	0.0001	< 0.0001		< 0.0001		0.006	
Antimony	mg/L	0.0001		< 0.0001		0.0004	0.006	
Arsenic	mg/L	0.0001	< 0.0001		< 0.0001		0.010	
Arsenic	mg/L	0.0001		< 0.0001		< 0.0001	0.010	
Barium	mg/L	0.001	0.002		0.002		2.0	
Barium	mg/L	0.001		0.002		0.003	2.0	
Beryllium	mg/L	0.002	< 0.002		< 0.002			
Beryllium	mg/L	0.002		< 0.002		< 0.002		

Canadian DW Guidelines - Drinking Water
CDWG - Canadian Drinking Water Guidelines

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Greg Clarkin , BSc., C. Chem
Lab Manager - Ottawa District

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CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: DW 105894 **REPORT No. B22-09529**

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Attention: Emmanuel Kayode

Caducеon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 06-Apr-22
DATE REPORTED: 12-Apr-22
SAMPLE MATRIX: Drinking Water

JOB/PROJECT NO.: Test A (WTP)
P.O. NUMBER: 460
WATERWORKS NO.

	Client I.D.		Test A- Raw WTP	Test A- Raw WTP (Total)	Test A- Potable WTP	Test A- Potable (Total)	**Canadian DW Guidelines CDWG**
	Sample I.D.		B22-09529-1	B22-09529-2	B22-09529-3	B22-09529-4	
	Date Collected		05-Apr-22	05-Apr-22	05-Apr-22	05-Apr-22	
Parameter	**Units**	**R.L.**					
Cadmium	mg/L	).000015	< 0.000015		< 0.000015		0.007
Cadmium	mg/L	).000015		< 0.000015		< 0.000015	0.007
Chromium	mg/L	0.002	< 0.002		< 0.002		0.05
Chromium	mg/L	0.002		< 0.002		< 0.002	0.05
Cobalt	mg/L	0.005	< 0.005		< 0.005		
Cobalt	mg/L	0.005		< 0.005		< 0.005	
Copper	mg/L	0.002	0.025		0.037		2
Copper	mg/L	0.002		0.025		0.036	2
Iron	mg/L	0.005	0.017		0.017		0.3
Iron	mg/L	0.005		0.029		0.030	0.3
Lead	mg/L	0.00002	0.00004		0.00029		0.005
Lead	mg/L	0.00002		0.00005		0.00009	0.005
Lithium	mg/L	0.01	< 0.01		< 0.01		
Lithium	mg/L	0.01		< 0.01		< 0.01	
Manganese	mg/L	0.001	0.004		0.004		0.12
Manganese	mg/L	0.001		0.004		0.004	0.12
Mercury	mg/L	0.00002	< 0.00002	< 0.00002	< 0.00002	< 0.00002	0.001
Molybdenum	mg/L	0.01	< 0.01		< 0.01		
Molybdenum	mg/L	0.01		< 0.01		< 0.01	
Nickel	mg/L	0.01	< 0.01		< 0.01		
Nickel	mg/L	0.01		< 0.01		< 0.01	
Selenium	mg/L	0.001	< 0.001		< 0.001		0.05
Selenium	mg/L	0.001		< 0.001		< 0.001	0.05
Silver	mg/L	0.0001	< 0.0001		< 0.0001		
Silver	mg/L	0.0001		< 0.0001		< 0.0001	
Strontium	mg/L	0.001	0.017		0.016		7.0

Canadian DW Guidelines - Drinking Water
CDWG - Canadian Drinking Water Guidelines

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Lab Manager - Ottawa District

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Caduceon Environmental Laboratories
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Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 06-Apr-22
DATE REPORTED: 12-Apr-22
SAMPLE MATRIX: Drinking Water

JOB/PROJECT NO.: Test A (WTP)
P.O. NUMBER: 460
WATERWORKS NO.

	Client I.D.		Test A- Raw WTP	Test A- Raw WTP (Total)	Test A- Potable WTP	Test A- Potable (Total)	Canadian DW Guidelines CDWG	
	Sample I.D.		B22-09529-1	B22-09529-2	B22-09529-3	B22-09529-4		
	Date Collected		05-Apr-22	05-Apr-22	05-Apr-22	05-Apr-22		
Parameter	**Units**	**R.L.**						
Strontium	mg/L	0.001		0.017		0.016	7.0	
Thallium	mg/L	0.00005	< 0.00005		< 0.00005			
Thallium	mg/L	0.00005		< 0.00005		< 0.00005		
Tin	mg/L	0.05	< 0.05		< 0.05			
Tin	mg/L	0.05		< 0.05		< 0.05		
Titanium	mg/L	0.005	< 0.005		< 0.005			
Titanium	mg/L	0.005		< 0.005		< 0.005		
Uranium	mg/L	0.00005	< 0.00005		< 0.00005		0.02	
Uranium	mg/L	0.00005		0.00007		< 0.00005	0.02	
Vanadium	mg/L	0.005	< 0.005		< 0.005			
Vanadium	mg/L	0.005		< 0.005		< 0.005		
Zinc	mg/L	0.005	< 0.005		< 0.005		5	
Zinc	mg/L	0.005		< 0.005		0.006	5	
Total Organic Carbon	mg/L	0.2	2.3		2.2			
TIC	mg/L	0.5	4.59		4.35			
Fecal Coliform	cfu/100mL	1	0		0			
Anion Sum	meq/L		0.450		0.456			
Cation Sum	meq/L		0.482		0.491			
% Difference	%		3.45		3.65			
Ion Ratio	AS/CS		0.933		0.930			
Sodium Adsorption Ratio	-		0.0965		0.0945			
Conductivity (calc.)	µmho/cm		49		51			
EC(calc.)/EC(actual)	-		1.06		1.07			
TDS(calc.)/EC(actual)	-		0.515		0.511			
Langelier Index(25°C)	S.I.		-1.96		-2.30			

1 . Subcontracted to Testmark Labs

Canadian DW Guidelines - Drinking Water
CDWG - Canadian Drinking Water Guidelines

Greg Clarkin , BSc., C. Chem
Lab Manager - Ottawa District

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CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: DW 105894 **REPORT No. B22-09529**

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Attention: Emmanuel Kayode

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2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 06-Apr-22
DATE REPORTED: 12-Apr-22
SAMPLE MATRIX: Drinking Water

JOB/PROJECT NO.: Test A (WTP)
P.O. NUMBER: 460
WATERWORKS NO.

Summary of Exceedances

Canadian DW Guidelines - Drinking Water
CDWG - Canadian Drinking Water Guidelines

Greg Clarkin , BSc., C. Chem
Lab Manager - Ottawa District

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CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: G095654 **REPORT No. B22-13155**

Report To:

City of Iqaluit
PO Box 460,
Iqaluit NU X0A 0H0
Attention: Emmanuel Kayode

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 06-May-22
DATE REPORTED: 12-May-22
SAMPLE MATRIX: Waste Water

JOB/PROJECT NO.: Test F
P.O. NUMBER:
WATERWORKS NO.

			Client I.D.		WWTP Influent	WWTP Effluent		
			Sample I.D.		B22-13155-1	B22-13155-2		
			Date Collected		04-May-22	04-May-22		
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
BOD(5 day)	mg/L	3	SM 5210B	06-May-22/K	749	119		
Total Suspended Solids	mg/L	3	SM2540D	11-May-22/K	1920	65		
Conductivity @25°C	µmho/cm	1	SM 2510B	09-May-22/O	651	331		
pH @25°C	pH Units		SM 4500H	09-May-22/O	6.30	7.04		
Nitrite (N)	mg/L	0.1	SM4110C	09-May-22/O	< 0.1	< 0.1		
Nitrate (N)	mg/L	0.1	SM4110C	09-May-22/O	0.1	< 0.1		
Ammonia (N)-Total	mg/L	0.01	SM4500-NH3-H	09-May-22/K	49.4	19.9		
o-Phosphate (P)	mg/L	0.002	PE4500-S	09-May-22/K	9.01	1.43		
Phosphorus-Total	mg/L	0.01	E3516.2	10-May-22/K	14.5	3.24		
Aluminum	mg/L	0.01	SM 3120	10-May-22/O	0.60	0.17		
Antimony	mg/L	0.0005	EPA 200.8	10-May-22/O	0.0011	0.0010		
Arsenic	mg/L	0.0005	EPA 200.8	10-May-22/O	< 0.0005	< 0.0005		
Barium	mg/L	0.001	SM 3120	10-May-22/O	0.020	0.005		
Beryllium	mg/L	0.002	SM 3120	10-May-22/O	< 0.002	< 0.002		
Cadmium	mg/L	).00007(	EPA 200.8	10-May-22/O	0.000199	< 0.000070		
Chromium	mg/L	0.002	SM 3120	10-May-22/O	0.003	< 0.002		
Cobalt	mg/L	0.005	SM 3120	10-May-22/O	< 0.005	< 0.005		
Copper	mg/L	0.002	SM 3120	10-May-22/O	0.433	0.241		
Iron	mg/L	0.005	SM 3120	10-May-22/O	1.87	0.254		
Lead	mg/L	0.0001	EPA 200.8	10-May-22/O	0.0227	0.0010		
Lithium	mg/L	0.01	SM 3120	10-May-22/O	< 0.01	< 0.01		
Manganese	mg/L	0.001	SM 3120	10-May-22/O	0.063	0.020		
Mercury	mg/L	0.00002	SM 3112 B	11-May-22/O	0.00017	< 0.00002		
Molybdenum	mg/L	0.01	SM 3120	10-May-22/O	< 0.01	< 0.01		
Nickel	mg/L	0.01	SM 3120	10-May-22/O	< 0.01	< 0.01		
Selenium	mg/L	0.005	EPA 200.8	10-May-22/O	< 0.005	< 0.005		

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Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill,B-Barrie

Greg Clarkin , BSc., C. Chem
Lab Manager - Ottawa District

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CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: G095654 **REPORT No. B22-13155**

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Attention: Emmanuel Kayode

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 06-May-22
DATE REPORTED: 12-May-22
SAMPLE MATRIX: Waste Water

JOB/PROJECT NO.: Test F
P.O. NUMBER:
WATERWORKS NO.

			Client I.D.		WWTP Influent	WWTP Effluent		
			Sample I.D.		B22-13155-1	B22-13155-2		
			Date Collected		04-May-22	04-May-22		
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
Silver	mg/L	0.0001	EPA 200.8	10-May-22/O	0.0003	< 0.0001		
Strontium	mg/L	0.001	SM 3120	10-May-22/O	0.035	0.022		
Thallium	mg/L	0.0003	EPA 200.8	10-May-22/O	< 0.0003	< 0.0003		
Tin	mg/L	0.05	SM 3120	10-May-22/O	< 0.05	< 0.05		
Titanium	mg/L	0.005	SM 3120	10-May-22/O	0.015	< 0.005		
Uranium	mg/L	0.0003	EPA 200.8	10-May-22/O	< 0.0003	< 0.0003		
Vanadium	mg/L	0.005	SM 3120	10-May-22/O	< 0.005	< 0.005		
Zinc	mg/L	0.005	SM 3120	10-May-22/O	0.229	0.084		
Total Coliform	cfu/100mL	1	MOE	06-May-22/O	92000000	27000000		
Fecal Coliform	cfu/100mL	1	MOE	06-May-22/O	6900000	2800000		

R.L. = Reporting Limit
Test methods may be modified from specified reference method unless indicated by an *
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill,B-Barrie

Greg Clarkin , BSc., C. Chem
Lab Manager - Ottawa District

CADUCEON ENVIRONMENTAL LABORATORIES
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CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: DW 105899 **REPORT No. B22-13165**

Report To:

City of Iqaluit
PO Box 460,
Iqaluit NU X0A 0H0
Attention: Emmanuel Kayode

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 06-May-22
DATE REPORTED: 18-May-22
SAMPLE MATRIX: Drinking Water

JOB/PROJECT NO.: Test A (WTP)
P.O. NUMBER:
WATERWORKS NO.

Parameter	Qty	Site Analyzed	Analyst Initials	Date Analyzed	Lab Method	Reference Method
A - Wet Chem	2	Holly Lane	SYL	09-May-22	A-ALK-02 O	EPA 310.2
Alkalinity (as CaCO3)	2	Holly Lane	SYL	09-May-22	A-ALK-03 (o)	SM 2320B
Conductivity	2	Holly Lane	SYL	09-May-22	A-COND-02 (o)	SM 2510B
Anions	2	Holly Lane	VK	06-May-22	A-IC-01 (o)	SM4110C
pH	1	Holly Lane	SYL	09-May-22	A-PH-01 (o)	SM 4500H
pH	1	Holly Lane	SYL	10-May-22	A-PH-01 (o)	SM 4500H
Physical	2	Richmond Hill	nka	10-May-22	A-REDOX	In-House
Total Suspended Solids	2	Kingston	TK	12-May-22	A-TSS-001 (k)	SM2540D
Turbidity	2	Holly Lane	ST	10-May-22	A-TURB-01 (o)	SM 2130
B - Bacteriological	2	Holly Lane	SLO	06-May-22	B-MFFC-01 (o)	MOE E3371
A - Wet Chem	2	Holly Lane	VK	09-May-22	C-TC	EPA 415.1
TOC	2	Holly Lane	VK	09-May-22	C-TOC-01	EPA 415.2
Mercury	4	Holly Lane	PBK	11-May-22	D-HG-02 (o)	SM 3112 B
Metals - ICP-OES	2	Holly Lane	AHM	10-May-22	D-ICP-01 (o)	SM 3120
Metals - ICP-OES	2	Holly Lane	JGC	06-May-22	D-ICP-01 (o)	SM 3120
Metals-ICP-MS	2	Holly Lane	TPR	10-May-22	D-ICPMS Dissolved 7800	EPA 200.8
Metals - ICP-MS	2	Holly Lane	TPR	11-May-22	D-ICPMS-01 (o)	EPA 200.8
Calculation	2	Holly Lane	JGC	10-May-22	D-Ion Balance	Calc.
Subcontracted	2	Default Site	TYP	12-May-22	S-Acidity	Subcontract

Canadian DW Guidelines - Drinking Water
CDWG - Canadian Drinking Water Guidelines

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Greg Clarkin , BSc., C. Chem
Lab Manager - Ottawa District

CADUCEON ENVIRONMENTAL LABORATORIES
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CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: DW 105899 **REPORT No. B22-13165**

Report To:

City of Iqaluit
PO Box 460,
Iqaluit NU X0A 0H0
Attention: Emmanuel Kayode

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 06-May-22
DATE REPORTED: 18-May-22
SAMPLE MATRIX: Drinking Water

JOB/PROJECT NO.: Test A (WTP)
P.O. NUMBER:
WATERWORKS NO.

	Client I.D.		Test A- Raw WTP	Test A- Raw WTP (Total)	Test A- Potable WTP	Test A- Potable (Total)	**Canadian DW Guidelines**	
	Sample I.D.		B22-13165-1	B22-13165-2	B22-13165-3	B22-13165-4	**CDWG**	
	Date Collected		04-May-22	04-May-22	04-May-22	04-May-22		
Parameter	**Units**	**R.L.**						
Hardness (as CaCO3)	mg/L	1	21		22			
Hardness (as CaCO3)	mg/L	1		22		22		
Alkalinity(CaCO3) to pH4.5	mg/L	5	22		16			
Bicarbonate(as CaCO3)	mg/L	5	22		16			
Carbonate (as CaCO3)	mg/L	5	< 5		< 5			
Hydroxide	mg/L	5	< 5		< 5			
Acidity (as CaCO3)	mg/L	5	< 5 [1]		< 5 [1]			
pH @25°C	pH Units				**6.25**		8.5	
pH @25°C	pH Units		6.51				8.5	
Conductivity @25°C	µmho/cm	1	47		49			
TDS(ion sum calc.)	mg/L	1	27		25		500	
Total Suspended Solids	mg/L	3	< 3		< 3			
Turbidity	NTU	0.1	0.3		0.2		1	
REDOX potential	mV		428		526			
Chloride	mg/L	0.5	1.7		3.3		250	
Sulphate	mg/L	1	3		3		500	
Aluminum	mg/L	0.01	< 0.01		< 0.01		2.9	
Aluminum	mg/L	0.01		0.02		0.02	2.9	
Antimony	mg/L	0.0001	< 0.0001		< 0.0001		0.006	
Antimony	mg/L	0.0001		0.0002		0.0003	0.006	
Arsenic	mg/L	0.0001	< 0.0001		< 0.0001		0.010	
Arsenic	mg/L	0.0001		< 0.0001		< 0.0001	0.010	
Barium	mg/L	0.001	0.002		0.002		2.0	
Barium	mg/L	0.001		0.002		0.002	2.0	
Beryllium	mg/L	0.002	< 0.002		< 0.002			

Canadian DW Guidelines - Drinking Water
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Greg Clarkin , BSc., C. Chem
Lab Manager - Ottawa District

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CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: DW 105899 **REPORT No. B22-13165**

Report To:

City of Iqaluit
PO Box 460,
Iqaluit NU X0A 0H0
Attention: Emmanuel Kayode

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 06-May-22
DATE REPORTED: 18-May-22
SAMPLE MATRIX: Drinking Water

JOB/PROJECT NO.: Test A (WTP)
P.O. NUMBER:
WATERWORKS NO.

	Client I.D.		Test A- Raw WTP	Test A- Raw WTP (Total)	Test A- Potable WTP	Test A- Potable (Total)	**Canadian DW Guidelines**	
	Sample I.D.		B22-13165-1	B22-13165-2	B22-13165-3	B22-13165-4	**CDWG**	
	Date Collected		04-May-22	04-May-22	04-May-22	04-May-22		
Parameter	**Units**	**R.L.**						
Beryllium	mg/L	0.002		< 0.002		< 0.002		
Cadmium	mg/L	0.000015	< 0.000015		< 0.000015		0.007	
Cadmium	mg/L	0.000015		< 0.000015		< 0.000015	0.007	
Chromium	mg/L	0.002	< 0.002		< 0.002		0.05	
Chromium	mg/L	0.002		< 0.002		< 0.002	0.05	
Cobalt	mg/L	0.005	< 0.005		< 0.005			
Cobalt	mg/L	0.005		< 0.005		< 0.005		
Copper	mg/L	0.002	< 0.002		0.042		2	
Copper	mg/L	0.002		0.004		0.042	2	
Iron	mg/L	0.005	0.015		0.013		0.3	
Iron	mg/L	0.005		0.038		0.031	0.3	
Lead	mg/L	0.00002	0.00010		0.00008		0.005	
Lead	mg/L	0.00002		0.00005		0.00008	0.005	
Lithium	mg/L	0.01	< 0.01		< 0.01			
Lithium	mg/L	0.01		< 0.01		< 0.01		
Manganese	mg/L	0.001	0.008		0.002		0.12	
Manganese	mg/L	0.001		0.008		0.004	0.12	
Mercury	mg/L	0.00002	< 0.00002	< 0.00002	< 0.00002	< 0.00002	0.001	
Molybdenum	mg/L	0.01	< 0.01		< 0.01			
Molybdenum	mg/L	0.01		< 0.01		< 0.01		
Nickel	mg/L	0.01	< 0.01		< 0.01			
Nickel	mg/L	0.01		< 0.01		< 0.01		
Selenium	mg/L	0.001	< 0.001		< 0.001		0.05	
Selenium	mg/L	0.001		< 0.001		< 0.001	0.05	
Silver	mg/L	0.0001	< 0.0001		< 0.0001			
Silver	mg/L	0.0001		< 0.0001		< 0.0001		

Canadian DW Guidelines - Drinking Water
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Lab Manager - Ottawa District

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Attention: Emmanuel Kayode

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Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 06-May-22
DATE REPORTED: 18-May-22
SAMPLE MATRIX: Drinking Water

JOB/PROJECT NO.: Test A (WTP)
P.O. NUMBER:
WATERWORKS NO.

	Client I.D.		Test A- Raw WTP	Test A- Raw WTP (Total)	Test A- Potable WTP	Test A- Potable (Total)	**Canadian DW Guidelines CDWG**
	Sample I.D.		B22-13165-1	B22-13165-2	B22-13165-3	B22-13165-4	
	Date Collected		04-May-22	04-May-22	04-May-22	04-May-22	
Parameter	**Units**	**R.L.**					
Strontium	mg/L	0.001	0.015		0.017		7.0
Strontium	mg/L	0.001		0.016		0.015	7.0
Thallium	mg/L	0.00005	< 0.00005		< 0.00005		
Thallium	mg/L	0.00005		< 0.00005		< 0.00005	
Tin	mg/L	0.05	< 0.05		< 0.05		
Tin	mg/L	0.05		< 0.05		< 0.05	
Titanium	mg/L	0.005	< 0.005		< 0.005		
Titanium	mg/L	0.005		< 0.005		< 0.005	
Uranium	mg/L	0.00005	< 0.00005		< 0.00005		0.02
Uranium	mg/L	0.00005		< 0.00005		< 0.00005	0.02
Vanadium	mg/L	0.005	< 0.005		< 0.005		
Vanadium	mg/L	0.005		< 0.005		< 0.005	
Zinc	mg/L	0.005	< 0.005		< 0.005		5
Zinc	mg/L	0.005		0.006		< 0.005	5
Total Organic Carbon	mg/L	0.2	2.4		2.3		
TIC	mg/L	0.5	9.0		8.6		
Fecal Coliform	cfu/100mL	1	0		0		
Anion Sum	meq/L		0.550		0.460		
Cation Sum	meq/L		0.479		0.493		
% Difference	%		6.84		3.46		
Ion Ratio	AS/CS		1.15		0.933		
Sodium Adsorption Ratio	-		0.0992		0.0971		
Conductivity (calc.)	µmho/cm		53		52		
EC(calc.)/EC(actual)	-		1.13		1.06		
TDS(calc.)/EC(actual)	-		0.567		0.503		
Langelier Index(25°C)	S.I.		-2.64		-3.03		

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Lab Manager - Ottawa District

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Final Report

C.O.C.: DW 105899 **REPORT No. B22-13165**

Report To:

City of Iqaluit
PO Box 460,
Iqaluit NU X0A 0H0
Attention: Emmanuel Kayode

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 06-May-22
DATE REPORTED: 18-May-22
SAMPLE MATRIX: Drinking Water

JOB/PROJECT NO.: Test A (WTP)
P.O. NUMBER:
WATERWORKS NO.

	Client I.D.		Test A- Raw WTP	Test A- Raw WTP (Total)	Test A- Potable WTP	Test A- Potable (Total)	**Canadian DW Guidelines CDWG**
	Sample I.D.		B22-13165-1	B22-13165-2	B22-13165-3	B22-13165-4	
	Date Collected		04-May-22	04-May-22	04-May-22	04-May-22	
Parameter	**Units**	**R.L.**					

1 . Subcontracted to Testmark Labs

Canadian DW Guidelines - Drinking Water
CDWG - Canadian Drinking Water Guidelines

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Lab Manager - Ottawa District

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2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 06-May-22
DATE REPORTED: 18-May-22
SAMPLE MATRIX: Drinking Water

JOB/PROJECT NO.: Test A (WTP)
P.O. NUMBER:
WATERWORKS NO.

Summary of Exceedances

Canadian Drinking Water Guidelines		
Test A- Potable WTP	Found Value	Limit
pH @25°C (pH Units)	6.25	8.5

Canadian DW Guidelines - Drinking Water
CDWG - Canadian Drinking Water Guidelines

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Lab Manager - Ottawa District

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CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: G095656 **REPORT No. B22-16642**

Report To:

City of Iqaluit
PO Box 460,
Iqaluit NU X0A 0H0
Attention: Emmanuel Kayode

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 02-Jun-22
DATE REPORTED: 14-Jun-22
SAMPLE MATRIX: Waste Water

JOB/PROJECT NO.: Test F
P.O. NUMBER:
WATERWORKS NO.

			Client I.D.		WWTP Influent	WWTP Effluent		
			Sample I.D.		B22-16642-1	B22-16642-2		
			Date Collected		01-Jun-22	01-Jun-22		
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
BOD(5 day)	mg/L	3	SM 5210B	03-Jun-22/K	174	173		
Total Suspended Solids	mg/L	3	SM2540D	09-Jun-22/K	1350	155		
Conductivity @25°C	µmho/cm	1	SM 2510B	03-Jun-22/O	430	470		
pH @25°C	pH Units		SM 4500H	03-Jun-22/O	7.14	7.52		
Nitrite (N)	mg/L	0.1	SM4110C	08-Jun-22/O	< 0.1	< 0.1		
Nitrate (N)	mg/L	0.1	SM4110C	08-Jun-22/O	< 0.1	0.1		
Ammonia (N)-Total	mg/L	0.01	SM4500-NH3-H	03-Jun-22/K	19.3	24.9		
o-Phosphate (P)	mg/L	0.002	PE4500-S	03-Jun-22/K	4.36	4.45		
Phosphorus-Total	mg/L	0.01	E3516.2	03-Jun-22/K	8.12	6.13		
Aluminum	mg/L	0.01	SM 3120	13-Jun-22/O	0.44	0.22		
Antimony	mg/L	0.0005	EPA 200.8	13-Jun-22/O	< 0.0005	< 0.0005		
Arsenic	mg/L	0.0005	EPA 200.8	13-Jun-22/O	< 0.0005	< 0.0005		
Barium	mg/L	0.001	SM 3120	13-Jun-22/O	0.013	0.009		
Beryllium	mg/L	0.002	SM 3120	13-Jun-22/O	< 0.002	< 0.002		
Cadmium	mg/L	).00007(	EPA 200.8	13-Jun-22/O	0.000257	0.000138		
Chromium	mg/L	0.002	SM 3120	13-Jun-22/O	0.004	0.003		
Cobalt	mg/L	0.005	SM 3120	13-Jun-22/O	< 0.005	< 0.005		
Copper	mg/L	0.002	SM 3120	13-Jun-22/O	0.417	0.251		
Iron	mg/L	0.005	SM 3120	13-Jun-22/O	1.41	0.409		
Lead	mg/L	0.0001	EPA 200.8	13-Jun-22/O	0.0096	0.0019		
Lithium	mg/L	0.01	SM 3120	13-Jun-22/O	0.01	0.01		
Manganese	mg/L	0.001	SM 3120	13-Jun-22/O	0.044	0.046		
Mercury	mg/L	0.00002	SM 3112 B	09-Jun-22/O	0.00017	0.00003		
Molybdenum	mg/L	0.01	SM 3120	13-Jun-22/O	< 0.01	< 0.01		
Nickel	mg/L	0.01	SM 3120	13-Jun-22/O	< 0.01	< 0.01		
Selenium	mg/L	0.005	EPA 200.8	13-Jun-22/O	< 0.005	< 0.005		

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Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill,B-Barrie

Greg Clarkin , BSc., C. Chem
Lab Manager - Ottawa District

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CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: G095656 **REPORT No. B22-16642**

Report To:

City of Iqaluit
PO Box 460,
Iqaluit NU X0A 0H0
Attention: Emmanuel Kayode

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 02-Jun-22
DATE REPORTED: 14-Jun-22
SAMPLE MATRIX: Waste Water

JOB/PROJECT NO.: Test F
P.O. NUMBER:
WATERWORKS NO.

				Client I.D.	WWTP Influent	WWTP Effluent		
				Sample I.D.	B22-16642-1	B22-16642-2		
				Date Collected	01-Jun-22	01-Jun-22		
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
Silver	mg/L	0.0001	EPA 200.8	13-Jun-22/O	< 0.0001	< 0.0001		
Strontium	mg/L	0.001	SM 3120	13-Jun-22/O	0.030	0.030		
Thallium	mg/L	0.0003	EPA 200.8	13-Jun-22/O	< 0.0003	< 0.0003		
Tin	mg/L	0.05	SM 3120	13-Jun-22/O	< 0.05	< 0.05		
Titanium	mg/L	0.005	SM 3120	13-Jun-22/O	0.014	< 0.005		
Uranium	mg/L	0.0003	EPA 200.8	13-Jun-22/O	< 0.0003	< 0.0003		
Vanadium	mg/L	0.005	SM 3120	13-Jun-22/O	< 0.005	< 0.005		
Zinc	mg/L	0.005	SM 3120	13-Jun-22/O	0.185	0.131		
Total Coliform	cfu/100mL	1	MOE E3371	02-Jun-22/O	125000000	110000000		
Fecal Coliform	cfu/100mL	1	MOE E3371	02-Jun-22/O	9000000	12600000		

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Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill,B-Barrie

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Lab Manager - Ottawa District

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CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: G095608 | **REPORT No. B22-17677**

Report To:

City of Iqaluit
PO Box 460,
Iqaluit NU X0A 0H0
Attention: Emmanuel Kayode

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 09-Jun-22
DATE REPORTED: 17-Jun-22
SAMPLE MATRIX: Waste Water

JOB/PROJECT NO.: Test E
P.O. NUMBER: 460
WATERWORKS NO.

			Client I.D.		Detention Pond 2			
			Sample I.D.		B22-17677-1			
			Date Collected		08-Jun-22			
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
BOD(5 day)	mg/L	3	SM 5210B	10-Jun-22/K	< 3			
COD	mg/L	5	SM5220C	14-Jun-22/K	68			
Total Organic Carbon	mg/L	0.2	EPA 415.2	10-Jun-22/O	1.9			
Total Suspended Solids	mg/L	3	SM2540D	15-Jun-22/K	36			
Turbidity	NTU	0.1	SM 2130	10-Jun-22/O	8.5			
pH @25°C	pH Units		SM 4500H	10-Jun-22/O	7.11			
Ammonia (N)-Total	mg/L	0.01	SM4500-NH3-H	10-Jun-22/K	0.34			
Total Kjeldahl Nitrogen	mg/L	0.1	E3516.2	10-Jun-22/K	1.9			
Phosphorus-Total	mg/L	0.01	E3516.2	10-Jun-22/K	0.29			
Aluminum	mg/L	0.01	SM 3120	13-Jun-22/O	0.32			
Arsenic	mg/L	0.0005	EPA 200.8	13-Jun-22/O	< 0.0005			
Antimony	mg/L	0.0005	EPA 200.8	13-Jun-22/O	< 0.0005			
Barium	mg/L	0.001	SM 3120	13-Jun-22/O	0.005			
Beryllium	mg/L	0.0005	EPA 200.8	13-Jun-22/O	< 0.0005			
Chromium	mg/L	0.001	EPA 200.8	13-Jun-22/O	0.002			
Cobalt	mg/L	0.0005	EPA 200.8	13-Jun-22/O	< 0.0005			
Copper	mg/L	0.0005	EPA 200.8	13-Jun-22/O	0.0027			
Iron	mg/L	0.005	SM 3120	13-Jun-22/O	0.783			
Lithium	mg/L	0.01	SM 3120	13-Jun-22/O	0.01			
Manganese	mg/L	0.001	SM 3120	13-Jun-22/O	0.036			
Mercury	mg/L	0.00002	SM 3112 B	14-Jun-22/O	< 0.00002			
Molybdenum	mg/L	0.0005	EPA 200.8	13-Jun-22/O	< 0.0005			
Nickel	mg/L	0.001	EPA 200.8	13-Jun-22/O	< 0.001			
Selenium	mg/L	0.005	EPA 200.8	13-Jun-22/O	< 0.005			
Silver	mg/L	0.0001	EPA 200.8	13-Jun-22/O	< 0.0001			
Strontium	mg/L	0.001	SM 3120	13-Jun-22/O	0.028			

Greg Clarkin , BSc., C. Chem
Lab Manager - Ottawa District

R.L. = Reporting Limit
Test methods may be modified from specified reference method unless indicated by an *
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill,B-Barrie

CADUCEON ENVIRONMENTAL LABORATORIES
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CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: G095608 **REPORT No. B22-17677**

Report To:

City of Iqaluit
PO Box 460,
Iqaluit NU X0A 0H0
Attention: Emmanuel Kayode

Caducebon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 09-Jun-22
DATE REPORTED: 17-Jun-22
SAMPLE MATRIX: Waste Water

JOB/PROJECT NO.: Test E
P.O. NUMBER: 460
WATERWORKS NO.

			Client I.D.		Detention Pond 2			
			Sample I.D.		B22-17677-1			
			Date Collected		08-Jun-22			
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
Tin	mg/L	0.05	SM 3120	13-Jun-22/O	< 0.05			
Titanium	mg/L	0.005	SM 3120	13-Jun-22/O	0.035			
Uranium	mg/L	0.0003	EPA 200.8	13-Jun-22/O	< 0.0003			
Vanadium	mg/L	0.0005	EPA 200.8	13-Jun-22/O	0.0007			
Zinc	mg/L	0.005	SM 3120	13-Jun-22/O	0.007			
Total Coliform	cfu/100mL	1	MOE E3371	09-Jun-22/O	< 2			
Fecal Coliform	cfu/100mL	1	MOE E3371	09-Jun-22/O	0			
Benzene	µg/L	0.5	EPA 8260	13-Jun-22/R	< 0.5			
Toluene	µg/L	0.5	EPA 8260	13-Jun-22/R	< 0.5			
Ethylbenzene	µg/L	0.5	EPA 8260	13-Jun-22/R	< 0.5			
Xylene, m,p-	µg/L	1.0	EPA 8260	13-Jun-22/R	< 1.0			
Xylene, o-	µg/L	0.5	EPA 8260	13-Jun-22/R	< 0.5			
Xylene, m,p,o-	µg/L	1.1	EPA 8260	13-Jun-22/R	< 1.1			
Toluene-d8 (SS)	% rec.		EPA 8260	13-Jun-22/R	96.5			
Poly-Chlorinated Biphenyls (PCB's)	µg/L	0.05	EPA 8082	13-Jun-22/K	< 0.05			

R.L. = Reporting Limit
Test methods may be modified from specified reference method unless indicated by an *
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill,B-Barrie

Greg Clarkin , BSc., C. Chem
Lab Manager - Ottawa District

CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: G095611 **REPORT No. B22-22252**

Report To:
City of Iqaluit
PO Box 460,
Iqaluit NU X0A 0H0
Attention: Emmanuel Kayode

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 14-Jul-22
DATE REPORTED: 22-Jul-22
SAMPLE MATRIX: Waste Water

JOB/PROJECT NO.: Test E
P.O. NUMBER: 460
WATERWORKS NO.

				Client I.D.	1QA-08A	1QA-08B	Pond #2 (Middle Decant)	
				Sample I.D.	B22-22252-1	B22-22252-2	B22-22252-3	
				Date Collected	13-Jul-22	13-Jul-22	13-Jul-22	
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
BOD(5 day)	mg/L	3	SM 5210B	15-Jul-22/K	4	4	13	
COD	mg/L	5	SM5220C	19-Jul-22/K	83	107	54	
Total Organic Carbon	mg/L	0.2	EPA 415.2	14-Jul-22/O	7.1	10.6	9.9	
Total Suspended Solids	mg/L	3	SM2540D	18-Jul-22/K	30	58	270	
Turbidity	NTU	0.1	SM 2130	18-Jul-22/O	6.3	3.4	11.9	
pH @25°C	pH Units		SM 4500H	14-Jul-22/O	7.98	8.78	8.10	
Ammonia (N)-Total	mg/L	0.01	SM4500-NH3-H	19-Jul-22/K	0.36	0.75	0.17	
Total Kjeldahl Nitrogen	mg/L	0.1	E3516.2	19-Jul-22/K	3.0	4.7	1.2	
Phosphorus-Total	mg/L	0.01	E3516.2	19-Jul-22/K	0.29	1.25	0.03	
Aluminum	mg/L	0.01	SM 3120	19-Jul-22/O	0.18	0.06	0.04	
Arsenic	mg/L	0.0005	EPA 200.8	15-Jul-22/O	0.0007	0.0016	0.0011	
Antimony	mg/L	0.0005	EPA 200.8	15-Jul-22/O	< 0.0005	0.0005	0.0005	
Barium	mg/L	0.001	SM 3120	19-Jul-22/O	0.022	0.009	0.022	
Beryllium	mg/L	0.0005	EPA 200.8	15-Jul-22/O	< 0.0005	< 0.0005	< 0.0005	
Chromium	mg/L	0.001	EPA 200.8	15-Jul-22/O	< 0.001	< 0.001	< 0.001	
Cobalt	mg/L	0.0005	EPA 200.8	15-Jul-22/O	< 0.0005	< 0.0005	0.0012	
Copper	mg/L	0.0005	EPA 200.8	15-Jul-22/O	0.0043	0.0019	0.0010	
Iron	mg/L	0.005	SM 3120	19-Jul-22/O	1.37	0.173	2.36	
Lithium	mg/L	0.01	SM 3120	19-Jul-22/O	0.02	0.01	< 0.01	
Manganese	mg/L	0.001	SM 3120	19-Jul-22/O	0.203	0.090	4.66	
Mercury	mg/L	0.00002	SM 3112 B	19-Jul-22/O	< 0.00002	< 0.00002	< 0.00002	
Molybdenum	mg/L	0.0005	EPA 200.8	15-Jul-22/O	0.0013	0.0007	0.0014	
Nickel	mg/L	0.001	EPA 200.8	15-Jul-22/O	0.001	0.005	0.003	
Selenium	mg/L	0.005	EPA 200.8	15-Jul-22/O	< 0.005	< 0.005	< 0.005	
Silver	mg/L	0.0001	EPA 200.8	15-Jul-22/O	< 0.0001	< 0.0001	< 0.0001	

R.L. = Reporting Limit
Test methods may be modified from specified reference method unless indicated by an *
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill,B-Barrie

Tahir Yapici Ph.D
Lab Supervisor

CADUCEON ENVIRONMENTAL LABORATORIES Client committed. Quality assured.

CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: G095611 **REPORT No. B22-22252**

Report To:

City of Iqaluit
PO Box 460,
Iqaluit NU X0A 0H0
Attention: Emmanuel Kayode

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 14-Jul-22
DATE REPORTED: 22-Jul-22
SAMPLE MATRIX: Waste Water

JOB/PROJECT NO.: Test E
P.O. NUMBER: 460
WATERWORKS NO.

				Client I.D.	1QA-08A	1QA-08B	Pond #2 (Middle Decant)	
				Sample I.D.	B22-22252-1	B22-22252-2	B22-22252-3	
				Date Collected	13-Jul-22	13-Jul-22	13-Jul-22	
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
Strontium	mg/L	0.001	SM 3120	19-Jul-22/O	0.294	0.273	0.344	
Tin	mg/L	0.05	SM 3120	19-Jul-22/O	< 0.05	< 0.05	< 0.05	
Titanium	mg/L	0.005	SM 3120	19-Jul-22/O	0.010	< 0.005	< 0.005	
Uranium	mg/L	0.0003	EPA 200.8	15-Jul-22/O	< 0.0003	< 0.0003	0.0003	
Vanadium	mg/L	0.0005	EPA 200.8	15-Jul-22/O	0.0006	0.0010	< 0.0005	
Zinc	mg/L	0.005	SM 3120	19-Jul-22/O	0.013	0.013	0.006	
Total Coliform	cfu/100mL	1	MOE E3371	14-Jul-22/O	2	0	7	
Fecal Coliform	cfu/100mL	1	MOE E3371	14-Jul-22/O	0	0	6	
Benzene	µg/L	0.5	EPA 8260	18-Jul-22/R	< 0.5	< 0.5	< 0.5	
Toluene	µg/L	0.5	EPA 8260	18-Jul-22/R	< 0.5	< 0.5	7.2	
Ethylbenzene	µg/L	0.5	EPA 8260	18-Jul-22/R	< 0.5	< 0.5	1.2	
Xylene, m,p-	µg/L	1.0	EPA 8260	18-Jul-22/R	< 1.0	< 1.0	11.8	
Xylene, o-	µg/L	0.5	EPA 8260	18-Jul-22/R	< 0.5	< 0.5	5.8	
Xylene, m,p,o-	µg/L	1.1	EPA 8260	18-Jul-22/R	< 1.1	< 1.1	17.6	
Toluene-d8 (SS)	% rec.		EPA 8260	18-Jul-22/R	109	110	108	
Poly-Chlorinated Biphenyls (PCB's)	µg/L	0.05	EPA 8082	20-Jul-22/K	< 0.05	< 0.05	< 0.05	

Tahir Yapici Ph.D
Lab Supervisor

R.L. = Reporting Limit
Test methods may be modified from specified reference method unless indicated by an *
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill,B-Barrie

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CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: ---

REPORT No. B22-23005

Report To:

City of Iqaluit
PO Box 460,
Iqaluit NU X0A 0H0
Attention: Emmanuel Kayode

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 20-Jul-22
DATE REPORTED: 28-Jul-22
SAMPLE MATRIX: Waste Water

JOB/PROJECT NO.: Test E
P.O. NUMBER: 460
WATERWORKS NO.

			Client I.D.		Pond #2 (End of Decant)			
			Sample I.D.		B22-23005-1			
			Date Collected		19-Jul-22			
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
BOD(5 day)	mg/L	3	SM 5210B	22-Jul-22/K	4			
COD	mg/L	5	SM5220C	26-Jul-22/K	124			
Total Organic Carbon	mg/L	0.2	EPA 415.2	20-Jul-22/O	13.5			
Total Suspended Solids	mg/L	3	SM2540D	22-Jul-22/K	28			
Turbidity	NTU	0.1	SM 2130	22-Jul-22/O	6.2			
pH @25°C	pH Units		SM 4500H	21-Jul-22/O	8.47			
Ammonia (N)-Total	mg/L	0.01	SM4500-NH3-H	25-Jul-22/K	0.41			
Total Kjeldahl Nitrogen	mg/L	0.1	E3516.2	26-Jul-22/K	6.0			
Phosphorus-Total	mg/L	0.01	E3516.2	26-Jul-22/K	1.34			
Aluminum	mg/L	0.01	SM 3120	25-Jul-22/O	0.19			
Arsenic	mg/L	0.0005	EPA 200.8	21-Jul-22/O	0.0017			
Antimony	mg/L	0.0005	EPA 200.8	21-Jul-22/O	0.0006			
Barium	mg/L	0.001	SM 3120	25-Jul-22/O	0.011			
Beryllium	mg/L	0.0005	EPA 200.8	21-Jul-22/O	< 0.0005			
Chromium	mg/L	0.001	EPA 200.8	21-Jul-22/O	< 0.001			
Cobalt	mg/L	0.0005	EPA 200.8	21-Jul-22/O	< 0.0005			
Copper	mg/L	0.0005	EPA 200.8	21-Jul-22/O	0.0013			
Iron	mg/L	0.005	SM 3120	25-Jul-22/O	0.419			
Lithium	mg/L	0.01	SM 3120	25-Jul-22/O	0.01			
Manganese	mg/L	0.001	SM 3120	25-Jul-22/O	0.103			
Mercury	mg/L	0.00002	SM 3112 B	21-Jul-22/O	< 0.00002			
Molybdenum	mg/L	0.0005	EPA 200.8	21-Jul-22/O	0.0012			
Nickel	mg/L	0.001	EPA 200.8	21-Jul-22/O	0.005			
Selenium	mg/L	0.005	EPA 200.8	21-Jul-22/O	< 0.005			
Silver	mg/L	0.0001	EPA 200.8	21-Jul-22/O	0.0002			

R.L. = Reporting Limit
Test methods may be modified from specified reference method unless indicated by an *
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill,B-Barrie

Tahir Yapici Ph.D
Lab Supervisor

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CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: --- **REPORT No. B22-23005**

Report To:

City of Iqaluit
PO Box 460,
Iqaluit NU X0A 0H0
Attention: Emmanuel Kayode

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 20-Jul-22
DATE REPORTED: 28-Jul-22
SAMPLE MATRIX: Waste Water

JOB/PROJECT NO.: Test E
P.O. NUMBER: 460
WATERWORKS NO.

			Client I.D.		Pond #2 (End of Decant)			
			Sample I.D.		B22-23005-1			
			Date Collected		19-Jul-22			
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
Strontium	mg/L	0.001	SM 3120	25-Jul-22/O	0.307			
Tin	mg/L	0.05	SM 3120	25-Jul-22/O	< 0.05			
Titanium	mg/L	0.005	SM 3120	25-Jul-22/O	0.008			
Uranium	mg/L	0.0003	EPA 200.8	21-Jul-22/O	< 0.0003			
Vanadium	mg/L	0.0005	EPA 200.8	21-Jul-22/O	0.0013			
Zinc	mg/L	0.005	SM 3120	25-Jul-22/O	0.015			
Total Coliform	cfu/100mL	1	MOE E3371	20-Jul-22/O	0			
Fecal Coliform	cfu/100mL	1	MOE E3371	20-Jul-22/O	0			
Benzene	µg/L	0.5	EPA 8260	22-Jul-22/R	< 0.5			
Toluene	µg/L	0.5	EPA 8260	22-Jul-22/R	< 0.5			
Ethylbenzene	µg/L	0.5	EPA 8260	22-Jul-22/R	< 0.5			
Xylene, m,p-	µg/L	1.0	EPA 8260	22-Jul-22/R	< 1.0			
Xylene, o-	µg/L	0.5	EPA 8260	22-Jul-22/R	< 0.5			
Xylene, m,p,o-	µg/L	1.1	EPA 8260	22-Jul-22/R	< 1.1			
Toluene-d8 (SS)	% rec.		EPA 8260	22-Jul-22/R	101			
Poly-Chlorinated Biphenyls (PCB's)	µg/L	0.05	EPA 8082	26-Jul-22/K	< 0.05			

Tahir Yapici Ph.D
Lab Supervisor

R.L. = Reporting Limit
Test methods may be modified from specified reference method unless indicated by an *
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill,B-Barrie

CADUCEON ENVIRONMENTAL LABORATORIES
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CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: --- **REPORT No. B22-24732**

Report To:

City of Iqaluit
PO Box 460,
Iqaluit NU X0A 0H0
Attention: Peter Martel

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 04-Aug-22
DATE REPORTED: 11-Aug-22
SAMPLE MATRIX: Waste Water

JOB/PROJECT NO.: Test F
P.O. NUMBER:
WATERWORKS NO.

			Client I.D.		WWTP Influent	WWTP Effluent		
			Sample I.D.		B22-24732-1	B22-24732-2		
			Date Collected		03-Aug-22	04-Aug-22		
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
BOD(5 day)	mg/L	3	SM 5210B	05-Aug-22/K	166	97		
Total Suspended Solids	mg/L	3	SM2540D	09-Aug-22/K	154	92		
Conductivity @25°C	µmho/cm	1	SM 2510B	08-Aug-22/O	384	443		
pH @25°C	pH Units		SM 4500H	08-Aug-22/O	7.25	7.44		
Nitrite (N)	mg/L	0.1	SM4110C	04-Aug-22/O	< 0.1	< 0.1		
Nitrate (N)	mg/L	0.1	SM4110C	04-Aug-22/O	< 0.1	< 0.1		
Ammonia (N)-Total	mg/L	0.01	SM4500-NH3-H	08-Aug-22/K	26.1	33.9		
o-Phosphate (P)	mg/L	0.002	PE4500-S	08-Aug-22/K	2.12	2.42		
Phosphorus-Total	mg/L	0.01	E3516.2	09-Aug-22/K	9.71	4.57		
Aluminum	mg/L	0.01	SM 3120	08-Aug-22/O	0.15	0.17		
Antimony	mg/L	0.0005	EPA 200.8	08-Aug-22/O	0.0007	< 0.0005		
Arsenic	mg/L	0.0005	EPA 200.8	08-Aug-22/O	< 0.0005	< 0.0005		
Barium	mg/L	0.001	SM 3120	08-Aug-22/O	0.007	0.008		
Beryllium	mg/L	0.002	SM 3120	08-Aug-22/O	< 0.002	< 0.002		
Cadmium	mg/L	).00007(	EPA 200.8	08-Aug-22/O	< 0.000070	0.000141		
Chromium	mg/L	0.002	SM 3120	08-Aug-22/O	< 0.002	< 0.002		
Cobalt	mg/L	0.005	SM 3120	08-Aug-22/O	< 0.005	< 0.005		
Copper	mg/L	0.002	SM 3120	08-Aug-22/O	0.293	0.257		
Iron	mg/L	0.005	SM 3120	08-Aug-22/O	0.473	0.892		
Lead	mg/L	0.0001	EPA 200.8	08-Aug-22/O	0.0014	0.0025		
Lithium	mg/L	0.01	SM 3120	08-Aug-22/O	< 0.01	< 0.01		
Manganese	mg/L	0.001	SM 3120	08-Aug-22/O	0.075	0.095		
Mercury	mg/L	0.00002	SM 3112 B	09-Aug-22/O	< 0.00002	0.00003		
Molybdenum	mg/L	0.01	SM 3120	08-Aug-22/O	< 0.01	< 0.01		
Nickel	mg/L	0.01	SM 3120	08-Aug-22/O	< 0.01	< 0.01		
Selenium	mg/L	0.005	EPA 200.8	08-Aug-22/O	< 0.005	< 0.005		

R.L. = Reporting Limit
Test methods may be modified from specified reference method unless indicated by an *
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill,B-Barrie

Tahir Yapici Ph.D
Lab Manager - Ottawa District

CERTIFICATE OF ANALYSIS

CADUCEON ENVIRONMENTAL LABORATORIES
Client committed. Quality assured.

Final Report

C.O.C.: --- **REPORT No. B22-24732**

Report To:

City of Iqaluit
PO Box 460,
Iqaluit NU X0A 0H0
Attention: Peter Martel

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 04-Aug-22
DATE REPORTED: 11-Aug-22
SAMPLE MATRIX: Waste Water

JOB/PROJECT NO.: Test F
P.O. NUMBER:
WATERWORKS NO.

			Client I.D.		WWTP Influent	WWTP Effluent		
			Sample I.D.		B22-24732-1	B22-24732-2		
			Date Collected		03-Aug-22	04-Aug-22		
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
Silver	mg/L	0.0001	EPA 200.8	08-Aug-22/O	0.0001	< 0.0001		
Strontium	mg/L	0.001	SM 3120	08-Aug-22/O	0.029	0.032		
Thallium	mg/L	0.0003	EPA 200.8	08-Aug-22/O	< 0.0003	< 0.0003		
Tin	mg/L	0.05	SM 3120	08-Aug-22/O	< 0.05	< 0.05		
Titanium	mg/L	0.005	SM 3120	08-Aug-22/O	< 0.005	< 0.005		
Uranium	mg/L	0.0003	EPA 200.8	08-Aug-22/O	< 0.0003	< 0.0003		
Vanadium	mg/L	0.005	SM 3120	08-Aug-22/O	< 0.005	< 0.005		
Zinc	mg/L	0.005	SM 3120	08-Aug-22/O	0.113	0.157		
Total Coliform	cfu/100mL	1	MOE E3371	04-Aug-22/O	180000000	150000000		
Fecal Coliform	cfu/100mL	1	MOE E3371	04-Aug-22/O	3000000	1200000		

Tahir Yapici Ph.D
Lab Manager - Ottawa District

R.L. = Reporting Limit
Test methods may be modified from specified reference method unless indicated by an *
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill,B-Barrie

CADUCEON ENVIRONMENTAL LABORATORIES
Client committed. Quality assured.

CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: G110355 **REPORT No. B22-28893**

Report To:

City of Iqaluit
PO Box 460,
Iqaluit NU X0A 0H0
Attention: Emmanuel Kayode

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 08-Sep-22
DATE REPORTED: 21-Sep-22
SAMPLE MATRIX: Waste Water

JOB/PROJECT NO.: Test F
P.O. NUMBER: 460
WATERWORKS NO.

			Client I.D.		WWTP Influent	WWTP Effluent		
			Sample I.D.		B22-28893-1	B22-28893-2		
			Date Collected		06-Sep-22	06-Sep-22		
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
BOD(5 day)	mg/L	3	SM 5210B	09-Sep-22/K	189	128		
Total Suspended Solids	mg/L	3	SM2540D	13-Sep-22/K	335	90		
Conductivity @25°C	µmho/cm	1	SM 2510B	09-Sep-22/O	435	476		
pH @25°C	pH Units		SM 4500H	09-Sep-22/O	7.46	7.56		
Nitrite (N)	mg/L	0.1	SM4110C	08-Sep-22/O	< 0.1	< 0.1		
Nitrate (N)	mg/L	0.1	SM4110C	08-Sep-22/O	< 0.1	< 0.1		
Ammonia (N)-Total	mg/L	0.01	SM4500-NH3-H	13-Sep-22/K	25.9	3.24		
o-Phosphate (P)	mg/L	0.002	PE4500-S	13-Sep-22/K	1.90	0.195		
Phosphorus-Total	mg/L	0.01	E3516.2	19-Sep-22/K	4.36	4.01		
Aluminum	mg/L	0.01	SM 3120	09-Sep-22/O	0.34	0.17		
Antimony	mg/L	0.0005	EPA 200.8	09-Sep-22/O	0.0008	0.0007		
Arsenic	mg/L	0.0005	EPA 200.8	09-Sep-22/O	< 0.0005	< 0.0005		
Barium	mg/L	0.001	SM 3120	09-Sep-22/O	0.013	0.009		
Beryllium	mg/L	0.002	SM 3120	09-Sep-22/O	< 0.002	< 0.002		
Cadmium	mg/L	).00007(	EPA 200.8	09-Sep-22/O	0.000182	0.000109		
Chromium	mg/L	0.002	SM 3120	09-Sep-22/O	0.004	< 0.002		
Cobalt	mg/L	0.005	SM 3120	09-Sep-22/O	< 0.005	< 0.005		
Copper	mg/L	0.002	SM 3120	09-Sep-22/O	0.289	0.192		
Iron	mg/L	0.005	SM 3120	09-Sep-22/O	1.34	0.597		
Lead	mg/L	0.0001	EPA 200.8	09-Sep-22/O	0.0107	0.0021		
Lithium	mg/L	0.01	SM 3120	09-Sep-22/O	< 0.01	< 0.01		
Manganese	mg/L	0.001	SM 3120	09-Sep-22/O	0.114	0.103		
Mercury	mg/L	0.00002	SM 3112 B	09-Sep-22/O	< 0.00002	< 0.00002		
Molybdenum	mg/L	0.01	SM 3120	09-Sep-22/O	< 0.01	< 0.01		
Nickel	mg/L	0.01	SM 3120	09-Sep-22/O	< 0.01	< 0.01		
Selenium	mg/L	0.005	EPA 200.8	09-Sep-22/O	< 0.005	< 0.005		

R.L. = Reporting Limit
Test methods may be modified from specified reference method unless indicated by an *
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill,B-Barrie

Tahir Yapici Ph.D
Lab Manager - Ottawa District

CADUCEON ENVIRONMENTAL LABORATORIES
Client committed. Quality assured.

CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: G110355 **REPORT No. B22-28893**

Report To:

City of Iqaluit
PO Box 460,
Iqaluit NU X0A 0H0
Attention: Emmanuel Kayode

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 08-Sep-22
DATE REPORTED: 21-Sep-22
SAMPLE MATRIX: Waste Water

JOB/PROJECT NO.: Test F
P.O. NUMBER: 460
WATERWORKS NO.

			Client I.D.		WWTP Influent	WWTP Effluent		
			Sample I.D.		B22-28893-1	B22-28893-2		
			Date Collected		06-Sep-22	06-Sep-22		
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
Silver	mg/L	0.0001	EPA 200.8	09-Sep-22/O	0.0004	0.0001		
Strontium	mg/L	0.001	SM 3120	09-Sep-22/O	0.057	0.052		
Thallium	mg/L	0.0003	EPA 200.8	09-Sep-22/O	< 0.0003	< 0.0003		
Tin	mg/L	0.05	SM 3120	09-Sep-22/O	< 0.05	< 0.05		
Titanium	mg/L	0.005	SM 3120	09-Sep-22/O	0.007	0.006		
Uranium	mg/L	0.0003	EPA 200.8	09-Sep-22/O	0.0003	< 0.0003		
Vanadium	mg/L	0.005	SM 3120	09-Sep-22/O	< 0.005	< 0.005		
Zinc	mg/L	0.005	SM 3120	09-Sep-22/O	0.175	0.086		
Total Coliform	cfu/100mL	1	MOE E3371	08-Sep-22/O	170000000	140000000		
Fecal Coliform	cfu/100mL	1	MOE E3371	08-Sep-22/O	9000000	7000000		

R.L. = Reporting Limit
Test methods may be modified from specified reference method unless indicated by an *
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill,B-Barrie

Tahir Yapici Ph.D
Lab Manager - Ottawa District

CADUCEON ENVIRONMENTAL LABORATORIES
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CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: ---

REPORT No. B22-31153

Report To:

City of Iqaluit
PO Box 460,
Iqaluit NU X0A 0H0
Attention: Peter Martel

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 04-Oct-22
DATE REPORTED: 18-Oct-22
SAMPLE MATRIX: Drinking Water

JOB/PROJECT NO.: Test A (WTP)
P.O. NUMBER: 460
WATERWORKS NO.

			Client I.D.		Test A- Raw WTP	Test A- Raw WTP (Total)	Test A- Potable WTP	Test A- Potable (Total)
			Sample I.D.		B22-31153-1	B22-31153-2	B22-31153-3	B22-31153-4
			Date Collected		03-Oct-22	03-Oct-22	03-Oct-22	03-Oct-22
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
Hardness (as CaCO3)	mg/L	1	SM 3120	07-Oct-22/O	17		18	
Hardness (as CaCO3)	mg/L	1	SM 3120	06-Oct-22/O		19		20
Alkalinity(CaCO3) to pH4.5	mg/L	5	SM 2320B	05-Oct-22/O	25		22	
Bicarbonate(as CaCO3)	mg/L	5	SM 2320B	05-Oct-22/O	25		22	
Carbonate (as CaCO3)	mg/L	5	SM 2320B	05-Oct-22/O	< 5		< 5	
Acidity (as CaCO3)	mg/L	5	Subcontract	12-Sep-22	< 5 [2]		9	
pH @25°C	pH Units		SM 4500H	05-Oct-22/O	6.37		6.48	
Conductivity @25°C	µmho/cm	1	SM 2510B	05-Oct-22/O	37		42	
TDS(ion sum calc.)	mg/L	1	Calc.	05-Oct-22/O	28		28	
Total Suspended Solids	mg/L	3	SM2540D	06-Oct-22/K	5		10	
Turbidity	NTU	0.1	SM 2130	06-Oct-22/O	0.8		0.7	
REDOX potential	mV		In-House	07-Oct-22/R	372		700	
Chloride	mg/L	0.5	SM4110C	04-Oct-22/O	1.3		3.0	
Sulphate	mg/L	1	SM4110C	04-Oct-22/O	5		5	
Aluminum	mg/L	0.01	SM 3120	07-Oct-22/O	< 0.01		< 0.01	
Aluminum	mg/L	0.01	SM 3120	06-Oct-22/O		< 0.01		< 0.01
Antimony	mg/L	0.0001	EPA 200.8	05-Oct-22/O	< 0.0001		< 0.0001	
Antimony	mg/L	0.0001	EPA 200.8	07-Oct-22/O		0.0004		0.0003
Arsenic	mg/L	0.0001	EPA 200.8	05-Oct-22/O	< 0.0001		< 0.0001	
Arsenic	mg/L	0.0001	EPA 200.8	07-Oct-22/O		< 0.0001		< 0.0001
Barium	mg/L	0.001	SM 3120	07-Oct-22/O	< 0.001		< 0.001	
Barium	mg/L	0.001	SM 3120	06-Oct-22/O		< 0.001		< 0.001
Beryllium	mg/L	0.002	SM 3120	07-Oct-22/O	< 0.002		< 0.002	
Beryllium	mg/L	0.002	SM 3120	06-Oct-22/O		< 0.002		< 0.002
Cadmium	mg/L	0.000010	EPA 200.8	05-Oct-22/O	< 0.000010		< 0.000010	
Cadmium	mg/L	0.000015	EPA 200.8	07-Oct-22/O		< 0.000015		< 0.000015
Chromium	mg/L	0.002	SM 3120	07-Oct-22/O	< 0.002		< 0.002	

R.L. = Reporting Limit
Test methods may be modified from specified reference method unless indicated by an *
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill,B-Barrie

Tahir Yapici Ph.D
Lab Manager - Ottawa District

CADUCEON ENVIRONMENTAL LABORATORIES
Client committed. Quality assured.

CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: --- **REPORT No. B22-31153**

Report To:

City of Iqaluit
PO Box 460,
Iqaluit NU X0A 0H0
Attention: Peter Martel

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 04-Oct-22
DATE REPORTED: 18-Oct-22
SAMPLE MATRIX: Drinking Water

JOB/PROJECT NO.: Test A (WTP)
P.O. NUMBER: 460
WATERWORKS NO.

			Client I.D.		Test A- Raw WTP	Test A- Raw WTP (Total)	Test A- Potable WTP	Test A- Potable (Total)
			Sample I.D.		B22-31153-1	B22-31153-2	B22-31153-3	B22-31153-4
			Date Collected		03-Oct-22	03-Oct-22	03-Oct-22	03-Oct-22
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
Chromium	mg/L	0.002	SM 3120	06-Oct-22/O		< 0.002		< 0.002
Cobalt	mg/L	0.005	SM 3120	07-Oct-22/O	0.006		< 0.005	
Cobalt	mg/L	0.005	SM 3120	06-Oct-22/O		< 0.005		< 0.005
Copper	mg/L	0.002	SM 3120	07-Oct-22/O	< 0.002		0.008	
Copper	mg/L	0.002	SM 3120	06-Oct-22/O		< 0.002		0.007
Iron	mg/L	0.005	SM 3120	07-Oct-22/O	< 0.005		< 0.005	
Iron	mg/L	0.005	SM 3120	06-Oct-22/O		0.026		0.025
Lead	mg/L	0.00002	EPA 200.8	05-Oct-22/O	0.00003		0.00020	
Lead	mg/L	0.00002	EPA 200.8	07-Oct-22/O		0.00003		0.00021
Lithium	mg/L	0.01	SM 3120	07-Oct-22/O	< 0.01		< 0.01	
Lithium	mg/L	0.01	SM 3120	06-Oct-22/O		0.02		< 0.01
Manganese	mg/L	0.001	SM 3120	07-Oct-22/O	0.004		0.003	
Manganese	mg/L	0.001	SM 3120	06-Oct-22/O		0.004		0.004
Mercury	mg/L	0.00002	SM 3112 B	06-Oct-22/O	< 0.00002	< 0.00002	< 0.00002	< 0.00002
Molybdenum	mg/L	0.01	SM 3120	07-Oct-22/O	< 0.01		< 0.01	
Molybdenum	mg/L	0.01	SM 3120	06-Oct-22/O		< 0.01		< 0.01
Nickel	mg/L	0.01	SM 3120	07-Oct-22/O	< 0.01		< 0.01	
Nickel	mg/L	0.01	SM 3120	06-Oct-22/O		< 0.01		< 0.01
Selenium	mg/L	0.001	EPA 200.8	05-Oct-22/O	< 0.001		< 0.001	
Selenium	mg/L	0.001	EPA 200.8	07-Oct-22/O		< 0.001		< 0.001
Silver	mg/L	0.0001	EPA 200.8	05-Oct-22/O	< 0.0001		< 0.0001	
Silver	mg/L	0.0001	EPA 200.8	07-Oct-22/O		< 0.0001		< 0.0001
Strontium	mg/L	0.001	SM 3120	07-Oct-22/O	0.012		0.012	
Strontium	mg/L	0.001	SM 3120	06-Oct-22/O		0.012		0.013
Thallium	mg/L	0.00005	EPA 200.8	05-Oct-22/O	< 0.00005		< 0.00005	
Thallium	mg/L	0.00005	EPA 200.8	07-Oct-22/O		< 0.00005		< 0.00005
Tin	mg/L	0.05	SM 3120	07-Oct-22/O	< 0.05		< 0.05	

R.L. = Reporting Limit
Test methods may be modified from specified reference method unless indicated by an *
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill,B-Barrie

Tahir Yapici Ph.D
Lab Manager - Ottawa District

CERTIFICATE OF ANALYSIS

CADUCEON ENVIRONMENTAL LABORATORIES
Client committed. Quality assured.

Final Report

C.O.C.: --- **REPORT No. B22-31153**

Report To:

City of Iqaluit
PO Box 460,
Iqaluit NU X0A 0H0
Attention: Peter Martel

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 04-Oct-22
DATE REPORTED: 18-Oct-22
SAMPLE MATRIX: Drinking Water

JOB/PROJECT NO.: Test A (WTP)
P.O. NUMBER: 460
WATERWORKS NO.

			Client I.D.		Test A- Raw WTP	Test A- Raw WTP (Total)	Test A- Potable WTP	Test A- Potable (Total)
			Sample I.D.		B22-31153-1	B22-31153-2	B22-31153-3	B22-31153-4
			Date Collected		03-Oct-22	03-Oct-22	03-Oct-22	03-Oct-22
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
Tin	mg/L	0.05	SM 3120	06-Oct-22/O		< 0.05		< 0.05
Titanium	mg/L	0.005	SM 3120	07-Oct-22/O	< 0.005		< 0.005	
Titanium	mg/L	0.005	SM 3120	06-Oct-22/O		< 0.005		< 0.005
Uranium	mg/L	0.00005	EPA 200.8	05-Oct-22/O	< 0.00005		< 0.00005	
Uranium	mg/L	0.00005	EPA 200.8	07-Oct-22/O		< 0.00005		< 0.00005
Vanadium	mg/L	0.005	SM 3120	07-Oct-22/O	< 0.005		< 0.005	
Vanadium	mg/L	0.005	SM 3120	06-Oct-22/O		< 0.005		< 0.005
Zinc	mg/L	0.005	SM 3120	07-Oct-22/O	< 0.005		< 0.005	
Zinc	mg/L	0.005	SM 3120	06-Oct-22/O		< 0.005		< 0.005
Total Organic Carbon	mg/L	0.2	EPA 415.2	05-Oct-22/O	1.5		1.7	
TIC	mg/L	0.5	EPA 415.1	05-Oct-22/O	11.25		9.02	
Fecal Coliform	cfu/100mL	1	MOE E3371	04-Oct-22/O	0		0	
Anion Sum	meq/L		Calc.	05-Oct-22/O	0.638		0.620	
Cation Sum	meq/L		Calc.	05-Oct-22/O	0.376		0.386	
% Difference	%		Calc.	05-Oct-22/O	25.8 [1]		23.2 [1]	
Ion Ratio	AS/CS		Calc.	05-Oct-22/O	1.70		1.60	
Sodium Adsorption Ratio	-		Calc.	05-Oct-22/O	0.0742		0.0699	
Conductivity (calc.)	µmho/cm		Calc.	05-Oct-22/O	52		54	
EC(calc.)/EC(actual)	-		Calc.	05-Oct-22/O	1.41		1.28	
TDS(calc.)/EC(actual)	-		Calc.	05-Oct-22/O	0.755		0.669	
Langelier Index(25°C)	S.I.		Calc.	05-Oct-22/O	-2.82		-2.99	

1. Outside of 15% Acceptance Criteria
2. Subcontracted to SGS Lakefield

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Tahir Yapici Ph.D
Lab Manager - Ottawa District

CADUCEON ENVIRONMENTAL LABORATORIES
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CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: --- **REPORT No. B22-31298**

Report To:

City of Iqaluit
PO Box 460,
Iqaluit NU X0A 0H0
Attention: Emmanuel Kayode

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 05-Oct-22
DATE REPORTED: 14-Oct-22
SAMPLE MATRIX: Waste Water

JOB/PROJECT NO.: Test F
P.O. NUMBER:
WATERWORKS NO.

			Client I.D.		WWTP Influent	WWTP Effluent		
			Sample I.D.		B22-31298-1	B22-31298-2		
			Date Collected		04-Oct-22	05-Oct-22		
Parameter	Units	R.L.	Reference Method	Date/Site Analyzed				
BOD(5 day)	mg/L	3	SM 5210B	07-Oct-22/K	184	86		
Total Suspended Solids	mg/L	3	SM2540D	11-Oct-22/K	440	140		
Conductivity @25°C	µmho/cm	1	SM 2510B	05-Oct-22/O	678	3980		
pH @25°C	pH Units		SM 4500H	05-Oct-22/O	7.78	7.71		
Nitrite (N)	mg/L	0.1	SM4110C	05-Oct-22/O	< 0.1	< 0.1		
Nitrate (N)	mg/L	0.1	SM4110C	05-Oct-22/O	< 0.1	< 0.1		
Ammonia (N)-Total	mg/L	0.01	SM4500-NH3-H	07-Oct-22/K	5.70	2.43		
o-Phosphate (P)	mg/L	0.002	PE4500-S	07-Oct-22/K	0.441	0.138		
Phosphorus-Total	mg/L	0.01	E3516.2	11-Oct-22/K	9.31	3.71		
Aluminum	mg/L	0.01	SM 3120	06-Oct-22/O	3.39	1.26		
Antimony	mg/L	0.0005	EPA 200.8	07-Oct-22/O	0.0006	< 0.0005		
Arsenic	mg/L	0.0005	EPA 200.8	07-Oct-22/O	0.0014	0.0005		
Barium	mg/L	0.001	SM 3120	06-Oct-22/O	0.038	0.016		
Beryllium	mg/L	0.002	SM 3120	06-Oct-22/O	< 0.002	< 0.002		
Cadmium	mg/L	).000070	EPA 200.8	07-Oct-22/O	0.000377	0.000080		
Chromium	mg/L	0.002	SM 3120	06-Oct-22/O	0.008	0.003		
Cobalt	mg/L	0.005	SM 3120	06-Oct-22/O	< 0.005	< 0.005		
Copper	mg/L	0.002	SM 3120	06-Oct-22/O	0.344	0.125		
Iron	mg/L	0.005	SM 3120	06-Oct-22/O	6.88	2.65		
Lead	mg/L	0.0001	EPA 200.8	07-Oct-22/O	0.0156	0.0031		
Lithium	mg/L	0.01	SM 3120	06-Oct-22/O	< 0.01	< 0.01		
Manganese	mg/L	0.001	SM 3120	06-Oct-22/O	0.219	0.154		
Mercury	mg/L	0.00002	SM 3112 B	07-Oct-22/O	0.00005	< 0.00002		
Molybdenum	mg/L	0.01	SM 3120	06-Oct-22/O	< 0.01	< 0.01		
Nickel	mg/L	0.01	SM 3120	06-Oct-22/O	< 0.01	< 0.01		
Selenium	mg/L	0.005	EPA 200.8	07-Oct-22/O	< 0.005	< 0.005		

Tahir Yapici Ph.D
Lab Manager - Ottawa District

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Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill,B-Barrie

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Final Report

C.O.C.: --- **REPORT No. B22-31298**

Report To:

City of Iqaluit
PO Box 460,
Iqaluit NU X0A 0H0
Attention: Emmanuel Kayode

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 05-Oct-22
DATE REPORTED: 14-Oct-22
SAMPLE MATRIX: Waste Water

JOB/PROJECT NO.: Test F
P.O. NUMBER:
WATERWORKS NO.

			Client I.D.		WWTP Influent	WWTP Effluent		
			Sample I.D.		B22-31298-1	B22-31298-2		
			Date Collected		04-Oct-22	05-Oct-22		
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
Silver	mg/L	0.0001	EPA 200.8	07-Oct-22/O	0.0002	< 0.0001		
Strontium	mg/L	0.001	SM 3120	06-Oct-22/O	0.066	0.054		
Thallium	mg/L	0.0003	EPA 200.8	07-Oct-22/O	< 0.0003	< 0.0003		
Tin	mg/L	0.05	SM 3120	06-Oct-22/O	< 0.05	< 0.05		
Titanium	mg/L	0.005	SM 3120	06-Oct-22/O	0.128	0.052		
Uranium	mg/L	0.0003	EPA 200.8	07-Oct-22/O	0.0006	0.0003		
Vanadium	mg/L	0.005	SM 3120	06-Oct-22/O	0.005	< 0.005		
Zinc	mg/L	0.005	SM 3120	06-Oct-22/O	0.482	0.076		
Total Coliform	cfu/100mL	1	MOE E3371	05-Oct-22/O	76000000	61000000		
Fecal Coliform	cfu/100mL	1	MOE E3371	05-Oct-22/O	8600000	5100000		

R.L. = Reporting Limit
Test methods may be modified from specified reference method unless indicated by an *
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill,B-Barrie

Tahir Yapici Ph.D
Lab Manager - Ottawa District

CADUCEON ENVIRONMENTAL LABORATORIES
Client committed. Quality assured.

CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: ---

REPORT No. B22-35266

Report To:

City of Iqaluit
PO Box 460,
Iqaluit NU X0A 0H0
Attention: Peter Martel

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 30-Nov-22
DATE REPORTED: 07-Dec-22
SAMPLE MATRIX: Drinking Water

JOB/PROJECT NO.: Test A (WTP)
P.O. NUMBER:
WATERWORKS NO.

			Client I.D.		Test A- Raw WTP	Test A- Raw WTP (Total)	Test A- WTP Drinking	Test A- WTP Drinking(Total)
			Sample I.D.		B22-35266-1	B22-35266-2	B22-35266-3	B22-35266-4
			Date Collected		30-Nov-22	30-Nov-22	30-Nov-22	30-Nov-22
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
Hardness (as CaCO3)	mg/L	1	SM 3120	05-Dec-22/O	20		20	
Hardness (as CaCO3)	mg/L	1	SM 3120	05-Dec-22/O		20		21
Alkalinity(CaCO3) to pH4.5	mg/L	5	SM 2320B	01-Dec-22/O	37		17	
Bicarbonate(as CaCO3)	mg/L	5	SM 2320B	01-Dec-22/O	37		17	
Carbonate (as CaCO3)	mg/L	5	SM 2320B	01-Dec-22/O	< 5		< 5	
Hydroxide	mg/L	5	EPA 310.2	01-Dec-22/O	< 5		< 5	
Acidity (as CaCO3)	mg/L	5	Subcontract	06-Dec-22	5 [2]		< 5 [2]	
pH @25°C	pH Units		SM 4500H	01-Dec-22/O	6.51		6.38	
Conductivity @25°C	µmho/cm	1	SM 2510B	01-Dec-22/O	48		47	
TDS(ion sum calc.)	mg/L	1	Calc.	01-Dec-22/O	34		24	
Total Suspended Solids	mg/L	3	SM2540D	05-Dec-22/K	< 3		< 3	
Turbidity	NTU	0.1	SM 2130	02-Dec-22/O	0.3		0.5	
REDOX potential	mV		In-House	06-Dec-22/R	202		696	
Chloride	mg/L	0.5	SM4110C	30-Nov-22/O	1.1		2.6	
Sulphate	mg/L	1	SM4110C	30-Nov-22/O	3		3	
Aluminum	mg/L	0.01	SM 3120	05-Dec-22/O	< 0.01		< 0.01	
Aluminum	mg/L	0.01	SM 3120	05-Dec-22/O		< 0.01		< 0.01
Antimony	mg/L	0.0001	EPA 200.8	02-Dec-22/O	< 0.0001		< 0.0001	
Antimony	mg/L	0.0001	EPA 200.8	02-Dec-22/O		0.0001		< 0.0001
Arsenic	mg/L	0.0001	EPA 200.8	02-Dec-22/O	< 0.0001		< 0.0001	
Arsenic	mg/L	0.0001	EPA 200.8	02-Dec-22/O		< 0.0001		< 0.0001
Barium	mg/L	0.001	SM 3120	05-Dec-22/O	0.001		0.002	
Barium	mg/L	0.001	SM 3120	05-Dec-22/O		0.001		0.002
Beryllium	mg/L	0.002	SM 3120	05-Dec-22/O	< 0.002		< 0.002	
Beryllium	mg/L	0.002	SM 3120	05-Dec-22/O		< 0.002		< 0.002
Cadmium	mg/L	).000010	EPA 200.8	02-Dec-22/O	< 0.000010		< 0.000010	
Cadmium	mg/L	).000015	EPA 200.8	02-Dec-22/O		< 0.000015		< 0.000015

R.L. = Reporting Limit
Test methods may be modified from specified reference method unless indicated by an *
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill,B-Barrie

Tahir Yapici Ph.D
Lab Manager - Ottawa District

CADUCEON ENVIRONMENTAL LABORATORIES
Client committed. Quality assured.

CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: ---

REPORT No. B22-35266

Report To:

City of Iqaluit
PO Box 460,
Iqaluit NU X0A 0H0
Attention: Peter Martel

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 30-Nov-22
DATE REPORTED: 07-Dec-22
SAMPLE MATRIX: Drinking Water

JOB/PROJECT NO.: Test A (WTP)
P.O. NUMBER:
WATERWORKS NO.

			Client I.D.		Test A- Raw WTP	Test A- Raw WTP (Total)	Test A- WTP Drinking	Test A- WTP Drinking(Total)
			Sample I.D.		B22-35266-1	B22-35266-2	B22-35266-3	B22-35266-4
			Date Collected		30-Nov-22	30-Nov-22	30-Nov-22	30-Nov-22
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
Chromium	mg/L	0.002	SM 3120	05-Dec-22/O	< 0.002		< 0.002	
Chromium	mg/L	0.002	SM 3120	05-Dec-22/O		< 0.002		< 0.002
Cobalt	mg/L	0.005	SM 3120	05-Dec-22/O	< 0.005		< 0.005	
Cobalt	mg/L	0.005	SM 3120	05-Dec-22/O		< 0.005		< 0.005
Copper	mg/L	0.002	SM 3120	05-Dec-22/O	< 0.002		0.100	
Copper	mg/L	0.002	SM 3120	05-Dec-22/O		< 0.002		0.094
Iron	mg/L	0.005	SM 3120	05-Dec-22/O	0.014		0.013	
Iron	mg/L	0.005	SM 3120	05-Dec-22/O		0.015		0.020
Lead	mg/L	0.00002	EPA 200.8	02-Dec-22/O	< 0.00002		0.00042	
Lead	mg/L	0.00002	EPA 200.8	02-Dec-22/O		0.00002		0.00047
Lithium	mg/L	0.01	SM 3120	05-Dec-22/O	0.02		0.01	
Lithium	mg/L	0.01	SM 3120	05-Dec-22/O		< 0.01		< 0.01
Manganese	mg/L	0.001	SM 3120	05-Dec-22/O	0.004		0.004	
Manganese	mg/L	0.001	SM 3120	05-Dec-22/O		0.003		0.004
Mercury	mg/L	0.00002	SM 3112 B	01-Dec-22/O	< 0.00002	< 0.00002	< 0.00002	< 0.00002
Molybdenum	mg/L	0.01	SM 3120	05-Dec-22/O	< 0.01		< 0.01	
Molybdenum	mg/L	0.01	SM 3120	05-Dec-22/O		< 0.01		< 0.01
Nickel	mg/L	0.01	SM 3120	05-Dec-22/O	< 0.01		< 0.01	
Nickel	mg/L	0.01	SM 3120	05-Dec-22/O		< 0.01		< 0.01
Selenium	mg/L	0.001	EPA 200.8	02-Dec-22/O	< 0.001		< 0.001	
Selenium	mg/L	0.001	EPA 200.8	02-Dec-22/O		< 0.001		< 0.001
Silver	mg/L	0.0001	EPA 200.8	02-Dec-22/O	< 0.0001		< 0.0001	
Silver	mg/L	0.0001	EPA 200.8	02-Dec-22/O		< 0.0001		< 0.0001
Strontium	mg/L	0.001	SM 3120	05-Dec-22/O	0.013		0.013	
Strontium	mg/L	0.001	SM 3120	05-Dec-22/O		0.013		0.013
Thallium	mg/L	0.00005	EPA 200.8	02-Dec-22/O	< 0.00005		< 0.00005	
Thallium	mg/L	0.00005	EPA 200.8	02-Dec-22/O		< 0.00005		< 0.00005

R.L. = Reporting Limit
Test methods may be modified from specified reference method unless indicated by an *
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill,B-Barrie

Tahir Yapici Ph.D
Lab Manager - Ottawa District

CADUCEON ENVIRONMENTAL LABORATORIES
Client committed. Quality assured.

CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: --- **REPORT No. B22-35266**

Report To:

City of Iqaluit
PO Box 460,
Iqaluit NU X0A 0H0
Attention: Peter Martel

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 30-Nov-22
DATE REPORTED: 07-Dec-22
SAMPLE MATRIX: Drinking Water

JOB/PROJECT NO.: Test A (WTP)
P.O. NUMBER:
WATERWORKS NO.

			Client I.D.		Test A- Raw WTP	Test A- Raw WTP (Total)	Test A- WTP Drinking	Test A- WTP Drinking(Total)
			Sample I.D.		B22-35266-1	B22-35266-2	B22-35266-3	B22-35266-4
			Date Collected		30-Nov-22	30-Nov-22	30-Nov-22	30-Nov-22
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
Tin	mg/L	0.05	SM 3120	05-Dec-22/O	< 0.05		< 0.05	
Tin	mg/L	0.05	SM 3120	05-Dec-22/O		< 0.05		< 0.05
Titanium	mg/L	0.005	SM 3120	05-Dec-22/O	< 0.005		< 0.005	
Titanium	mg/L	0.005	SM 3120	05-Dec-22/O		< 0.005		< 0.005
Uranium	mg/L	0.00005	EPA 200.8	02-Dec-22/O	< 0.00005		< 0.00005	
Uranium	mg/L	0.00005	EPA 200.8	02-Dec-22/O		< 0.00005		< 0.00005
Vanadium	mg/L	0.005	SM 3120	05-Dec-22/O	< 0.005		< 0.005	
Vanadium	mg/L	0.005	SM 3120	05-Dec-22/O		< 0.005		< 0.005
Zinc	mg/L	0.005	SM 3120	05-Dec-22/O	< 0.005		< 0.005	
Zinc	mg/L	0.005	SM 3120	05-Dec-22/O		< 0.005		< 0.005
Total Organic Carbon	mg/L	0.2	EPA 415.2	30-Nov-22/O	1.2		1.3	
TIC	mg/L	0.5	EPA 415.1	30-Nov-22/O	15.17		7.65	
Fecal Coliform	cfu/100mL	1	MOE E3371	30-Nov-22/O	0		0	
Anion Sum	meq/L		Calc.	01-Dec-22/O	0.823		0.480	
Cation Sum	meq/L		Calc.	01-Dec-22/O	0.440		0.441	
% Difference	%		Calc.	01-Dec-22/O	30.3 [1]		4.18	
Ion Ratio	AS/CS		Calc.	01-Dec-22/O	1.87		1.09	
Sodium Adsorption Ratio	-		Calc.	01-Dec-22/O	0.0747		0.0800	
Conductivity (calc.)	µmho/cm		Calc.	01-Dec-22/O	62		49	
EC(calc.)/EC(actual)	-		Calc.	01-Dec-22/O	1.30		1.06	
TDS(calc.)/EC(actual)	-		Calc.	01-Dec-22/O	0.718		0.524	
Langelier Index(25°C)	S.I.		Calc.	01-Dec-22/O	-2.46		-2.91	

1. Outside of 15% Acceptance Criteria

2. Subcontracted to Testmark Labs

Tahir Yapici Ph.D
Lab Manager - Ottawa District

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Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill,B-Barrie

CERTIFICATE OF ANALYSIS

CADUCEON ENVIRONMENTAL LABORATORIES
Client committed. Quality assured.

Final Report

C.O.C.: G 110359 **REPORT No. B22-35431**

Report To:

City of Iqaluit
PO Box 460,
Iqaluit NU X0A 0H0
Attention: Emmanuel Kayode

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 02-Dec-22
DATE REPORTED: 13-Dec-22
SAMPLE MATRIX: Waste Water

JOB/PROJECT NO.: Test F
P.O. NUMBER: 460
WATERWORKS NO.

			Client I.D.		WWTP Influent	WWTP Effluent		
			Sample I.D.		B22-35431-1	B22-35431-2		
			Date Collected		01-Dec-22	01-Dec-22		
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
BOD(5 day)	mg/L	3	SM 5210B	07-Dec-22/K	121	83		
Total Suspended Solids	mg/L	3	SM2540D	07-Dec-22/K	205	104		
Conductivity @25°C	µmho/cm	1	SM 2510B	02-Dec-22/O	425	480		
pH @25°C	pH Units		SM 4500H	02-Dec-22/O	7.75	7.75		
Nitrite (N)	mg/L	0.1	SM4110C	05-Dec-22/O	< 0.1	< 0.1		
Nitrate (N)	mg/L	0.1	SM4110C	05-Dec-22/O	< 0.1	< 0.1		
Ammonia (N)-Total	mg/L	0.01	SM4500-NH3-H	06-Dec-22/K	31.3	37.8		
o-Phosphate (P)	mg/L	0.002	PE4500-S	06-Dec-22/K	4.15	3.85		
Phosphorus-Total	mg/L	0.01	E3516.2	07-Dec-22/K	6.08	5.65		
Aluminum	mg/L	0.01	SM 3120	08-Dec-22/O	0.28	0.24		
Antimony	mg/L	0.0005	EPA 200.8	07-Dec-22/O	0.0007	0.0006		
Arsenic	mg/L	0.0005	EPA 200.8	07-Dec-22/O	< 0.0005	< 0.0005		
Barium	mg/L	0.001	SM 3120	08-Dec-22/O	0.010	0.007		
Beryllium	mg/L	0.002	SM 3120	08-Dec-22/O	< 0.002	< 0.002		
Cadmium	mg/L	).00007(	EPA 200.8	07-Dec-22/O	0.000134	0.000092		
Chromium	mg/L	0.002	SM 3120	08-Dec-22/O	< 0.002	< 0.002		
Cobalt	mg/L	0.005	SM 3120	08-Dec-22/O	< 0.005	< 0.005		
Copper	mg/L	0.002	SM 3120	08-Dec-22/O	0.313	0.241		
Iron	mg/L	0.005	SM 3120	08-Dec-22/O	0.873	0.419		
Lead	mg/L	0.0001	EPA 200.8	07-Dec-22/O	0.0041	0.0021		
Lithium	mg/L	0.01	SM 3120	08-Dec-22/O	< 0.01	< 0.01		
Manganese	mg/L	0.001	SM 3120	08-Dec-22/O	0.081	0.078		
Mercury	mg/L	0.00002	SM 3112 B	08-Dec-22/O	< 0.00002	< 0.00002		
Molybdenum	mg/L	0.01	SM 3120	08-Dec-22/O	< 0.01	< 0.01		
Nickel	mg/L	0.01	SM 3120	08-Dec-22/O	< 0.01	< 0.01		
Selenium	mg/L	0.005	EPA 200.8	07-Dec-22/O	< 0.005	< 0.005		

R.L. = Reporting Limit
Test methods may be modified from specified reference method unless indicated by an *
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill,B-Barrie

Tahir Yapici Ph.D
Lab Manager - Ottawa District

CADUCEON ENVIRONMENTAL LABORATORIES
Client committed. Quality assured.

CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: G 110359 **REPORT No. B22-35431**

Report To:

City of Iqaluit
PO Box 460,
Iqaluit NU X0A 0H0
Attention: Emmanuel Kayode

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 02-Dec-22
DATE REPORTED: 13-Dec-22
SAMPLE MATRIX: Waste Water

JOB/PROJECT NO.: Test F
P.O. NUMBER: 460
WATERWORKS NO.

			Client I.D.		WWTP Influent	WWTP Effluent		
			Sample I.D.		B22-35431-1	B22-35431-2		
			Date Collected		01-Dec-22	01-Dec-22		
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
Silver	mg/L	0.0001	EPA 200.8	07-Dec-22/O	< 0.0001	< 0.0001		
Strontium	mg/L	0.001	SM 3120	08-Dec-22/O	0.030	0.027		
Thallium	mg/L	0.0003	EPA 200.8	07-Dec-22/O	< 0.0003	< 0.0003		
Tin	mg/L	0.05	SM 3120	08-Dec-22/O	< 0.05	< 0.05		
Titanium	mg/L	0.005	SM 3120	08-Dec-22/O	0.011	< 0.005		
Uranium	mg/L	0.0003	EPA 200.8	07-Dec-22/O	< 0.0003	< 0.0003		
Vanadium	mg/L	0.005	SM 3120	08-Dec-22/O	< 0.005	< 0.005		
Zinc	mg/L	0.005	SM 3120	08-Dec-22/O	0.145	0.094		
Total Coliform	cfu/100mL	1	MOE E3371	02-Dec-22/O	110000000	50000000		
Fecal Coliform	cfu/100mL	1	MOE E3371	02-Dec-22/O	7000000	3900000		

Tahir Yapici Ph.D
Lab Manager - Ottawa District

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Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill,B-Barrie

CADUCEON ENVIRONMENTAL LABORATORIES
Client committed. Quality assured.

CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: G 36009 **REPORT No. B22-36009**

Report To:

City of Iqaluit
PO Box 460,
Iqaluit NU X0A 0H0
Attention: Peter Martel

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 13-Dec-22
DATE REPORTED: 03-Jan-23
SAMPLE MATRIX: Drinking Water

JOB/PROJECT NO.: Test A (WTP)
P.O. NUMBER:
WATERWORKS NO.

			Client I.D.		Test A- Raw WTP	Test A- Raw WTP (Total)	Test A- Potable WTP	Test A- Potable (Total)
			Sample I.D.		B22-36009-1	B22-36009-2	B22-36009-3	B22-36009-4
			Date Collected		12-Dec-22	12-Dec-22	12-Dec-22	12-Dec-22
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
Hardness (as CaCO3)	mg/L	1	SM 3120	21-Dec-22/O	18		21	
Hardness (as CaCO3)	mg/L	1	SM 3120	15-Dec-22/O		23		22
Alkalinity(CaCO3) to pH4.5	mg/L	5	SM 2320B	22-Dec-22/O	18		15	
Bicarbonate(as CaCO3)	mg/L	5	SM 2320B	22-Dec-22/O	18		15	
Carbonate (as CaCO3)	mg/L	5	SM 2320B	22-Dec-22/O	< 5		< 5	
Hydroxide	mg/L	5	EPA 310.2	13-Dec-22/O	< 5		< 5	
Acidity (as CaCO3)	mg/L	5	Subcontract	16-Dec-22	< 5 [2]		< 5 [2]	
pH @25°C	pH Units		SM 4500H	22-Dec-22/O	6.76		6.46	
Conductivity @25°C	µmho/cm	1	SM 2510B	22-Dec-22/O	46		48	
TDS(ion sum calc.)	mg/L	1	Calc.	14-Dec-22/O	28		24	
Total Suspended Solids	mg/L	3	SM2540D	15-Dec-22/K	< 3		< 3	
Turbidity	NTU	0.1	SM 2130	15-Dec-22/O	0.3		0.4	
REDOX potential	mV		In-House	21-Dec-22/R	354		622	
Chloride	mg/L	0.5	SM4110C	22-Dec-22/O	1.9		3.2	
Sulphate	mg/L	1	SM4110C	22-Dec-22/O	4		4	
Aluminum	mg/L	0.01	SM 3120	21-Dec-22/O	< 0.01		< 0.01	
Aluminum	mg/L	0.01	SM 3120	15-Dec-22/O		< 0.01		< 0.01
Antimony	mg/L	0.0001	EPA 200.8	16-Dec-22/O	< 0.0001		< 0.0001	
Antimony	mg/L	0.0001	EPA 200.8	15-Dec-22/O		< 0.0001		< 0.0001
Arsenic	mg/L	0.0001	EPA 200.8	16-Dec-22/O	< 0.0001		< 0.0001	
Arsenic	mg/L	0.0001	EPA 200.8	15-Dec-22/O		< 0.0001		< 0.0001
Barium	mg/L	0.001	SM 3120	21-Dec-22/O	0.001		0.002	
Barium	mg/L	0.001	SM 3120	15-Dec-22/O		0.002		0.002
Beryllium	mg/L	0.002	SM 3120	21-Dec-22/O	< 0.002		< 0.002	
Beryllium	mg/L	0.002	SM 3120	15-Dec-22/O		< 0.002		< 0.002
Cadmium	mg/L	).000010	EPA 200.8	16-Dec-22/O	< 0.000010		< 0.000010	
Cadmium	mg/L	).000015	EPA 200.8	15-Dec-22/O		< 0.000015		< 0.000015

R.L. = Reporting Limit
Test methods may be modified from specified reference method unless indicated by an *
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill,B-Barrie

Tahir Yapici Ph.D
Lab Manager - Ottawa District

CADUCEON ENVIRONMENTAL LABORATORIES Client committed. Quality assured.

CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: G 36009 **REPORT No. B22-36009**

Report To:

City of Iqaluit
PO Box 460,
Iqaluit NU X0A 0H0
Attention: Peter Martel

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 13-Dec-22
DATE REPORTED: 03-Jan-23
SAMPLE MATRIX: Drinking Water

JOB/PROJECT NO.: Test A (WTP)
P.O. NUMBER:
WATERWORKS NO.

				Client I.D.	Test A- Raw WTP	Test A- Raw WTP (Total)	Test A- Potable WTP	Test A- Potable (Total)
				Sample I.D.	B22-36009-1	B22-36009-2	B22-36009-3	B22-36009-4
				Date Collected	12-Dec-22	12-Dec-22	12-Dec-22	12-Dec-22
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
Chromium	mg/L	0.002	SM 3120	21-Dec-22/O	< 0.002		< 0.002	
Chromium	mg/L	0.002	SM 3120	15-Dec-22/O		< 0.002		< 0.002
Cobalt	mg/L	0.005	SM 3120	21-Dec-22/O	< 0.005		< 0.005	
Cobalt	mg/L	0.005	SM 3120	15-Dec-22/O		< 0.005		< 0.005
Copper	mg/L	0.002	SM 3120	21-Dec-22/O	< 0.002		0.107	
Copper	mg/L	0.002	SM 3120	15-Dec-22/O		< 0.002		< 0.002
Iron	mg/L	0.005	SM 3120	21-Dec-22/O	< 0.005		0.013	
Iron	mg/L	0.005	SM 3120	15-Dec-22/O		0.015		0.019
Lead	mg/L	0.00002	EPA 200.8	16-Dec-22/O	< 0.00002		0.00065	
Lead	mg/L	0.00002	EPA 200.8	15-Dec-22/O		< 0.00002		0.00065
Lithium	mg/L	0.01	SM 3120	21-Dec-22/O	0.04		0.04	
Lithium	mg/L	0.01	SM 3120	15-Dec-22/O		< 0.01		< 0.01
Manganese	mg/L	0.001	SM 3120	21-Dec-22/O	< 0.001		0.005	
Manganese	mg/L	0.001	SM 3120	15-Dec-22/O		0.004		0.006
Mercury	mg/L	0.00002	SM 3112 B	15-Dec-22/O	< 0.00002	< 0.00002	< 0.00002	< 0.00002
Molybdenum	mg/L	0.01	SM 3120	21-Dec-22/O	< 0.01		< 0.01	
Molybdenum	mg/L	0.01	SM 3120	15-Dec-22/O		< 0.01		< 0.01
Nickel	mg/L	0.01	SM 3120	21-Dec-22/O	< 0.01		< 0.01	
Nickel	mg/L	0.01	SM 3120	15-Dec-22/O		< 0.01		< 0.01
Selenium	mg/L	0.001	EPA 200.8	16-Dec-22/O	< 0.001		< 0.001	
Selenium	mg/L	0.001	EPA 200.8	15-Dec-22/O		< 0.001		< 0.001
Silver	mg/L	0.0001	EPA 200.8	16-Dec-22/O	< 0.0001		< 0.0001	
Silver	mg/L	0.0001	EPA 200.8	15-Dec-22/O		< 0.0001		< 0.0001
Strontium	mg/L	0.001	SM 3120	21-Dec-22/O	0.013		0.015	
Strontium	mg/L	0.001	SM 3120	15-Dec-22/O		0.014		0.014
Thallium	mg/L	0.00005	EPA 200.8	16-Dec-22/O	< 0.00005		< 0.00005	
Thallium	mg/L	0.00005	EPA 200.8	15-Dec-22/O		< 0.00005		< 0.00005

Tahir Yapici Ph.D
Lab Manager - Ottawa District

R.L. = Reporting Limit
Test methods may be modified from specified reference method unless indicated by an *
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill,B-Barrie

CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: G 36009 **REPORT No. B22-36009**

Report To:

City of Iqaluit
PO Box 460,
Iqaluit NU X0A 0H0
Attention: Peter Martel

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 13-Dec-22
DATE REPORTED: 03-Jan-23
SAMPLE MATRIX: Drinking Water

JOB/PROJECT NO.: Test A (WTP)
P.O. NUMBER:
WATERWORKS NO.

			Client I.D.		Test A- Raw WTP	Test A- Raw WTP (Total)	Test A- Potable WTP	Test A- Potable (Total)
			Sample I.D.		B22-36009-1	B22-36009-2	B22-36009-3	B22-36009-4
			Date Collected		12-Dec-22	12-Dec-22	12-Dec-22	12-Dec-22
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
Tin	mg/L	0.05	SM 3120	21-Dec-22/O	< 0.05		< 0.05	
Tin	mg/L	0.05	SM 3120	15-Dec-22/O		< 0.05		< 0.05
Titanium	mg/L	0.005	SM 3120	21-Dec-22/O	< 0.005		< 0.005	
Titanium	mg/L	0.005	SM 3120	15-Dec-22/O		< 0.005		< 0.005
Uranium	mg/L	0.00005	EPA 200.8	16-Dec-22/O	< 0.00005		< 0.00005	
Uranium	mg/L	0.00005	EPA 200.8	15-Dec-22/O		< 0.00005		< 0.00005
Vanadium	mg/L	0.005	SM 3120	21-Dec-22/O	< 0.005		< 0.005	
Vanadium	mg/L	0.005	SM 3120	15-Dec-22/O		< 0.005		< 0.005
Zinc	mg/L	0.005	SM 3120	21-Dec-22/O	< 0.005		< 0.005	
Zinc	mg/L	0.005	SM 3120	15-Dec-22/O		< 0.005		< 0.005
Total Organic Carbon	mg/L	0.2	EPA 415.2	14-Dec-22/O	1.4		1.6	
TIC	mg/L	0.5	EPA 415.1	14-Dec-22/O	31.0		136.8	
Fecal Coliform	cfu/100mL	1	MOE E3371	13-Dec-22/O	0		0	
Anion Sum	meq/L		Calc.	14-Dec-22/O	0.564		0.466	
Cation Sum	meq/L		Calc.	14-Dec-22/O	0.402		0.460	
% Difference	%		Calc.	14-Dec-22/O	16.8 [1]		0.744	
Ion Ratio	AS/CS		Calc.	14-Dec-22/O	1.40		1.01	
Sodium Adsorption Ratio	-		Calc.	14-Dec-22/O	0.0786		0.0789	
Conductivity (calc.)	µmho/cm		Calc.	14-Dec-22/O	52		51	
EC(calc.)/EC(actual)	-		Calc.	14-Dec-22/O	1.13		1.06	
TDS(calc.)/EC(actual)	-		Calc.	14-Dec-22/O	0.608		0.514	
Langelier Index(25°C)	S.I.		Calc.	14-Dec-22/O	-2.55		-2.87	

1. outside of 10% Acceptance Criteria
2. Subcontracted to Testmark Labs

Tahir Yapici Ph.D
Lab Manager - Ottawa District

R.L. = Reporting Limit
Test methods may be modified from specified reference method unless indicated by an *
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill,B-Barrie

APPENDIX C

2022 APEX PUMPING FINAL REPORT

Project Summary Report:

Iqaluit 2022 Lake Geraldine Resupply (Apex River Supplementary Pumping Program): Report of Activities 3AM-IQA1626 and 22-HCAA-02043

March 15, 2023

Prepared for:
City of Iqaluit
Iqaluit, Nunavut

Prepared by:
Nunami Stantec Limited

Project Number: 144903306

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Executive Summary

This report presents results of monitoring undertaken pursuant to Water License 3AM-IQA1626 Amendment No. 4, Emergency Amendment No. 7 and *Fisheries Act* Authorization 22-HCAA-02043 (DFO 2022: the FAA) issued to the City of Iqaluit. The report addresses the reporting requirements of the Amendment No. 4 and the FAA as they pertain to the 2022 Apex River Supplementary Pumping Program (SPP). Additional supplementation from Unnamed Lake was authorized by Amendment No. 7 but was not undertaken in 2022 and therefore the reporting requirements of Amendment No. 7 were not applicable in 2022.

The 2022 SPP was completed between April 30, 2022 (kickoff meeting) and October 19, 2022 (demobilization). Works and activities completed include:

- Mobilization of equipment and infrastructure to Apex River pumping sites
- Placement of pumps, screens, and connection to manifolds at Apex River
- Completion of fish and fish habitat baseline study, fish and fish habitat monitoring and flow monitoring in Apex River
- Installation and operation of pumps in Apex River
- Conveyance of water from Apex River to Lake Geraldine
- Supporting activities such as power supply, maintenance, refueling, and daily monitoring
- Demobilization of equipment and infrastructure (except semi-permanent pipeline)

Supplementary pumping from the Apex River to the Lake Geraldine Reservoir was completed between June 12 and September 19, 2022. A total of 444,390 m^3 of water were transferred to Lake Geraldine Reservoir. The maximum daily pumped volume was 14,541 m^3 on June 16, 2022. Pumping records were maintained by the contractor at the pumping site and were provided to the City's representative (Nunami Stantec Limited) for review and tabulation throughout the program. The Supplementary Pumping Program was completed in two periods. Pumping Period 1 occurred between June 12 and September 12 and followed guidance outlined in Amendment No. 4. Pumping Period 2 occurred between September 13 to September 19 and followed guidance outlined in Amendment No. 4 and the FAA. No supplementary pumping occurred between July 10 and July 23, 2022 due to low flows in the Apex River. Monitoring completed in Pumping Period 2 indicated that no harmful alteration, disruption, and destruction of fish habitat resulted from Apex River pumping under the conditions of the FAA. Therefore, no fish or fish habitat offsetting requirements are recommended.

Abbreviations

City .... City of Iqaluit
DFO .... Fisheries and Oceans Canada
FAA .... *Fisheries Act* Authorization
GPS .... Global Positioning System
km .... kilometre
m .... metre
m^3 .... cubic metres
m^3/s .... cubic metres per second
MAD .... Mean annual discharge
mg/L .... milligram per litre
Apex River .... Niaqunguk River
SPP .... Supplementary Pumping Program
TAL .... Tower Arctic Ltd.
UTM .... Universal Transverse Mercator
WSC .... Water Survey of Canada

1 INTRODUCTION

The City of Iqaluit (City) obtains and distributes potable water from Lake Geraldine, an engineered reservoir located approximately 1 kilometer (km) north of the City center. Owing to the need to supplement the reservoir in 2018 and 2019 on an emergency basis from the nearby Apex River, the City applied to the Nunavut Water Board to amend its Type A Water License 3AM-IQA1626 to permit supplementation of the Lake Geraldine Reservoir from the Niaqunguk (Apex) River during the open water season on an annual basis until 2026 (the term of the license). In September 2019, the City received an amendment (Amendment No. 4) to its Water License. Amendment No. 4 of the City's Type A Water License 3AM-IQA1626, permits an annual maximum of 500,000 cubic metres (m^3) of water to be extracted from Apex River for transfer to the Lake Geraldine Reservoir. The water withdrawals can occur when flows in the river exceed 30% of the mean annual discharge (MAD), and withdrawal rates do not exceed 10% of the instantaneous flow of the river, except if otherwise authorized by Fisheries and Oceans Canada (DFO).

The Supplementary Pumping Program (SPP) was facilitated by a semi-permanent pipeline from the Apex River to Lake Geraldine that was installed in 2019. Temporary pumping infrastructure was required to be installed and operated annually within the Apex River to withdraw water. Supplementary pumping (non-emergency) was previously completed during the 2020 and 2021 open water seasons.

In April 2022, Tower Arctic Ltd. (TAL; the contractor) was retained by the City to complete the SPP during the open water season of 2022. Oversight was provided by Nunami Stantec, also under contract to the City. The objective of the SPP was to increase the volume of water in the reservoir prior to the onset of freezing conditions in compliance with Amendment No. 4. Water levels in the Lake Geraldine Reservoir were monitored throughout the 2022 SPP using data from the WSC Station 10UH013 (Lake Geraldine Near Iqaluit). Lake Geraldine water levels for 2018 – 2022 as well as the historical minimum and maximum are illustrated in Figure 1-1. In Figure 1-1, the 2022 reservoir levels prior to freshet were the lowest observed over the last five years.

On August 12, 2022, the City applied to the Nunavut Water Board to amend its Type A Water License 3AM-IQA1626, on an emergency basis to address the potential potable water shortage in Iqaluit due to low water levels in Lake Geraldine and its tributaries. Figure 1.1shows how freshet was not sufficient to replenish the reservoir as it had in previous years, in fact levels in the reservoir began to decline well short of full reservoir replenishment. On July 10, 2022 based on the observed water levels in the reservoir and hydrologic trends in the Iqaluit area, the City requested authorization to withdraw up to 600,000 m^3 from an additional source – Unnamed Lake and to increase the amount of water authorized to be withdrawn from the Apex River to 900,000 m^3. Amendment No. 7 to the City's Type A Water License 3AM-IQA1626 was issued on August 22, 2022 (Nunavut Water Board 2022) and approved by the Minister of Northern Affairs on August 26, 2022. This amendment was to allow pumping from Unnamed Lake into the Apex River at a location upstream of the current pumping location. The supplemental water introduced into the Apex River, would then be pumped at the existing pumping location. The increase to the allowable volume of annual pumping from the Apex River was established to account for the additional supplementation to the river from Unnamed Lake.

Concurrently, the City applied to DFO to receive authorization to take between 10% and 80% of the flow of the Apex River at the existing pumping location during open water season, to replenish the water storage at the Lake Geraldine Reservoir in preparation for the winter season. The *Fisheries Act* Authorization – Emergency Circumstances 22-HCAA-02043 (DFO 2022: the FAA) was issued on August 12, 2022.

Nunami Stantec has identified that pumping from the Apex River has an impact on recorded flows at WSC 10UH015, which is immediately upstream of the pump site. The WSC station is under reporting flows compared to real-time measured flows upstream of the pump site.

For purposes of the SPP and to apply conservatism to the protection of fish and fish habitat, Nunami Stantec assumed that flows recorded at WSC 10UH015 were representative of flows directly upstream of the pumping location within the Apex River.

This report includes a summary of the 2022 SPP and details the monitoring undertaken pursuant to Type A Water License 3AM-IQA1626 Amendment No. 4 and the FAA. Supplementation as was authorized by the Amendment No. 7 (supplementation from Unnamed Lake) was not implemented in 2022 and reporting requirements of Amendment No. 7 are not applicable and are not included in this report.

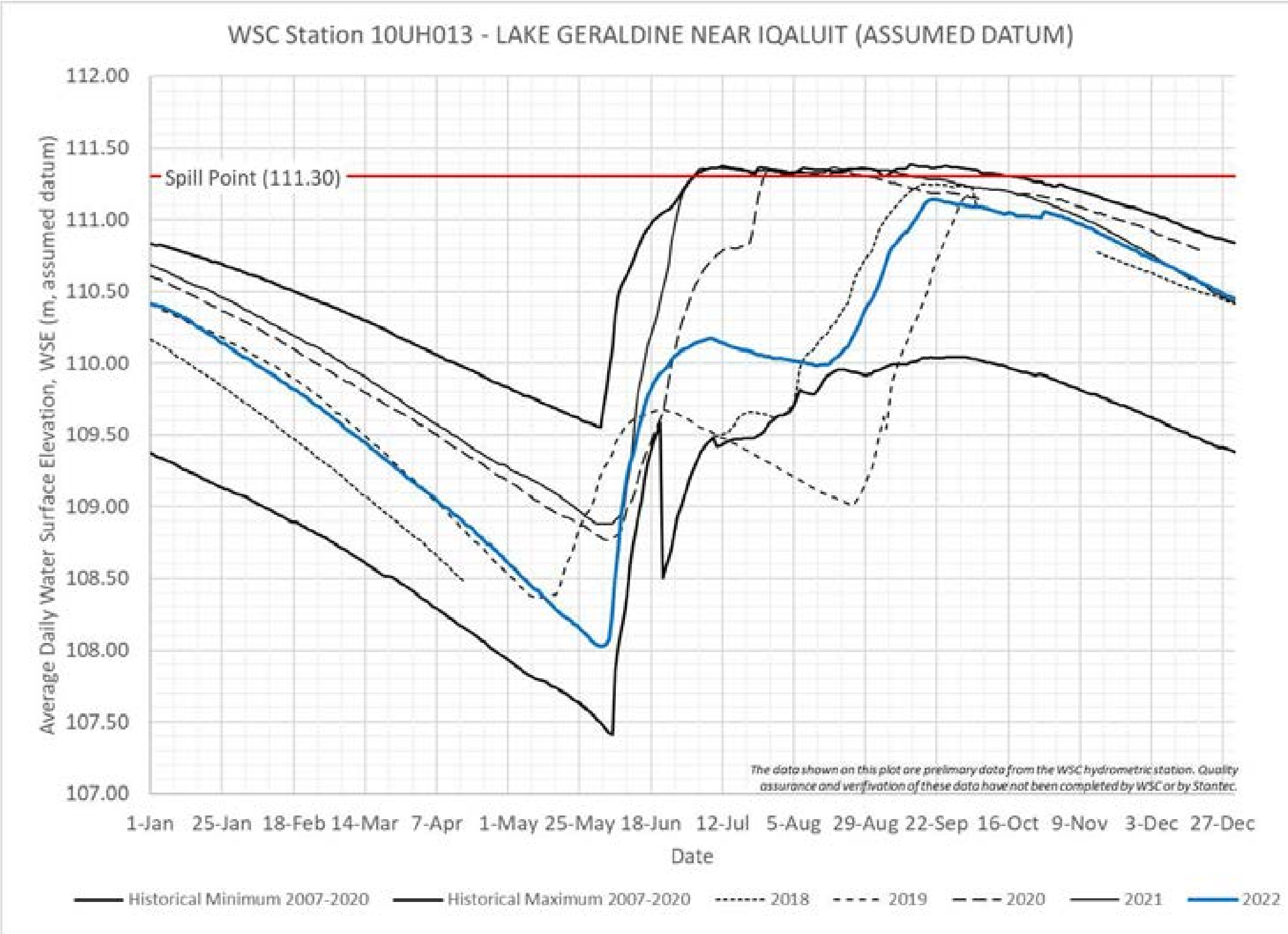


Figure 1.1 WSC Station 10UH013 – Lake Geraldine Near Iqaluit (Assumed Datum)

2 PROJECT WORKS AND ACTIVITIES

The 2022 SPP was completed between April 30, 2022 (kickoff meeting) and October 19, 2022 (demobilization). Pumping activities started on June 12 and continued through to September 19. No pumping occurred between July 10 and July 23, 2022 due to low flow conditions (less than 30% MAD) in the Apex River. Works and activities completed included:

- Mobilization of equipment and infrastructure to Apex River pumping sites
- Placement of pumps, screens, and connection to manifolds at Apex River
- Installation and operation of pumps in Apex River
- Completion of fish and fish habitat baseline study, fish and fish habitat monitoring and flow monitoring in Apex River
- Conveyance of water from Apex River to Lake Geraldine
- Supporting activities such as power supply, maintenance, refueling, and monitoring
- Demobilization of equipment and infrastructure (except semi-permanent pipeline)

The location of works and activities are shown in Figure 2.1. The Apex River pumping site was previously established at this location in 2018, 2019, 2020 and 2021. The location in 2022 was fixed by the need to connect to a semi-permanent pipeline installed in 2019 as well as the location of Water Survey of Canada (WSC) station 10UH015 (Apex River 1km Above Bridge to Nowhere) immediately upstream of the pumping site. The 2022 SPP followed the same protocol and operation as in previous years (2020 and 2021).

Water was pumped from the Apex River using three high-head 94 horsepower (Hp) submersible pumps and conveyed overland to Lake Geraldine. Pumps were housed in a screened cage, where mesh sizes met the DFO Freshwater Intake End-of-Pipe Fish Screen Guidelines (DFO 2020). Pumping took place between June 12, 2022 and September 19, 2022. An access trail and semi-permanent pipeline between the Apex River and Lake Geraldine have remained in place for future pumping requirements.

Unnamed Lake (UNL) was considered as an optional component to the SPP in 2022. The City moved forward with setup of the temporary equipment (trail maintenance, aligning flexible hoses, rental of pumping equipment); however, the 2022 program did not require this system to be placed in service. As such, no water was pumped from UNL. All temporary infrastructure and equipment were demobilized by October 19, 2022 and equipment manifest handover to the City on November 3, 2022.

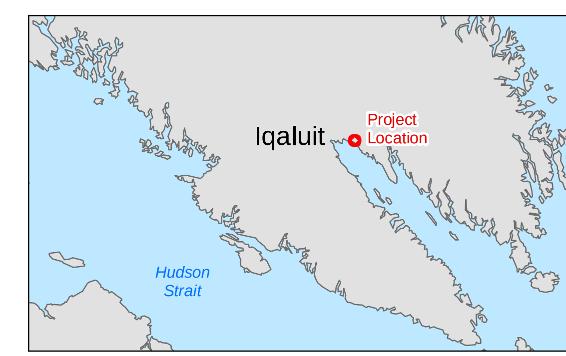
Stantec

- WSC or SNP Station
- Point of Interest
- Discharge Point
- Pipeline
- Pumping Site

N

0 160 320 metres
(At original document size of 11x17)
1:8,500

Notes
1. Coordinate System: NAD 1983 CSRS UTM Zone 19N
2. Background: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Esri, HERE, Garmin, (c) OpenStreetMap contributors, and the GIS user community



Project Location
Iqaluit
Nunavut

Client/Project 14490306

Iqaluit Water Supply

Figure No.
2-1

Title
Iqaluit 2022 Apex Pumping Project
Site Overview

3 OPERATIONAL MONITORING PLAN

Two Operational Monitoring Plans were designed for the 2022 SPP. Pumping Period 1 Operational Monitoring Plan (June 12, 2022 to September 12, 2022) was created to maintain compliance with the Type A Water License Amendment No.4. Pumping Period 2 Operational Monitoring Plan (September 13, 2022 to September 19, 2022) was created to maintain compliance with Amendment No. 4 and the requirements for monitoring under the FAA. The Pumping Period 1 and Pumping Period 2 Operational Monitoring Plans are outlined in Section 3.1 and Section 3.2, respectively.

3.1 Pumping Period 1 - Operational Monitoring Plan

The objective of Pumping Period 1 monitoring activities was to observe hydrologic conditions in the Apex River during pumping operations and to inform changes in pumping rates that were required variably throughout the program. In accordance Amendment No. 4, water withdrawals of no greater than 10% of instantaneous flow were permitted when natural flows in the Apex River were above 30% of MAD. Nunami Stantec used WSC Station 10UH015 data to advise TAL on when pumping operations could begin and when pumping rates needed to be changed based on river flows. Each day water levels in Lake Geraldine and flows in Apex River were obtained from WSC stations and were compared to pumping logs provided by TAL. Daily scheduled emails were sent to TAL to advise on the maximum pumping rates to remain within withdrawal limits. Emails were sent more frequently if notable flow changes were observed that necessitated additional communication.

A summary of monitoring locations and activities completed during the program to satisfy the applicable criteria to Pumping Period 1 are presented in Table 3.1 and in Figure 3.1.

Table 3.1 Monitoring Location and Requirements Summary (per Water Licence Requirements)

Monitoring Location ID	UTM Coordinates (Zone 19V)		Monitoring Parameter	Method	Data Source (Nunami Stantec, Contractor, or WSC Location)
	Easting (m)	Northing (m)			
SNP IQA-10	525802	7070474	Pumped Flow and Volume	Volumetric Flow Meter	Contractor
“Apex River at Apex” (station ID: UH10UH002)	527087	7067694	Water level and flow data for Apex River approximately 4 km downstream of pump site	Access data online	WSC
“Apex River 1km Above Bridge to Nowhere” (station ID: 10UH015)	525802	7070531	Water level and flow data for immediately upstream of Apex pump site	Access data online	WSC
“Lake Geraldine Near Iqaluit” (station ID: 10UH013)	524463	7069963	Water level in Lake Geraldine	Access data online	WSC

3.2 Pumping Period 2 - Operational Monitoring Plan

Additional monitoring was required once pumping activities exceeded 10% of instantaneous flow, as authorized in FAA (22-HCAA-02043) per Section 2.2 – 3.2. The purpose of this additional monitoring specified in the FAA was to observe potential changes to fish and fish habitat along the affected reaches of the Apex River prior to, during and after Pumping Period 2 was completed.

A summary of monitoring locations and activities completed during the program to satisfy the FAA are presented in Table 3.2. Monitoring locations are shown in Figure 3.1.

Table 3.2 Monitoring Locations and Requirements Summary (per *Fisheries Act* Authorization Requirements)

Station ID	Station Description	UTM Coordinates (Zone 19V)		Monitoring Parameters	Monitoring Rationale
		Easting (m)	Northing (m)		
AR-06	Immediately upstream (125 m) of pump location	525712	7070535	Wetted width Water level/depth Habitat conditions Fish presence	Monitor natural inflow conditions, immediately upstream of pumping location
SNP IQA-10 (Apex Pump Location)	At pumping location	525820	7070467	Wetted width Water level/depth Habitat conditions Fish presence Fish stranding Fish mortality	Monitor fish habitat conditions and fish presence at pumping location
AR-07	Immediately downstream (46 m) of pumping location	525850	7070428	Wetted width Water level/depth Habitat conditions Fish presence Fish stranding Fish mortality	Monitor fish habitat conditions and fish presence immediately downstream of pumping location
A1	Downstream of pumping location, upstream of Road to Nowhere Bridge	526497	7070003	Wetted width Water level/depth Habitat conditions Fish presence Fish stranding Fish mortality	Monitor fish habitat conditions and fish presence downstream of pumping location Continuity of monitoring location with 2016 fisheries program
A2	Downstream of pumping location, upstream of Swimming Lake	526299	7069247	Wetted width Water level/depth Habitat conditions Fish presence Fish stranding Fish mortality	Monitor fish habitat conditions and fish presence downstream of pumping location Continuity of monitoring location with 2016 fisheries program (fish previously captured here)
AR-03	Downstream of pumping location, at the downstream end of a pool within the Swimming Lake area	526495	7068724	Wetted width Water level/depth Habitat conditions Fish presence Fish stranding Fish mortality	Observe fish habitat conditions and fish presence downstream of pumping location and within the Swimming Lake area

Station ID	Station Description	UTM Coordinates (Zone 19V)		Monitoring Parameters	Monitoring Rationale
		Easting (m)	Northing (m)		
AR-02	Downstream of pumping location and downstream of Swimming Lake	526592	7068573	Wetted width Water level/depth Habitat conditions Fish presence Fish stranding Fish mortality	Monitor fish habitat conditions and fish presence downstream of pumping location and immediately downstream of Swimming Lake Continuity of monitoring location with 2016 fisheries program

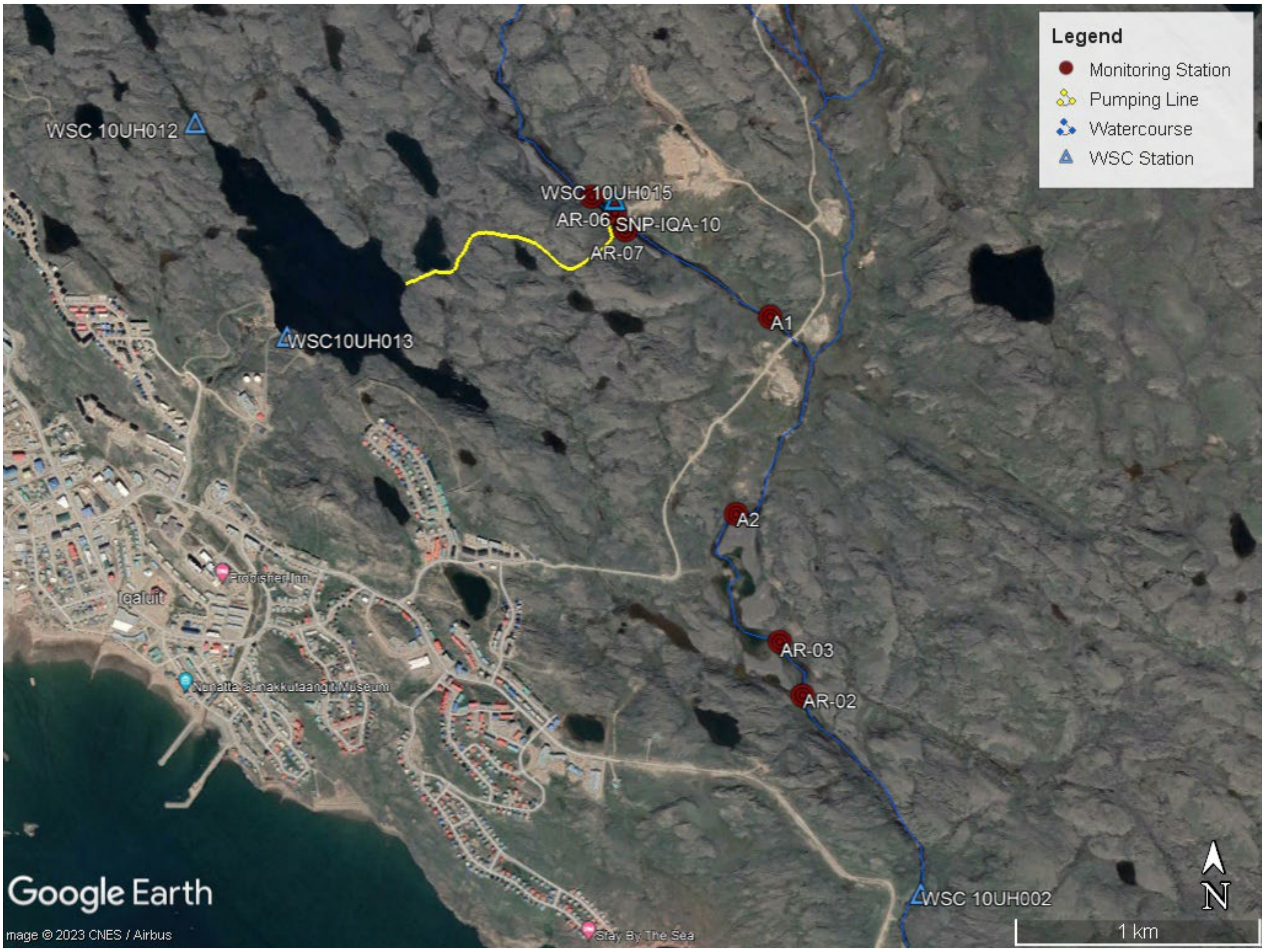


Figure 3.1 Monitoring Locations for Pumping Period 1 and Pumping Period 2

4 2022 SUPPLEMENTAL PUMPING PROGRAM RESULTS

The intent of the 2022 SPP monitoring programs (Pumping Period 1 and Pumping Period 2) was to maintain compliance with the requirements of the water licence (Amendment No. 4 and FAA). Pumping Period 1 took place between June 12, 2022 and September 12, 2022, under the conditions that annual maximum withdrawal from the Apex River was not to exceed 500,000 m^3 and that a maximum withdrawal rate of 10% of instantaneous flow was permitted as long as flows were above 30% MAD. Pumping Period 2 took place between September 13, 2022 and September 19, 2022 and followed the same annual volume restrictions as Pumping Period 1, but allowable withdrawal rates were increased to up to 80% of instantaneous flow (FAA), as long as flows were greater than 30% MAD. Activities completed under the SPP included monitoring, recording, and analyzing the effects of the 2022 SPP on the natural system. The following sections describe the results of SPP (Pumping Period 1 and 2) and its monitoring programs.

4.1 Operational Challenges

Operationally, the system performed as per the design. Based upon knowledge from previous years and emergency supplementation programs completed in 2018 and 2019, and the non-emergency operation of the Apex River semi-permanent infrastructure in 2020 and 2021, Nunami Stantec and the City understood the challenges with operation and the importance of daily monitoring for compliance to Amendment No. 4 which included compliance with the DFO Low Risk Criteria (DFO 2013). As in 2020 and 2021, the system began operations during spring melt. The 2022 operations included an emergency operation period in September.

Two challenges were identified earlier in the 2022 SPP.

1. WSC Stations Data Availability

The WSC stations require spring setup by WSC staff every year, including calibration. In 2022, the WSC was delayed in setting up these stations and bringing data online. This setup was not completed before pumping operations began, and as a result, only stage was reported from June 12, 2022 to June 22, 2022. During these 11 days in June, Nunami Stantec provided guidance on permitted pumping rates based on the preliminary rating curve provided by WSC (provided to Nunami Stantec through the City) and the reported stage data.

2. Emergency Planning & Operation

In 2022, there was a large spring deficit in Lake Geraldine. The minimum water level as measured at WSC 10UH013 was 108.027 m on June 1, 2022. This minimum water level was 0.679 m lower than the historical mean water level for June 1 in Lake Geraldine. Furthermore, as shown in Figure 1.1, a short-duration freshet period was observed in 2022. The large spring deficit was influenced by:

a) Flushing by the City of the contaminated water distribution system in late 2021 and early 2022. The system flushing would have contributed to a higher-than-normal demand on Lake Geraldine, especially from the requested household flushing programs.

b) Intentional winter operational bleeds within the City's potable water distribution system to allow for continuous circulation of the potable water loops and unintentional leaks accounted for increased demands (up to 40% over expected). These increased demands were observed outside of the emergency flushing earlier in the winter and were reduced in June.

Based upon the short freshet and Lake Geraldine deficits, the City requested Nunami Stantec provide emergency response support to increase the likelihood of a full reservoir before freeze-up. As part of this and based upon late-season time constraints, two emergency responses were executed in parallel: working with DFO to be able to pump from the Apex River at a rate greater than 10% instantaneous flow while providing additional fisheries monitoring (the FAA); and, obtaining authorization to supplement from Unnamed Lake (Amendment No. 7). Temporary pumping infrastructure was set up at Unnamed Lake in similar configuration to 2019, but was not activated, as the City made the decision to pump from the existing setup in Apex River at an increased rate (as permitted under the FAA).

4.2 Water Withdrawal Pumping Volumes

Permitted extraction volumes and rates for the 2022 SPP were as follows:

- Pumping Period 1: A maximum volume of 500,000 m^3 annually from Apex River and up to 10% of instantaneous flow when the natural flow is at or above 30% MAD in the Apex River (Amendment No. 4).
- Pumping Period 2: A maximum of volume 500,000 m^3 annually from Apex River (Amendment No. 4) and up to 80% of the flow of the Apex River during open water season (FAA).

It should be noted that the maximum volume of water permitted to be withdrawn is cumulative between the two Pumping Periods.

4.2.1 30% MAD Calculation

Nunami Stantec used the available period of record for the WSC Apex River at Apex station 10UH002 from 1973 to 2021 (38-year record, no data recorded from 1996 to 2005) to calculate the 30% MAD at the pumping location in the Apex River. Comparison of concurrent flow records from 2021 at WSC Station 10UH002 (Apex River at Apex) and WSC Station 10UH015 (Apex River 1 km Above Bridge to Nowhere) demonstrated that seasonal scaling factors could be used to convert WSC Station 10UH002 flows to WSC Station 10UH015 flows. The seasonal scaling factors were 0.513 for August and September and 0.746 for the rest of the year. After applying the seasonal scaling factors, a synthetic data set for Station 10UH015 was produced. This synthetic dataset was used to calculate MAD for WSC Station 10UH015 and was estimated to be 0.432 m^3/s. Therefore, 30% MAD was estimated to be 0.130 m^3/s for the Apex River at the pumping station.

4.2.2 Pumping Rates and Volumes

Nunami Stantec provided guidance on permitted pumping rates each day for TAL's pumping operations based on the instantaneous flow recorded at WSC Station 10UH015. At the end of each day, TAL provided Nunami Stantec with the daily pump volumes at SNP IQA-10. Nunami Stantec converted the pump volumes into an average daily pumping rates. Figure 4.1(vertical axis range of 0.0 – 4.0 m^3/s) illustrates the flow in the Apex River throughout the 2022 pumping period, the flow that represents 30% MAD at the pumping station (0.130 m^3/s) is also included on the graph.

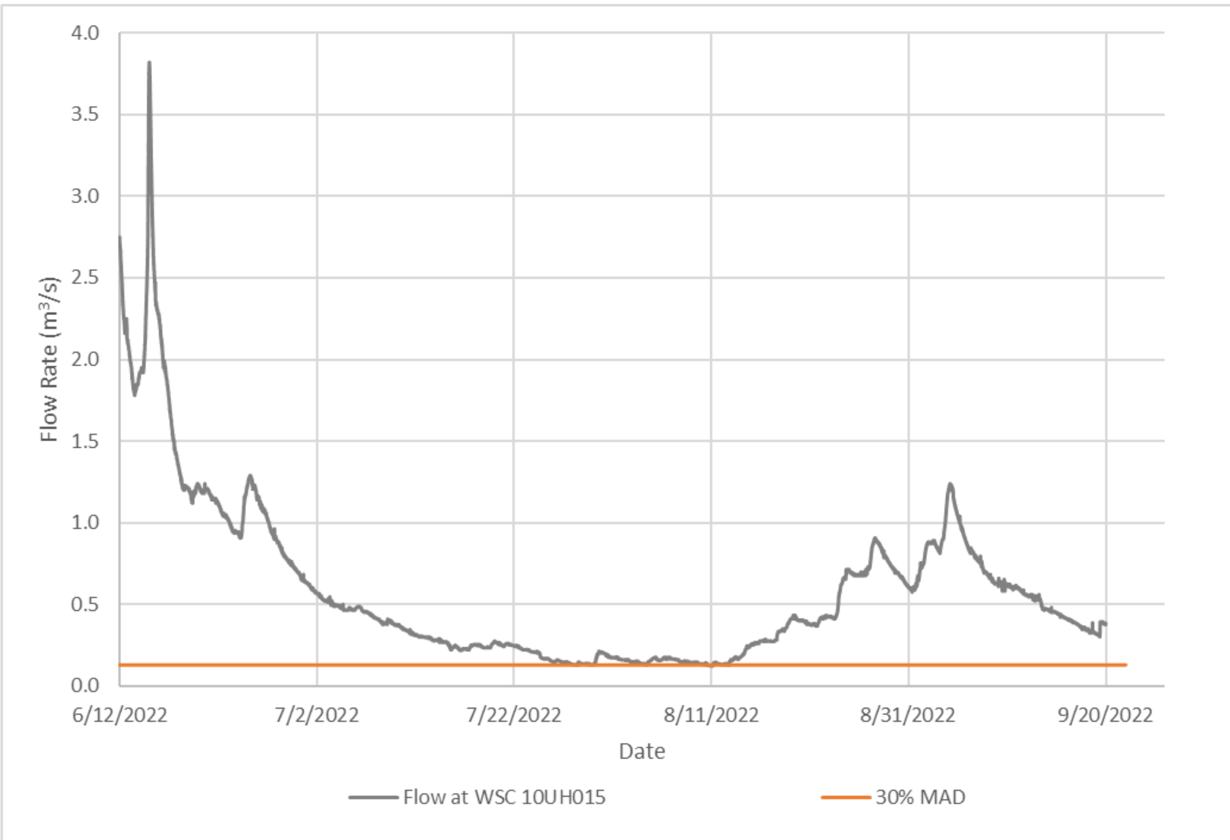


Figure 4.1 Flow at WSC 10UH015 Compared to 30% MAD

4.2.2.1 Pumping Period 1

Between June 12, 2022 and September 12, 2022 (Pumping Period 1) the pumping rate guidance that Nunami Stantec provided to TAL was based on pumping up 10% of the instantaneous flows at the pumping station when flow was greater than 30% MAD (0.130 m^3/s). Flow information used to determine pumping rates was taken from real-time flows at WSC Station 10UH015, except for the period between June 12 and June 22, 2022 when the station was not reporting real-time discharges (but was reporting stage). During this 11-day period in June, Nunami Stantec used the real-time stage information and a preliminary rating curve from WSC (provided to Nunami Stantec through the City) to determine real-time discharges.

A total of 367,501 m^3 was pumped from the Apex River to Lake Geraldine from June 12 to September 12, 2022. The maximum daily pumped volume was approximately 14,541 m^3 on June 16, 2022.

Figure 4.2 illustrates the average daily pumping rate compared to the 10% instantaneous flow criteria. A summary of daily pumping volumes during the SPP is provided in Appendix A.

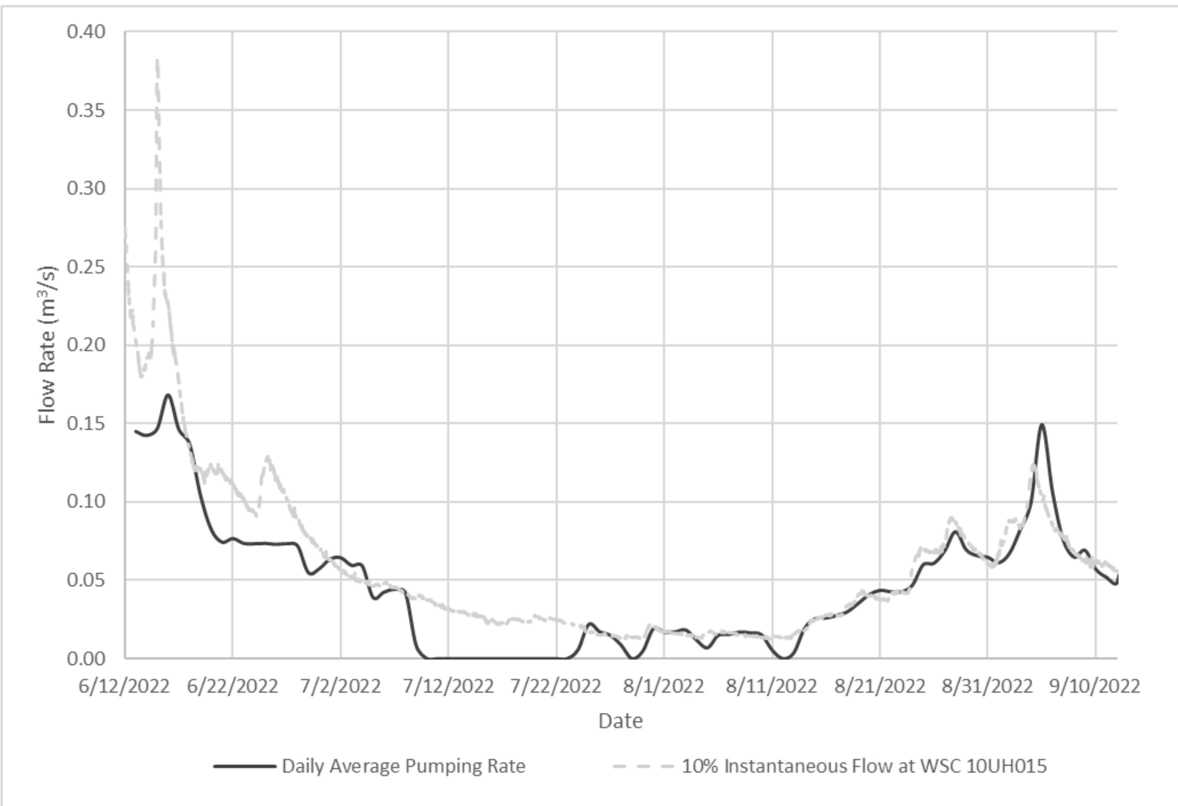


Figure 4.2 Daily Average Flow at WSC 10UH015 and Daily Average Pumping Rate During Pumping Period 1

As shown in Figure 4.2 there were 15 days during Pumping Period 1 (June 12 – September 12) where the daily average pumping rate exceeded 10% of the instantaneous flow at WSC Station 10UH015 at some point during that day. The recorded pumping rate during the days with exceedances were as follows: 16% was the rate for one day, 13% was the rate for two days, 12% was the rate for three days, and 11% was the rate for nine days.

4.2.2.2 Pumping Period 2

Between September 13 and September 19, 2022 (Pumping Period 2) the pumping rate guidance that Nunami Stantec provided to TAL was based on allowing pumping rates up to 80% of the observed flow as long as flows were above 30% MAD, and as limited by the capacity of the pumping infrastructure (designed to pump up to 0.161 m^3/s). The flow values upstream of the pumping station were taken from the real-time flows reported for WSC Station 10UH015.

A total of 76,889 m^3 was pumped from the Apex River to Lake Geraldine from September 13 to September 19, 2022. The maximum daily pumped volume during this time was approximately 12,644 m^3 on September 15, 2022.

Figure 4.3 illustrates flow rates during Pumping Period 2 when the when the upper limit of permitted pump rate was increased per the FAA. A summary of daily pumping volumes during the SPP is provided in Appendix A. The maximum withdrawal (as percent of observed flow) was approximately 42% on September 18, 2022 and the average withdrawal was approximately 31% of flow.

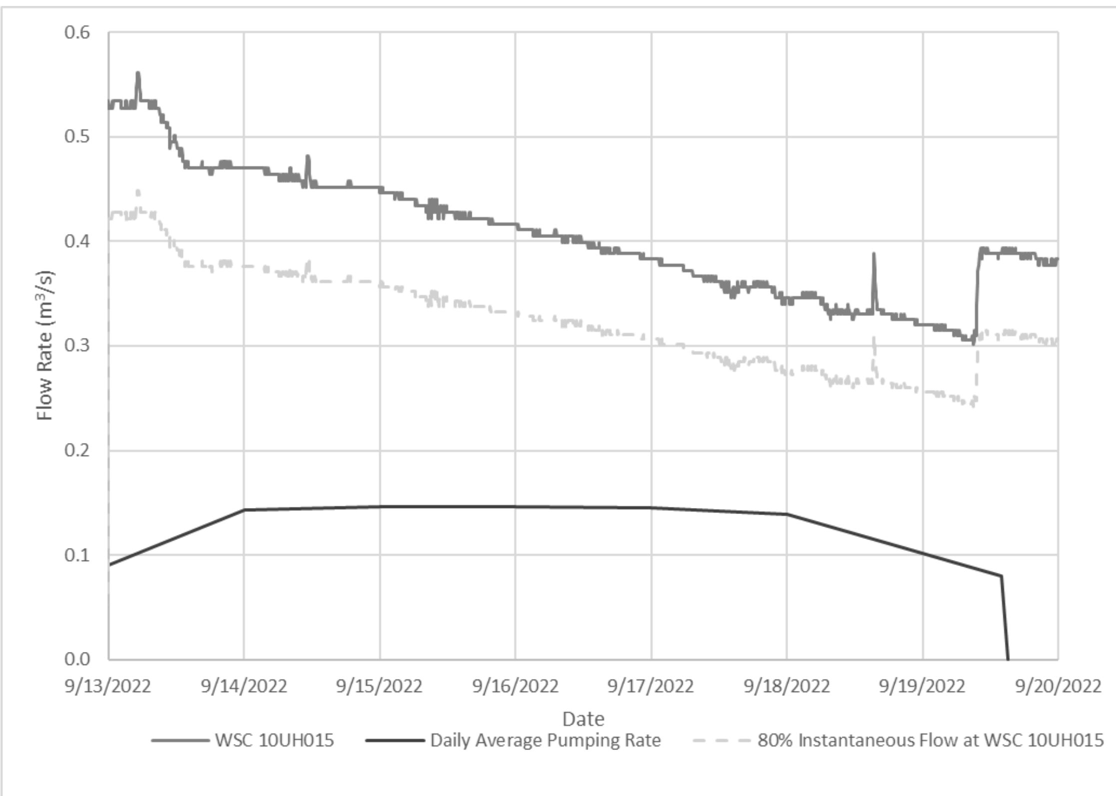


Figure 4.3 Daily Average Flow at WSC 10UH015 and Daily Average Pumping Rate During Pumping Period 2

Figure 4.3 demonstrates the flow at WSC 10UH015 period at the start of Pumping Period 2 when the pumping rate was ramped up by 5% of flow per hour until two pumps were operating at full capacity (design pump rate of 0.161 m^3/s which resulted in a pump rate of approximately 0.145 m^3/s in actuality). Two pumps were run at full capacity for the remainder of the pumping period until, September 19th when pumps were required to be shut down due to a mechanical component failure with the generator.

4.3 Impacts on Fish and Fish Habitat

Impacts to fish and fish habitat were monitored following the conditions of Amendment No. 4 during Pumping Period 1 and following the FAA during Pumping Period 2. The subsequent sections describe the conditions followed in further detail.

4.3.1 Impacts on Fish and Fish Habitat Pumping Period 1

During Pumping Period 1 the Low-Risk Criteria (DFO 2013) outlined in Amendment No. 4 were followed. The criteria included monitoring of Lake Geraldine water levels, flows in the Apex River, and pumping rates from the Apex River. Monitoring was completed as detailed in Section 3.1.

4.3.2 Impacts on Fish and Fish Habitat Pumping Period 2

Additional monitoring was required during Pumping Period 2 per the FAA conditions. This included monitoring seven stations as described in Section 3.2 for relative water level (m), wetted width (m), habitat conditions and fish presence in addition to the monitoring completed during Pumping Period 1. Daily monitoring reports summarizing in field observations are provided in Appendix B. Condition-by condition commentary to the FAA are provided in Appendix C. The baseline fish habitat report is included in Appendix D.

Table 4.1 summarizes the measured relative water level and wetted width in metres. The percent difference between the presented valued and the previously recorded value is provided below the bolded measured value.

Table 4.1 Relative Water Level and Wetted Width Measured at Monitoring Stations from September 13 to September 19, 2022

Monitoring Station	Relative Water Level (m) (% difference from previous observation)							Wetted Width (m) (% difference from previous observation)		
Date 2022	Sept 13	Sept 14	Sept 15	Sept 16	Sept 17	Sept 18	Sept 19	Sept 13	Sept 16	Sept 17
AR-06	**3.22**	**3.21** -0.3%	NM	**3.2** -0.3%	**3.19** -0.3%	**3.18** -0.3%	**3.17** -0.3%	**50**	**50.6** 1.2%	**50.8** 0.4%
SNP IQA-10	**0.526**	**0.516** -2%	**0.512** -1%	**0.509** -1%	**0.498** -2%	**0.495** -1%	**0.498** 1%	**32.8**	**33.5** 2%	**33.7** 1%
AR-07	**4.2**	**4.19** -0.2%	**4.18** -0.2%	**4.18** 0.0%	**4.17** -0.2%	NM	**4.16** -0.2%	**46.7**	**43.1** -7.7%	**45.2** 4.9%
A1	**2.16**	**2.15** -0.5%	**2.13** -1%	**2.12** -0.5%	**2.11** -0.5%	**2.1** -0.5%	**2.09** -0.5%	**21.54**	**20.7** -3.9%	**21.5** 3.9%
A2	**1.17**	**1.16** -1%	NM	**1.15** -1%	**1.14** -1%	NM	**1.12** -2%	**10**	**9.95** -1%	**10** 1%
AR-03	**0.271**	**0.26** -4%	NM	**0.249** -4%	**0.23** -8%	NM	**0.223** -3%	**21.25**	**21.16** 0%	**21.2** 0%
AR-02	**0.152**	**0.22** 45%	NM	**0.144** -35%	**0.132** -8%	NM	**0.17** 29%	**12.18**	**12.12** 0%	**12.1** 0%

NM – Not Measured

As illustrated in Table 4.1, most percent differences measured for relative water level and wetted width were within 10% of the previous value measured except for relative depths measured at AR-02. As shown in Appendix B, the cross section at AR-02 was uniform and directly downstream of a large pool and was therefore insensitive to hydrological changes. Furthermore AR-02 did not follow the same trend as shown in the upstream stations on the 14 and the 19 (depth increased instead of decreased), therefore the larger percent difference may be a result of measurement error. It is assumed that measurements with less than 10% difference between the previous measurement result in a negligible impact on habitat conditions.

Figure 4.4 illustrates the flow upstream of the pumping location measured at WSC 10UH015 and the flow downstream of the pumping location in comparison to the synthetic average daily minimum, lower quartile and mean. The flow downstream of the pumping location was obtained by taking the flow upstream of the pumping location and subtracting the average daily pumping rate. Synthetic daily averages were used because the period of record at 10UH015 is not long enough to provide historical averages. Therefore, data from WSC 10UH002 downstream of the pumping location was used with a 0.513 scaling factor (as described in section 4.2.1).

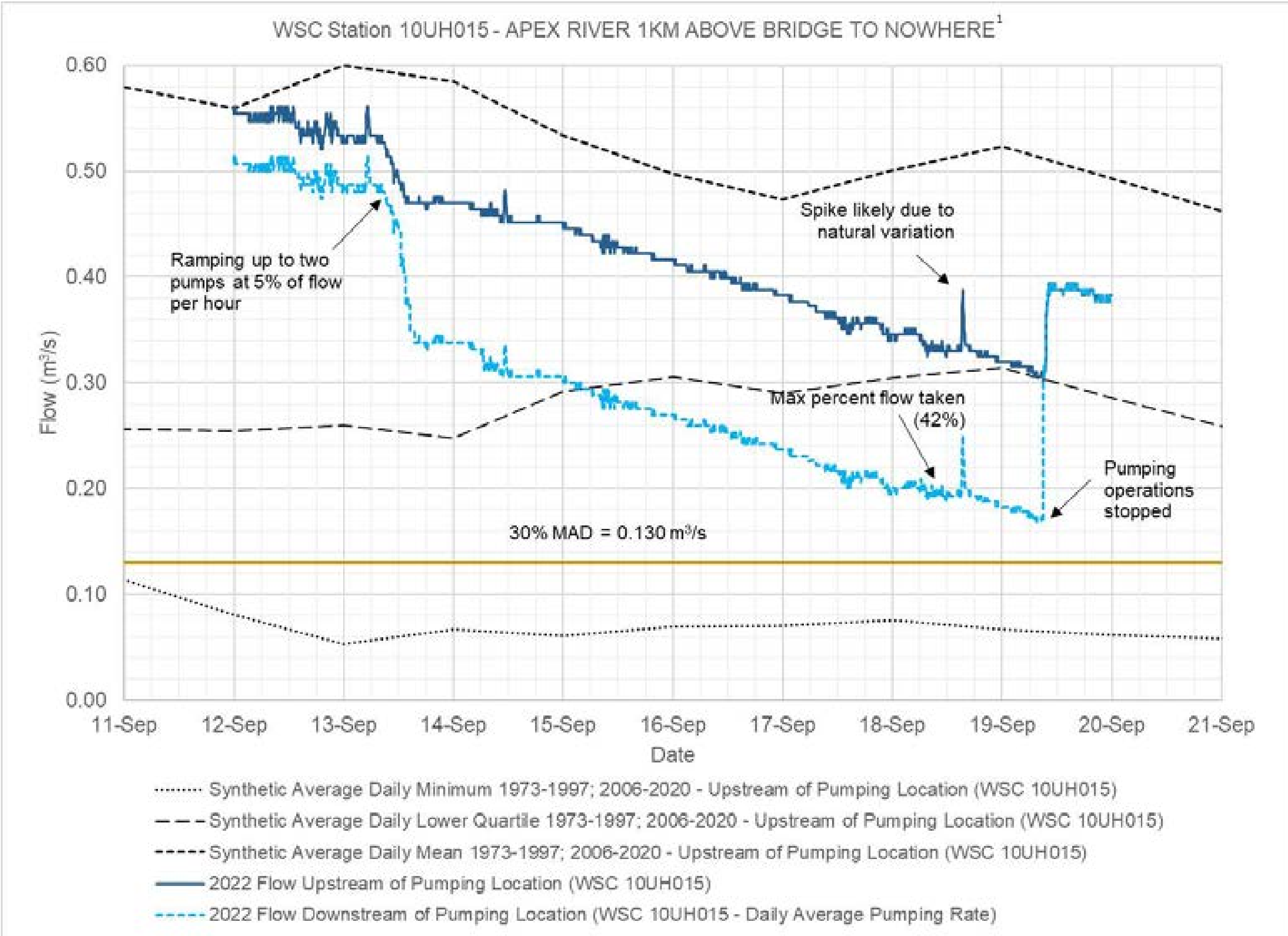


Figure 4.4 Flow Upstream and Downstream of the Pumping Location During Pumping Period 2

1 - The data shown on this plot for 2022 are preliminary data from the WSC hydrometric station. Quality assurance and verification of these data have not been completed by WSC or by Stantec. Synthetic mean, minimum and lower quartile data are from the WSC Station Apex River at Apex (10UH002) with a 0.513 scaling factor applied.

Figure 4.4 illustrates the difference between flows measured upstream of the pumping location (at WSC 10UH015) and affected flows downstream of the pumping location. A consistent pumping rate throughout Pumping Period 2 is shown by the consistent slope of the 2022 flow lines. Since pumping rates were kept consistent throughout this period, variation in flow shown in Figure 4.4 was likely caused by natural variation. The spike that occurred on September 18 occurred during the period of consistent pumping and was therefore likely a result of natural variation. As shown in the figure, once pumping operation stopped on September 19 at 2 pm, the flow upstream and downstream of the pumping location were equal. Furthermore, flow rates downstream of the pumping station (i.e., after withdrawals) were between the synthetic daily average mean and minimum at WSC 10UH015.

Table 4.2 provides a summary of the pumping activities and the average daily flow at WSC 10UH015 throughout Pumping Period 2.

Table 4.2 Summary of Pumping Activities and Average Daily Flow at WSC 10UH015 During Pumping Period 2

Date	Apex River Flow Recorded at WSC 10UH015 (m^3/s)	Daily Pump Rate (m^3/s)	Percent Flow Taken	Average Percent Flow Taken
September 13	0.512	0.091	18%	31%
September 14	0.471	0.132	30%	
September 15	0.442	0.146	33%	
September 16	0.409	0.146	36%	
September 17	0.374	0.145	39%	
September 18	0.335	0.139	42%	
September 19	0.357	0.080	22%	

Table 4.2 indicates that the maximum withdrawal (as percent of observed flow) was approximately 42% on September 18, 2022 and the average withdrawal was approximately 31% of flow. Percent flow taken throughout Pumping Period 2 stayed within the maximum percent flow allowed outlined in the FAA (80%).

Additional monitoring details are provided in the daily reports provided in Appendix B, and condition-by-condition commentary is provided in Appendix C. A summary of the main actions taken during Pumping Period 2 are provided below.

- Prior to the commencement of the emergency authorization, monitoring locations (listed in Table 3.2) were established.
- At each monitoring station, wetted width, depth and habitat condition were recorded on September 13 prior to the activation of the emergency circumstances FAA. Daily monitoring reports can be found in Appendix B.
- At the start of the activation of the FAA, the pumping rate was ramped at 5% of flow per hour until two pumps were operating at full capacity. This approach was selected to reduce the likelihood of

fish stranding and fish mortality. During the ramping up period, the affected reaches were monitored for any presence of fish stranding and/or mortality. No fish stranding and/or mortality was observed, and no fish presence was observed.

- Once two pumps had reached full operating capacity, the pumping rate was held relatively consistently for the remainder of Pumping Period 2.
- The monitoring program outlined in Table 3.2 was followed throughout Pumping Period 2. This included the measurement of wetted width, depth, habitat condition and fish presence at each monitoring station.
- No notable impacts to fish and fish habitat were measured throughout the program as determined by wetted width and depth measurements (Table 4.1).
- No fish stranding and/or mortality was observed, and no fish presence was observed throughout Pumping Period 2.
- Flows were measured upstream of the pumping location each day during the FAA pumping period and the percentage of flow that was pumped was calculated (Table 4.2).
- Pumping stopped abruptly on September 19 due to a mechanical component failure with the generator.

During the pumping program no documented impacts to fish and fish habitat occurred. As presented above, the withdrawals and reductions of flow during the program did not result in flows beyond the range of the historical flow regime during similar historical periods. Based on this, Nunami Stantec's opinion that no harmful alteration, disruption, and destruction of fish habitat resulted from SPP Period 2. Therefore, it is recommended that no fish or fish habitat offsetting requirements are needed per the FAA.

5 DEMOBILIZATION

Pumping operations ended on September 19, 2022. Demobilization followed and included Unnamed Lake pumping equipment and hose return to supplier and Government of Nunavut, respectively. Demobilization also involved return of City-owned equipment to the Coke Plant. The formal equipment handover from TAL to the City on October 19, 2022 with all three parties (Nunami Stantec, City, TAL) signing off on the equipment return on October 25, 2022. On this day, Nunami Stantec, the City (Shane Turner), and TAL (Eric Jacobsen) participated in a formal equipment handover. The manifest from this handover can be found in Appendix E, as well as a final site review memo (dated November 3, 2022).

6 CONCLUSION

Pumping from the Apex River to the Lake Geraldine Reservoir in accordance with Water Licence 3AM-IQA1626 Amendment No. 4 (up to 10% of observed flow when flows are more than 30% MAD) was completed between June 12 to September 12, 2022. A total of 367,501 m^3 were pumped with a maximum daily pumped volume of approximately 14,541 m^3 during this time. Under the emergency *Fisheries Act* authorization (22-HCAA-02043), withdrawals of up to 80% of observed flow were allowed. Pumping was completed between September 13 to September 19, 2022. A total of 76,889 m^3 was pumped during this time, with a maximum daily volume of 12,644 m^3, the maximum withdrawal rate of 42% occurred on September 18. Monitoring completed between September 13 and September 19, 2022 indicated that no harmful alteration, disruption, and destruction of fish habitat was evident from Apex River pumping under the conditions of the FAA. Therefore, no fish or fish habitat offsetting requirements are recommended.

The total volume withdrawn from the Apex River to the Lake Geraldine Reservoir in 2022 was 444,390 m^3. This total volume is less than the maximum allowable pumped volume from the Apex River of 500,000 m^3 as defined in Amendment No. 4.

Pumping records were maintained by the contractor at the pumping site. Pumping was required throughout the entire open water season. The highest water level reached within Lake Geraldine during the 2022 pumping period was 111.141 m (corresponding to an estimated volume of 1,619,154 m^3) recorded on September 21, 2022.

7 LIMITATIONS

This document titled Final Report: Iqaluit 2022 Lake Geraldine Resupply (Apex Pumping): Report of Activities was prepared by Nunami Stantec Ltd. ("Nunami Stantec") for the account of the City of Iqaluit (the "Client"). This report is intended solely for the use by the Client in accordance with Stantec's contract with the Client. While the Report may be provided to applicable authorities having jurisdiction and others for whom the Client is responsible, Stantec does not warrant the services to any third party. The report may not be relied upon by any other party without the expressed written consent of Stantec, which may be withheld at Stantec's discretion. The material in this document reflects Nunami Stantec's professional judgment in light of the scope, schedule and other limitations stated in the document and in the contract between Nunami Stantec and the Client. The opinions in the document are based on conditions and information existing at the time the document was published and do not take into account any subsequent changes. In preparing the document, Nunami Stantec did not verify information supplied to it by others. Any use which a third party makes of this document is the responsibility of such third party. Such third party agrees that Nunami Stantec shall not be responsible for costs or damages of any kind, if any, suffered by it or any other third party as a result of decisions made or actions taken based on this document.

8 CLOSURE

Nunami Stantec Ltd. has prepared this report for the sole benefit of the City of Iqaluit (the City) for the purpose of summarizing the results from water withdrawal and environmental monitoring during the supplementary pumping from the Apex River in 2022. This document was prepared to summarize pumping activities from the 2022 pumping program.

Nunami Stantec trusts the contents of this report meet your expectations at this time. If you have any questions, please do not hesitate to contact the undersigned

Respectfully Submitted,

NUNAMI STANTEC LIMITED

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9 REFERENCES

Fisheries and Oceans Canada (DFO). 2022. Paragraphs 34.4(2)(b) and 35(2)(b) *Fisheries Act* Authorization Emergency Circumstances 22-HCAA-02043. Authorization Issued to the City of Iqaluit.

Fisheries and Oceans Canada (DFO). 2020. Interim code of practice: End-of -pipe fish protection screens for small water intakes in freshwater.

Fisheries and Oceans Canada (DFO). 2013. Framework for Assessing the Ecological Flow Requirements to Support Fisheries in Canada.

Government of Canada (GoC). 2022. Letter from Hon. Daniel Vandal, P.C., M.P. to Lootie Toomasie, Chair, Nunavut Water Board. Ottawa.

Nunavut Water Board. 2022. "NWB Water Licence Type "A" No. 3AM-IQA1626, City of Iqaluit - Request for the Minister's Consent to Process the Application on an Emergency Basis and Attached Reasons for Decision and Amendment No. 7 for the Minister's Consideration." Gjoa Haven.

APPENDIX A

Daily and Monthly Withdrawals from the Apex River

Total Amount Withdrawn from Niaqunguk River in 2022 = 444,390 m^3

Date	Daily (m^3)	Total June (m^3)
6/12/2022	1,885	
6/13/2022	12,524	
6/14/2022	12,309	
6/15/2022	12,691	
6/16/2022	14,541	
6/17/2022	12,635	
6/18/2022	11,814	
6/19/2022	8,996	
6/20/2022	7,119	
6/21/2022	6,423	155,166
6/22/2022	6,625	
6/23/2022	6,358	
6/24/2022	6,334	
6/25/2022	6,356	
6/26/2022	6,304	
6/27/2022	6,337	
6/28/2022	6,219	
6/29/2022	4,741	
6/30/2022	4,953	

Date	Daily (m^3)	Total July (m^3)
7/1/2022	5,481	
7/2/2022	5,566	
7/3/2022	5,142	
7/4/2022	5,111	
7/5/2022	3,374	
7/6/2022	3,664	
7/7/2022	3,822	
7/8/2022	3,630	
7/9/2022	715	
7/10/2022	-	
7/11/2022	-	
7/12/2022	-	
7/13/2022	-	
7/14/2022	-	
7/15/2022	-	
7/16/2022	-	44,466
7/17/2022	-	
7/18/2022	-	
7/19/2022	-	
7/20/2022	-	
7/21/2022	-	
7/22/2022	-	
7/23/2022	-	
7/24/2022	489	
7/25/2022	1,892	
7/26/2022	1,485	
7/27/2022	1,284	
7/28/2022	745	
7/29/2022	-	
7/30/2022	409	
7/31/2022	1,658	

Date	Daily (m^3)	Total August (m^3)
8/1/2022	1,466	
8/2/2022	1,479	
8/3/2022	1,579	
8/4/2022	1,020	
8/5/2022	599	
8/6/2022	1,284	
8/7/2022	1,332	
8/8/2022	1,467	
8/9/2022	1,418	
8/10/2022	1,322	
8/11/2022	478	
8/12/2022	-	
8/13/2022	314	
8/14/2022	1,660	
8/15/2022	2,204	
8/16/2022	2,240	87,252
8/17/2022	2,382	
8/18/2022	2,595	
8/19/2022	3,054	
8/20/2022	3,528	
8/21/2022	3,764	
8/22/2022	3,690	
8/23/2022	3,692	
8/24/2022	4,049	
8/25/2022	5,175	
8/26/2022	5,261	
8/27/2022	5,938	
8/28/2022	6,996	
8/29/2022	6,000	
8/30/2022	5,677	
8/31/2022	5,589	

Date	Daily (m^3)	Total September (m^3)
9/1/2022	5,290	
9/2/2022	5,806	
9/3/2022	7,106	
9/4/2022	8,601	
9/5/2022	12,904	
9/6/2022	9,179	
9/7/2022	6,519	
9/8/2022	5,595	
9/9/2022	5,978	
9/10/2022	4,936	157,507
9/11/2022	4,485	
9/12/2022	4,220	
9/13/2022	7,823	
9/14/2022	12,326	
9/15/2022	12,644	
9/16/2022	12,629	
9/17/2022	12,538	
9/18/2022	12,018	
9/19/2022	6,913	

APPENDIX B

Daily Monitoring Reports

Stantec

Apex River Supplemental Pumping: Fish and Fish Habitat Monitoring Plan

Daily Field Report

GENERAL INFORMATION			
Project:	**Apex River Supplemental Pumping**	Report No.:	**1**
Date of Visit:	**September 12th, 2022**	File #:	**144903261**
Site visit time:	**8:00 – 5:00**	Location:	**Iqaluit, NU**
Weather	**7 °C Cloudy, no precipitation, wind gusting up to 52 km/hr from the southeast**		

KEY PERSONAL PRESENT	
Name	Company
Erin Kelly	Stantec
Isaac Freda	Stantec
Lenny Emiktaut	Stantec

FIELD ACTIVITIES	
Item	**Description**
1.1	Set up the 7 aquatic monitoring stations outlined in the Fish and Fish Habitat Monitoring Plan

DAILY AVERAGE WATER WITHDRAWAL	
Daily Withdrawal (measured at SNP IQA-10)	0.049 m^3/s
Discharge (measured at 10UH015)	0.560 m^3/s
Percentage of Instantaneous Flow	9%

EXCEEDANCE OF LOW RISK CRITERIA				
Station	Water Level	Wetted Width	Habitat Conditions	Fish Presence (stranding and mortality)
AR-06	NM	NM	The head of the pool from which the supplemental water is being drawn. Water has high clarity, 80% large rounded rocks, 20% large rounded boulders.	No
SNP IQA-10	NM	NM	Pumping location, pool, water has high clarity, no vegetation.	No
AR-07	NM	NM	The tail end of the pool from which the water is being drawn. Water has high clarity, no indication of sediment from construction or pumping activities.	No
A1	NM	NM	Within a riffle directly upstream of bridge to nowhere. Water has clarity, mix of large angular boulders, rounded boulders and large rounded rocks.	No

A2	NM	NM	This location is a riffle. Channel slightly embedded at this location. Water has high clarity, mostly rounded rocks.	No
AR-03	NM	NM	The tail end of a Swimming Lake pool just upstream of where the river transitions into a run. Water has high clarity, 80% rounded rocks, some rounded cobbles and sand.	No
AR-02	NM	NM	Within a riffle, downstream of the tail end of a run. Water has high clarity with 40% rounded boulders, 40% large rounded rocks, 10% cobble.	No

NM= Not Measured

PHOTO INVENTORY	
AR-06	

AR-07	
A1	

A2	
AR-03	

Project:	Apex Supplemental Pumping	Project No.:	144903261	Report No.:	**1**

AR-02	

Stantec

Apex River Supplemental Pumping: Fish and Fish Habitat Monitoring Plan

Daily Field Report

GENERAL INFORMATION			
Project:	**Apex River Supplemental Pumping**	Report No.:	**2**
Date of Visit:	**September 13th, 2022**	File #:	**144903261**
Site visit time:	**8:00 – 5:00**	Location:	**Iqaluit, NU**
Weather	**7 °C Cloudy, no precipitation, wind 15 km/hr**		

KEY PERSONAL PRESENT	
Name	Company
Erin Kelly	Stantec
Lenny Emiktaut	Stantec

FIELD ACTIVITIES	
Item	**Description**
1.1	Took wetted width measurements and depth measurements at all monitoring stations prior to the commencement of Emergency FAA
1.2	Monitored for fish stranding and fish mortalities during the ramp up to 2 pumps operating at full capacity (increased pumping rate by 25 lps per hour)

DAILY AVERAGE WATER WITHDRAWAL	
Daily Withdrawal (measured at SNP IQA-10)	0.091 m^3/s
Discharge (measured at 10UH015)	0.512 m^3/s
Percentage of Instantaneous Flow	18%

EXCEEDANCE OF LOW RISK CRITERIA				
Station	Water Level[1] (m)	Wetted Width (m)	Habitat Conditions	Fish Presence (stranding and mortality)
AR-06	3.22	50	The head of the pool from which the supplemental water is being drawn. Water has high clarity, 80% large rounded rocks, 20% large rounded boulders.	No
SNP IQA-10	0.526	32.8	Pumping location, pool, water has high clarity, no vegetation.	No
AR-07	4.20	46.70	The tail end of the pool from which the water is being drawn. Water has high clarity, no indication of sediment from construction or pumping activities.	No

Project:	Apex Supplemental Pumping	Project No.:	144903261	Report No.:	2

A1	2.16	21.54	Within a riffle directly upstream of bridge to nowhere. Water has clarity, mix of large angular boulders, rounded boulders and large rounded rocks.	No
A2	1.17	10.00	This location is a riffle. Channel slightly embedded at this location. Water has high clarity, mostly rounded rocks.	No
AR-03	0.271	21.25	The tail end of a Swimming Lake pool just upstream of where the river transitions into a run. Water has high clarity, 80% rounded rocks, some rounded cobbles and sand.	No
AR-02	0.152	12.18	Within a riffle, downstream of the tail end of a run. Water has high clarity with 40% rounded boulders, 40% large rounded rocks, 10% cobble.	No

NM= Not Measured

1- Relative height on gauge of monitoring station

PHOTO INVENTORY	
AR-06	

SNP IQA-10	
AR-07	

A1	
A2	

Project:	Apex Supplemental Pumping	Project No.:	144903261	Report No.:	**2**

AR-03	
AR-02	

Stantec

Apex River Supplemental Pumping: Fish and Fish Habitat Monitoring Plan

Daily Field Report

GENERAL INFORMATION			
Project:	**Apex River Supplemental Pumping**	Report No.:	**3**
Date of Visit:	**September 14th, 2022**	File #:	**144903261**
Site visit time:	**8:00 – 5:00**	Location:	**Iqaluit, NU**
Weather	**6 °C Cloudy, 0.3 mm precipitation**		

KEY PERSONAL PRESENT	
Name	Company
Erin Kelly	Stantec
Lenny Emiktaut	Stantec

FIELD ACTIVITIES	
Item	**Description**
1.1	Walked reaches, took observations at monitoring stations
1.2	Monitored for fish stranding and fish mortalities

DAILY AVERAGE WATER WITHDRAWAL	
Daily Withdrawal (measured at SNP IQA-10)	0.143 m^3/s
Discharge (measured at 10UH015)	0.471 m^3/s
Percentage of Instantaneous Flow	30%

EXCEEDANCE OF LOW RISK CRITERIA				
Station	Water Level[1] (difference from previous observation) (m)	Wetted Width (m)	Habitat Conditions	Fish Presence (stranding and mortality)
AR-06	3.21 (-0.01)	NM	The head of the pool from which the supplemental water is being drawn. Water has high clarity, 80% large rounded rocks, 20% large rounded boulders.	No
SNP IQA-10	0.516 (-0.01)	NM	Pumping location, pool, water has high clarity, no vegetation.	No
AR-07	4.19 (-0.01)	NM	The tail end of the pool from which the water is being drawn. Water has high clarity, no indication of sediment from construction or pumping activities.	No

Project:	Apex Supplemental Pumping	Project No.:	144903261	Report No.:	**3**

A1	2.15 (-0.02)	NM	Within a riffle directly upstream of bridge to nowhere. Water has clarity, mix of large angular boulders, rounded boulders and large rounded rocks.	No
A2	1.16 (-0.02)	NM	This location is a riffle. Channel slightly embedded at this location. Water has high clarity, mostly rounded rocks.	No
AR-03	0.260 (-0.011)	NM	The tail end of a Swimming Lake pool just upstream of where the river transitions into a run. Water has high clarity, 80% rounded rocks, some rounded cobbles and sand.	No
AR-02	0.22 (+0.068)	NM	Within a riffle, downstream of the tail end of a run. Water has high clarity with 40% rounded boulders, 40% large rounded rocks, 10% cobble.	No

NM= Not Measured

1- Relative height on gauge of monitoring station

PHOTO INVENTORY	
AR-06	

Project:	Apex Supplemental Pumping	Project No.:	144903261	Report No.:	**3**

AR-07	
A1	

A2	
AR-03	

Stantec

Apex River Supplemental Pumping: Fish and Fish Habitat Monitoring Plan

Daily Field Report

GENERAL INFORMATION			
Project:	**Apex River Supplemental Pumping**	Report No.:	**4**
Date of Visit:	**September 15th, 2022**	File #:	**144903261**
Site visit time:	**8:00 – 5:00**	Location:	**Iqaluit, NU**
Weather	**6 °C Cloudy**		

KEY PERSONAL PRESENT	
Name	Company
Erin Kelly	Stantec
Lenny Emiktaut	Stantec

FIELD ACTIVITIES	
Item	**Description**
1.1	Walked reaches, took observations at monitoring stations
1.2	Monitored for fish stranding and fish mortalities

DAILY AVERAGE WATER WITHDRAWAL	
Daily Withdrawal (measured at SNP IQA-10)	0.146 m^3/s
Discharge (measured at 10UH015)	0.442 m^3/s
Percentage of Instantaneous Flow	33%

EXCEEDANCE OF LOW RISK CRITERIA				
Station	Water Level[1] (difference from previous observation) (m)	Wetted Width (m)	Habitat Conditions	Fish Presence (stranding and mortality)
AR-06	NM	NM	The head of the pool from which the supplemental water is being drawn. Water has high clarity, 80% large rounded rocks, 20% large rounded boulders.	No
SNP IQA-10	0.512 (-0.004)	NM	Pumping location, pool, water has high clarity, no vegetation.	No
AR-07	4.18 (-0.01)	NM	The tail end of the pool from which the water is being drawn. Water has high clarity, no indication of sediment from construction or pumping activities.	No

A1	2.13 (-0.02)	NM	Within a riffle directly upstream of bridge to nowhere. Water has clarity, mix of large angular boulders, rounded boulders and large rounded rocks.	No
A2	NM	NM	This location is a riffle. Channel slightly embedded at this location. Water has high clarity, mostly rounded rocks.	No
AR-03	NM	NM	The tail end of a Swimming Lake pool just upstream of where the river transitions into a run. Water has high clarity, 80% rounded rocks, some rounded cobbles and sand.	No
AR-02	NM	NM	Within a riffle, downstream of the tail end of a run. Water has high clarity with 40% rounded boulders, 40% large rounded rocks, 10% cobble.	No

NM= Not Measured

1- Relative height on gauge of monitoring station

PHOTO INVENTORY	
AR-06	

AR-07	
A1	

AR-02	

Stantec

Apex River Supplemental Pumping: Fish and Fish Habitat Monitoring Plan

Daily Field Report

GENERAL INFORMATION			
Project:	**Apex River Supplemental Pumping**	Report No.:	**5**
Date of Visit:	**September 16th, 2022**	File #:	**144903261**
Site visit time:	**8:00 – 5:00**	Location:	**Iqaluit, NU**
Weather	**6 °C Sunny**		

KEY PERSONAL PRESENT	
Name	Company
Erin Kelly	Stantec
Lenny Emiktaut	Stantec

FIELD ACTIVITIES	
Item	**Description**
1.1	Walked reaches, took observations at monitoring stations
1.2	Monitored for fish stranding and fish mortalities

DAILY AVERAGE WATER WITHDRAWAL	
Daily Withdrawal (measured at SNP IQA-10)	0.146 m^3/s
Discharge (measured at 10UH015)	0.409 m^3/s
Percentage of Instantaneous Flow	36%

EXCEEDANCE OF LOW RISK CRITERIA				
Station	Water Level[1] (difference from previous observation) (m)	Wetted Width (m)	Habitat Conditions	Fish Presence (stranding and mortality)
AR-06	3.20 (-0.02)	50.60	The head of the pool from which the supplemental water is being drawn. Water has high clarity, 80% large rounded rocks, 20% large rounded boulders.	No
SNP IQA-10	0.509 (-0.003)	33.5	Pumping location, pool, water has high clarity, no vegetation.	No
AR-07	4.18 (0.00)	43.10	The tail end of the pool from which the water is being drawn. Water has high clarity, no indication of sediment from construction or pumping activities.	No

A1	2.12 (-0.01)	20.70	Within a riffle directly upstream of bridge to nowhere. Water has clarity, mix of large angular boulders, rounded boulders and large rounded rocks.	No
A2	1.15 (-0.01)	9.95	This location is a riffle. Channel slightly embedded at this location. Water has high clarity, mostly rounded rocks.	No
AR-03	0.249 (-0.011)	21.16	The tail end of a Swimming Lake pool just upstream of where the river transitions into a run. Water has high clarity, 80% rounded rocks, some rounded cobbles and sand.	No
AR-02	0.144 (-0.076)	12.12	Within a riffle, downstream of the tail end of a run. Water has high clarity with 40% rounded boulders, 40% large rounded rocks, 10% cobble.	No

NM= Not Measured

1- Relative height on gauge of monitoring station

PHOTO INVENTORY	
AR-06	

Project:	Apex Supplemental Pumping	Project No.:	144903261	Report No.:	**5**

SNP IQA-10	
AR-07	

A1	
A2	

Project:	Apex Supplemental Pumping	Project No.:	144903261	Report No.:	**5**

AR-03	
AR-02	

Stantec

Apex River Supplemental Pumping: Fish and Fish Habitat Monitoring Plan

Daily Field Report

GENERAL INFORMATION			
Project:	**Apex River Supplemental Pumping**	Report No.:	**6**
Date of Visit:	**September 17th, 2022**	File #:	**144903261**
Site visit time:	**8:00 – 5:00**	Location:	**Iqaluit, NU**
Weather	**6 °C sun-cloud, wind gusting up to 50 km/hr**		

KEY PERSONAL PRESENT	
Name	Company
Erin Kelly	Stantec
Lenny Emiktaut	Stantec

FIELD ACTIVITIES	
Item	**Description**
1.1	Walked reaches, took observations at monitoring stations
1.2	Monitored for fish stranding and fish mortalities

DAILY AVERAGE WATER WITHDRAWAL	
Daily Withdrawal (measured at SNP IQA-10)	0.145 m^3/s
Discharge (measured at 10UH015)	0.374 m^3/s
Percentage of Instantaneous Flow	39%

EXCEEDANCE OF LOW RISK CRITERIA				
Station	Water Level[1] (difference from previous observation) (m)	Wetted Width (m)	Habitat Conditions	Fish Presence (stranding and mortality)
AR-06	3.19 (-0.01)	50.80	The head of the pool from which the supplemental water is being drawn. Water has high clarity, 80% large rounded rocks, 20% large rounded boulders.	No
SNP IQA-10	0.498 (-0.011)	33.7	Pumping location, pool, water has high clarity, no vegetation.	No
AR-07	4.17 (-0.01)	45.2	The tail end of the pool from which the water is being drawn. Water has high clarity, no indication of sediment from construction or pumping activities.	No

Project:	Apex Supplemental Pumping	Project No.:	144903261	Report No.:	**6**

A1	2.11 (-0.02)	21.50	Within a riffle directly upstream of bridge to nowhere. Water has clarity, mix of large angular boulders, rounded boulders and large rounded rocks.	No
A2	1.14 (-0.01)	10.00	This location is a riffle. Channel slightly embedded at this location. Water has high clarity, mostly rounded rocks.	No
AR-03	0.230 (-0.019)	21.20	The tail end of a Swimming Lake pool just upstream of where the river transitions into a run. Water has high clarity, 80% rounded rocks, some rounded cobbles and sand.	No
AR-02	0.132 (-0.012)	12.10	Within a riffle, downstream of the tail end of a run. Water has high clarity with 40% rounded boulders, 40% large rounded rocks, 10% cobble.	No

NM= Not Measured

1- Relative height on gauge of monitoring station

PHOTO INVENTORY	
AR-06	

SNP IQA-10	
AR-07	

Project:	Apex Supplemental Pumping	Project No.:	144903261	Report No.:	**6**

A1	
A2	

AR-03	
AR-02	

Stantec

Apex River Supplemental Pumping: Fish and Fish Habitat Monitoring Plan

Daily Field Report

GENERAL INFORMATION			
Project:	**Apex River Supplemental Pumping**	Report No.:	**7**
Date of Visit:	**September 18th, 2022**	File #:	**144903261**
Site visit time:	**8:00 – 12:00**	Location:	**Iqaluit, NU**
Weather	**6 °C Sunny, wind gusting up to 50 km/hr**		

KEY PERSONAL PRESENT	
Name	Company
Erin Kelly	Stantec
Lenny Emiktaut	Stantec

FIELD ACTIVITIES	
Item	**Description**
1.1	Walked reaches, took observations at monitoring stations
1.2	Monitored for fish stranding and fish mortalities

DAILY AVERAGE WATER WITHDRAWAL	
Daily Withdrawal (measured at SNP IQA-10)	0.139 m^3/s
Discharge (measured at 10UH015)	0.335 m^3/s
Percentage of Instantaneous Flow	42%

EXCEEDANCE OF LOW RISK CRITERIA				
Station	Water Level[1] (difference from previous observation) (m)	Wetted Width (m)	Habitat Conditions	Fish Presence (stranding and mortality)
AR-06	3.18 (-0.01)	NM	The head of the pool from which the supplemental water is being drawn. Water has high clarity, 80% large rounded rocks, 20% large rounded boulders.	No
SNP IQA-10	0.495 (-0.003)	NM	Pumping location, pool, water has high clarity, no vegetation.	No
AR-07	NM	NM	The tail end of the pool from which the water is being drawn. Water has high clarity, no indication of sediment from construction or pumping activities.	No

Project:	Apex Supplemental Pumping	Project No.:	144903261	Report No.:	**7**

A1	2.10 (-0.01)	NM	Within a riffle directly upstream of bridge to nowhere. Water has clarity, mix of large angular boulders, rounded boulders and large rounded rocks.	No
A2	NM	NM	This location is a riffle. Channel slightly embedded at this location. Water has high clarity, mostly rounded rocks.	No
AR-03	NM	NM	The tail end of a Swimming Lake pool just upstream of where the river transitions into a run. Water has high clarity, 80% rounded rocks, some rounded cobbles and sand.	No
AR-02	NM	NM	Within a riffle, downstream of the tail end of a run. Water has high clarity with 40% rounded boulders, 40% large rounded rocks, 10% cobble.	No

NM= Not Measured

1- Relative height on gauge of monitoring station

PHOTO INVENTORY	
AR-06	

SNP IQA-10	
AR-07	

Project:	Apex Supplemental Pumping	Project No.:	144903261	Report No.:	**7**

A1	

Stantec

Apex River Supplemental Pumping: Fish and Fish Habitat Monitoring Plan

Daily Field Report

GENERAL INFORMATION			
Project:	**Apex River Supplemental Pumping**	Report No.:	**8**
Date of Visit:	**September 19th, 2022**	File #:	**144903261**
Site visit time:	**8:00 – 5:00 pm**	Location:	**Iqaluit, NU**
Weather	**6 °C Sunny, wind gusting up to 34 km/hr**		

KEY PERSONAL PRESENT	
Name	Company
Lenny Emiktaut	Stantec

FIELD ACTIVITIES	
Item	**Description**
1.1	Walked reaches, took observations at monitoring stations
1.2	Monitored for fish stranding and fish mortalities, during ramp down of pumps

DAILY AVERAGE WATER WITHDRAWAL	
Daily Withdrawal (measured at SNP IQA-10)	0.080 m^3/s
Discharge (measured at 10UH015)	0.357 m^3/s
Percentage of Instantaneous Flow	22%

EXCEEDANCE OF LOW RISK CRITERIA				
Station	Water Level[1] (difference from previous observation) (m)	Wetted Width (m)	Habitat Conditions	Fish Presence (stranding and mortality)
AR-06	3.17 (-0.01)	NM	The head of the pool from which the supplemental water is being drawn. Water has high clarity, 80% large rounded rocks, 20% large rounded boulders.	No
SNP IQA-10	0.498 (+0.003)	NM	Pumping location, pool, water has high clarity, no vegetation.	No
AR-07	4.16 (-0.01)	NM	The tail end of the pool from which the water is being drawn. Water has high clarity, no indication of sediment from construction or pumping activities.	No
A1	2.09 (-0.01)	NM	Within a riffle directly upstream of bridge to nowhere. Water has clarity, mix of large angular boulders, rounded boulders and large rounded rocks.	No

Project:	Apex Supplemental Pumping	Project No.:	144903261	Report No.:	**8**

A2	1.12 (-0.02)	NM	This location is a riffle. Channel slightly embedded at this location. Water has high clarity, mostly rounded rocks.	No
AR-03	0.223 (-0.007)	NM	The tail end of a Swimming Lake pool just upstream of where the river transitions into a run. Water has high clarity, 80% rounded rocks, some rounded cobbles and sand.	No
AR-02	0.17 (+0.038)	NM	Within a riffle, downstream of the tail end of a run. Water has high clarity with 40% rounded boulders, 40% large rounded rocks, 10% cobble.	No

NM= Not Measured

1- Relative height on gauge of monitoring station

APPENDIX C

Conditions that relate to monitoring and reporting of measures and standards to avoid and mitigate impacts to fish and fish habitat

Fisheries Act Authorization Emergency Circumstances - PATH No. 22-HCAA-02043

Conditions of Authorization		
FAA Condition No.	**Action**	**Proof**
1	Activity completed within the given period of August 12, 2022 to October 31, 2022	Pumping Period 2 completed between September 13 - September 19
2	*Conditions that relate to measures and standards to avoid and mitigate impacts to fish and fish habitat*	
2.1	ESC measured installed in compliance with Amendment No. 4	"Apex River Water Withdrawal: Erosion and Sedimentation Control Plan" Dated December 21, 2018
2.2	*List of measures and standards to avoid and mitigate impacts to fish and fish habitat:*	
2.2.1	No fish observed during monitoring program. Environmental professional was on site.	
2.2.2	Screens sized as per DFO's code of practice for the End-of-pipe fish protection screens for small water intakes in freshwater.	Pumps were housed in a screened cage to meet DFO guideline.
2.2.3.	Nunavut Water Board Approved a Spill Contingency Plan under Amendment No. 4	"Apex River Water Withdrawal: Site Specific Spill Contingency Plan" dated December 21, 2018
2.3	Fish and fish habitat monitoring completed by measuring wetted width, depth and habitat condition. In addition to fis presence and mortality.	Monitoring indicated that measures and standards to avoid and mitigate impacts to fish and fish habitat were successful
2.4	Measures and standards to avoid and mitigate impacts to fish and fish habitat completed	
3.1.1	Completed. Please refer to daily reports in Appendix C.	
3.1.1.1	Completed. Please refer to daily reports in Appendix C.	
3.1.1.2	No fish observed during monitoring, therefore no relocation actvities completed.	
3.1.1.3	Contigency measures not needed, not applicable.	
3.2	*Other monitoring and reporting conditions:*	
3.2.1	Completed. Please refer to report in Appendix E.	
3.2.2	Completed. Please refer to daily reports in Appendix C.	
3.2.2.1	From baseline conditions study flows only required upstream of pumping location. Those flows minus the pumped flow is the flow downstream of the pumping location. Baseline study in Appendix E.	
3.2.2.2	Completed, measured wetted width at monitoring sites. Please refer to daily reports in Appendix C.	
3.2.2.3	Completed. Please refer to daily reports in Appendix C.	
3.2.2.4	Completed. Please refer to daily reports in Appendix C.	
3.2.2.5	No fish mortalities observed.	
3.2.2.6	Not applicable, no contingency measures needed.	
All conditions in Section 4	Not applicable. Offsetting not required, as detailed in report.	

APPENDIX D

Fish Habitat Assessment of the Niaqunguk (Apex) River, Nunavut, March 15, 2023

Fish Habitat Assessment of the Niaqunguk (Apex) River, Nunavut

Prepared for:

City of Iqaluit
Iqaluit, Nunavut

Prepared by:

Nunami Stantec Limited

March 15, 2023

Project No.: 144903306

Limitations and Sign-off

This document entitled Fish Habitat Assessment of the Niaqunguk (Apex) River was prepared by Nunami Stantec Limited (“Nunami Stantec”) for the account of City of Iqaluit (the “Client”). Any reliance on this document by any third party is strictly prohibited. The material in it reflects Nunami Stantec’s professional judgment in light of the scope, schedule and other limitations stated in the document and in the contract between Nunami Stantec and the Client. The opinions in the document are based on conditions and information existing at the time the document was published and do not take into account any subsequent changes. In preparing the document, Nunami Stantec did not verify information supplied to it by others. Any use which a third party makes of this document is the responsibility of such third party. Such third party agrees that Nunami Stantec shall not be responsible for costs or damages of any kind, if any, suffered by it or any other third party as a result of decisions made or actions taken based on this document.

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Approved by ________________________________
(signature)
Erica Bonhomme M.Sc., P.Geo
Principal, Environmental Services, Northern Canada

Executive Summary

The City of Iqaluit retained Nunami Stantec Ltd. to complete fish habitat assessments along the Niaqunguk (Apex) River, develop a habitat suitability index for Artic char (*Salvelinus alpinus*), and conduct eDNA samples. The sampling was conducted in support of a monitoring program if supplementary water withdrawal for the Lake Geraldine Reservoir exceeds the allowable 10% instantaneous flow. A field survey was conducted between August 16 to August 20, 2022. Ten 100 m reaches were assessed four upstream of the temporary pumping location, the temporary pumping location, and five downstream of the temporary pumping location.

At each sampled reach habitat features were measured and observed, water quality, and flow measures taken. Areas of river between sampling reaches were walked and habitat features observed and recorded. Fish habitat was rated at each reach by the field biologist for the life history requirements of spawning, rearing, fish passage and overwintering.

A habitat suitability index (HSI) model for Arctic char was adapted from an existing model for Dolly Varden char (*S. malma*) and bull trout (*S. confluentus*) as there was insufficient data in the literature on habitat preferences of Arctic char. The HSI model was applied to the reach at the temporary pumping location (PP-01) and downstream assessed reaches as proposed monitoring locations as a comparison of field assessed habitat ratings.

Water samples were collected at one site upstream of the temporary pumping location for the collection of eDNA to determine the potential for Arctic char upstream of the temporary pumping location. Analysis of the water samples indicated the potential presence of Arctic char at or above the sampling site. No other fish species were identified through the eDNA analysis.

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Abbreviations

City	City of Iqaluit
DFO	Fisheries and Oceans Canada
DNA.	Deoxyribonucleic acid
eDNA	environmental DNA
HSI	habitat suitability index
km	kilometre
m	metre
MAD	Mean annual discharge

Glossary

Fish passage	Features used by fish to migrate through a watercourse or waterbody to access different habitats to carry out additional life stages
Adult foraging	Areas used by adult fish for feeding
Metabarcoding	Used for the identification of species assemblages from DNA barcode genes
Overwintering habitat	Habitat used by fish during the winter, typically when watercourses and waterbodies are ice-covered
Rearing habitat	Habitat used by larval and juvenile fish for feeding and shelter
Spawning habitat	Habitat used by adult fish to carry out spawning activities

1 Introduction

The City of Iqaluit (the City) sources its potable water from Lake Geraldine; however, in recent years, low water levels in the reservoir due to lower levels of precipitation than normal have required the City to divert water from other sources in order to supply the community. The City is permitted to divert water as a supplementary water supply from the Niaqunguk (Apex) River to Lake Geraldine when flows in the Apex River are above 30% mean annual discharge (MAD). During HSI time, the City is permitted to divert water at a flow rate equal to or less than 10% of the instantaneous flow of the Apex River. The City has determined that increased diversion rates are required in order to continue to supply the community with potable water.

On August 5, 2022, the City of Iqaluit submitted an application for emergency Authorization under the *Fisheries Act* (22-HCAA-02043) to Fisheries and Oceans Canada (DFO) to withdraw water from the Apex River above the allowable limit of 10% instantaneous flow and when conditions are above 30% of the mean annual discharge, as specified in the City's water licence (3AM-IQA1626). The *Fisheries Act* Emergency Authorization was issued on August 12, 2022. A monitoring plan (Nunami Stantec 2022) was developed for water diversion from the Apex River and would be implemented if water is withdrawn over the 10% instantaneous flow level. This monitoring plan was submitted to DFO as part of the application for emergency Authorization. The initial fish and fish habitat assessment was completed in 2016 (Nunami Stantec 2017) and was submitted with the application for emergency Authorization; however, additional recent fish and fish habitat data is required to support ongoing regulatory reviews.

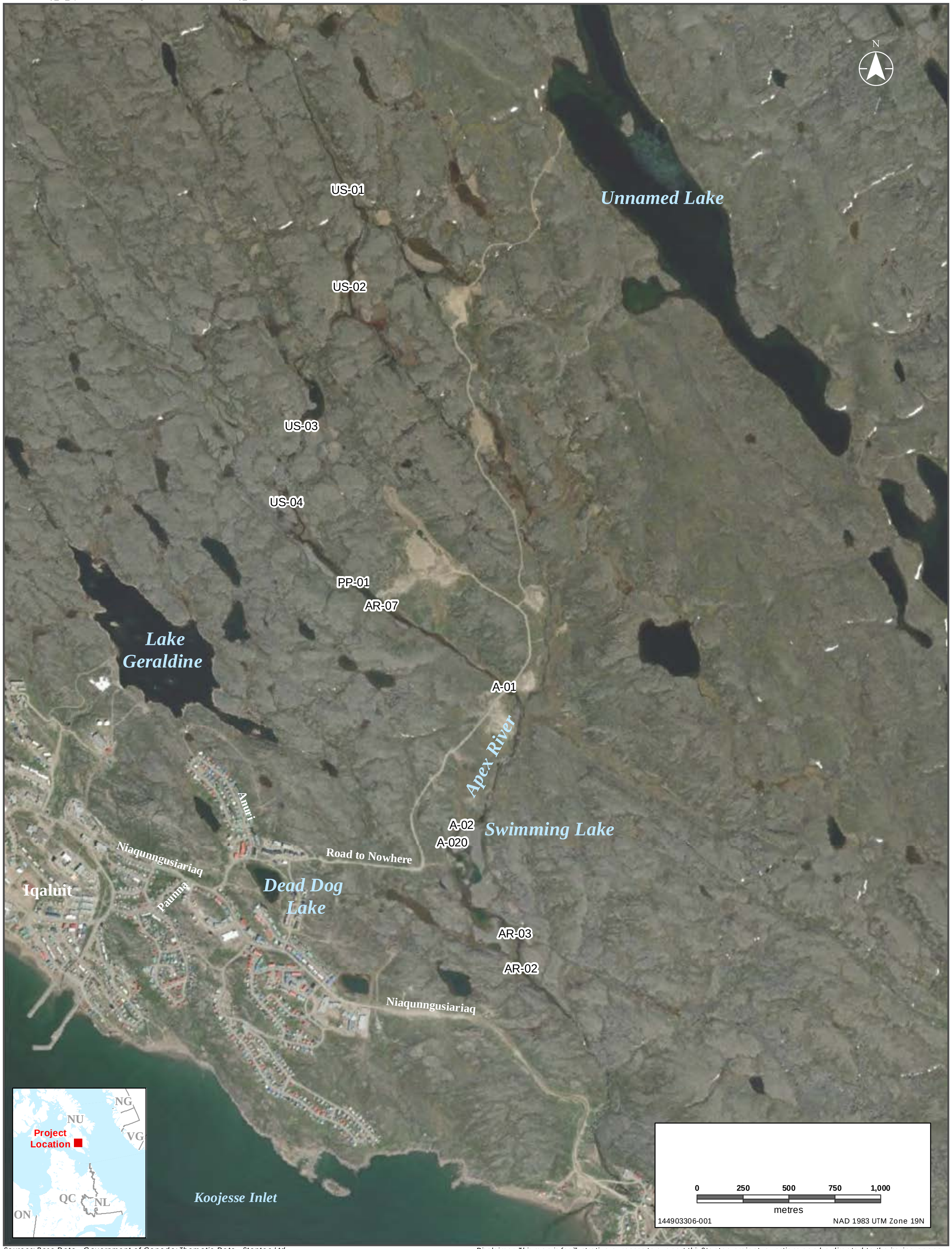
Nunami Stantec Ltd. (Nunami) was retained by the City in July 2022 to develop a revised fish and fish habitat assessment that included:

- Characterization of pre-water diversion fish habitat conditions at proposed monitoring sites along the Apex River
- Develop a habitat suitability index (HSI) model for Arctic char
- Evaluate potential for Arctic char presence above the temporary pumping location using environmental DNA (eDNA)

1.1 Study Area

The Apex River originates at an unnamed lake north of Iqaluit and flows through a tundra landscape into Koojesse Inlet. The Apex River is approximately 8 kilometres (km) in length. A two metre (m) waterfall at the mouth of the Apex River prevents fish from Koojesse Inlet from entering the river. The study area and sampling locations are presented in Figure 1.1.

W:\Clients\City_of_Iqaluit\144903306\Figures\144903306-001-Survey_sites.mxd wahowse



Sources: Base Data - Government of Canada; Thematic Data - Stantec Ltd.

Disclaimer: This map is for illustrative purposes to support this Stantec project; questions can be directed to the issuing agency.

Service Layer Credits: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

Survey Locations

NUNAMI STANTEC LIMITED

FISH AND FISH HABITAT ASSESSMENT STUDY

Figure 1-1

2 Methods

2.1 HSI Model

Habitat suitability indexes (HSI) are used as a tool used to objectively assess the range of environmental conditions that fully, marginally, or do not meet the life history requirements of a species (Wakeley 1988). The HSI provides a numeric measurement of the habitat variable between 0 (does not meet species requirements) and 1 (fully meets the species requirements) (de Kerckhove et al. 2008) (Table 2.1). Habitat suitability metrics (e.g., water velocity, substrate, and water depth) reflect units that are used in an overall HSI numerical index to describe the suitability of habitat to a specific life stage of Arctic char. The HSI provide environmental-variable suitability values ranging between 0 and 1, where a score of 1 is considered most suitable habitat and a score of 0 is considered least suitable habitat for Arctic char.

The HSI model relies heavily on habitat preferences for Dolly Varden char (*Salvelinus malma*) and bull trout (*S. confluentus*) as they share similar habitat preferences as Arctic char and detailed habitat preference data is lacking on Arctic char in the literature.

The HSI for each 100 m reach was calculated by adding the ranks for each parameter for a life history component modelled and dividing by the number of parameters for that life History component. For example for spawning potential, four habitat parameters (P) were used and therefore the HSI for spawning was calculated as $P_1 + P_2 + P_3 + P_4 / 4$ = HSI for spawning.

Table 2.1 Habitat Ranking

Assigned Rank	Habitat Suitability Rating	Description
1.00	Excellent	Available habitat is highly suitable. No limitations to suitability are identified the life stage under consideration
0.75	Above Average	Available habitat has slight limitations for life stage under consideration.
0.50	Average	Available habitat is capable of supporting life stage under consideration, but may not be most desirable habitat
0.25	Below Average	Moderate to severe limitations in habitat suitability are present for the life stage under consideration.
0.00	Least suitable	Habitat suitability is negligible or nonexistent.

2.2 Fish Habitat

The field survey was conducted between August 16 and August 20, 2022 by a qualified aquatic biologist. At each site (Table 2.2; Figure 1.1), fish habitat was assessed along 100 m reaches. Along each 100 m reach, five transects were established to collect fish habitat data; located at 0 m (i.e., reach ID location), and downstream at 25 m, 50 m, 75 m, and 100 m along each reach. At each transect the following data were collected:

- Date and time;

- general channel morphology;
- channel width;
- wetted width;
- water depth at 0.25, 0.5 and 0.75 of wetted width
- water velocity using a Hach FH950 flow meter;
- water quality (e.g., oxygen, conductivity, and pH);
- substrate composition (visually estimated);
- bank description (i.e., height, slope, and stability);
- functional cover type and abundance;
- riparian vegetation composition;
- global positioning system (GPS) recordings and photographs.

River stretches between sampling sites were walked by the aquatic biologist and habitat characteristics observed and recorded. No measurements were taken between sampled reaches.

Habitat characteristics were incorporated into a physical habitat classification system that rates the quality of each macro-habitat type based on physical features (e.g., depth, cover, substrate) with respect to the life requirements of Arctic char (e.g., rearing, spawning, fish passage, overwintering) suspected to occur in the waterbody. Each life history requirement was rated as good, moderate, poor or none, based on the professional judgement of the fish biologist. In addition, the HSI model (Section 3.1) was also applied for the life requirements (spawning, rearing, foraging, and overwintering) of Arctic char for each assessed site.

Table 2.2 Reach Locations (all locations are in UTM Zone 19 V)

Location Number	Easting	Northing
A-01	526548	7069946
A-02	526260	7069180
AR-02	526625	7068410
AR-03	526559	7068632
AR-07	525871	7070396
PP-01	525736	7070513
US-01	525685	7072648
US-02	525666	7072105
US-03	525419	7071445
US-04	525371	7070950

2.3 eDNA

Five eDNA samples were collected from the US-01 Reach. Samples were collected off the left downstream bank to ensure the crew did not enter the water prior to sample collection to prevent contamination. Nitrile gloves were worn when handling sampling equipment and the filters. Each sample was filtered *in-situ* through a 5 µm pore-size Smith-Root self-preserving eDNA filter. Water was pulled through the filters using a drill-operated Masterflex L/S® Easy-Load® peristaltic pump. Two liters of water were filtered per sample. All samples were labelled, bagged and frozen until they were shipped to NatureMetrics for eDNA metabarcoding species analysis. A negative control filter was prepared by filtering two liters of distilled water. Detailed DNA analysis conducted by NatureMetrics is provided in Appendix A.

3 Results

3.1 HSI

Tables 3.1 to 3.4 provides the HSI model adapted for Arctic char from a HSI model developed by AMEX (2012) for Dolly Varden char.

Table 3.1 Spawning/egg Incubation Habitat

Physical Habitat	Spawning/egg Incubation					References/Notes[1]
	Excellent	Above Average	Average	Below Average	Unsuitable	
HSI Value	**1.00**	**0.75**	**0.50**	**0.25**	**0.00**	
Dominant substrate	gravel	Gravel/cobble	Fine gravel	Cobble/boulder	Rock/bedrock	ADFG 1985 (DV+AC); Griffith 1979 (DV); Leggett 1980 (DV); Kitano and Shimazaki 1995 (DV)
Substrate size (mm)	10-50	50-100	0-10	125-256	≥256	-
Depth-Range (m)	.0.05-0.19	0.19-0.30	0.29-0.40	-	<0.04 >0.40	ADFG 1985 (DV+AC); Armstrong and Morrow 1980 (DV); Griffith 1979 (DV); Hagan and Taylor 2001 (DV); Kitano and Shimazaki 1995 (DV)
Temperature °C	4-12	-	12-15	-	<4, >15	ADFG 1985 (DV+AC); Craig and Poulen 1974 (DV); Griffith 1979 (DV); McPhail 2007 (DV); McPhail and Baxter 1996 (BT)
Water velocity (m/s)	0.1-0.3	0.3-0.6	0.6-1.0	1.0-1.3	>1.3	ADFG 1985(DV+AC); Griffith 1979(DV); Kitano and Shimazaki1995(DV)
Stream morphology	Pool-tails or riffle crests contiguous to holding pools	Riffle-run	Pool-riffle	Runs, pools	-	McCart 1980 (DV)
Additional considerations	Areas of groundwater discharge are considered key habitat spawning					ADFG 1985 (DV+AC); Stewart *et al.* 2007

Notes:
[1] Brackets denote species habitat use information from which HSI was derived from: DV = Dolly Varden; BT = bull trout; AC = Arctic char
"-" no data

Table 3.2 Juvenile Rearing Habitat

Physical Habitat	Juvenile Rearing					References/Notes[1]
	Excellent	**Above Average**	**Average**	**Below Average**	**Unsuitable**	
HSI Value	**1.00**	**0.75**	**0.50**	**0.25**	**0.00**	
Dominant substrate	Gravel-cobble	boulder	-	Fines, debris/organic	Rock/bedrock	Dollof and Reeves 1990 (DV); Griffith 1979 (DV)
Substrate size (mm)	2-256	>256	-	<2, NA	>400	Dollof and Reeves 1990 (DV); Griffith 1979 (DV)
Instream cover	Boulders, undercut banks	Undercut bank	Overhead vegetation + undercut bank	Overhead vegetation, aquatic vegetation, boulder	Cobble	Dollof and Reeves 1990 (DV); Griffith 1979 DV)
Depth-Range (m)	0.16-0.29	0.06-0.10, 0.21-0.39	0.10-0.15	<0.05, 0.40-0.49	≥0.50	Bugert *et al.* 1991 (DV); Dollof and Reeves 1990 (DV)
Gradient (%)	5-7	0-4	8-11	12-18	>18	Bryant *et al.* 2004 (DV)
Water velocity (m/s)	0.06-0.19	0.0-0.09	0.20-0.29	0.30-0.39	>0.40, <0.1	Bugert *et al.* 1991 (DV), Griffith 1979 (DV), Sinnatamby et al. 2012 (AC)
Discharge (m^3/sec)	0.01-0.10	0.10-0.30	0.30-0.50	0.50-0.79	>80	Bryant *et al.* 2009 (DV); Dollof and Reeves 1990 (DV)
Stream morphology	Riffles, riffle/glide, side channels	Run-riffle	Pool	Run-pool	--	Griffith 1979 (DV); McCart 1980 (DV); Smith and Slaney 1980 (DV)

Note:
[1] Brackets denote species habitat use information from which HSI was derived from: DV = Dolly Varden; BT = bull trout; AC = Arctic char

Table 3.3 Adult Foraging

Physical Habitat	Adult Foraging					References/Notes[1]
	Excellent	**Above Average**	**Average**	**Below Average**	**Unsuitable**	
HSI Value	**1.00**	**0.75**	**0.50**	**0.25**	**0.00**	
Dominant substrate	Cobble-boulder	Gravel	-	Rock	Fines, debris, organic	Stewart *et al.* 2007 (BT)
Cover type	Depth, undercut banks, boulders	Large woody debris, cobble	Overhead vegetation	Aquatic vegetation	Small woody debris	ADFG 1985 (DV+AC); Stewart *et al.* 2007 (BT)
Depth-Range (m)	0.30-0.90	0.20-0.30, 0.90-1.20	>1.2	0.20-0.1	<0.1	Hagan and Taylor 2001 (DV), Stewart *et al.* 2007 (BT)
Temperature °C	4-8	8-12.5	12.5-15	<4, 15-20	>20	McPhail 2007 (DV); McPhail and Baxter 1996 (BT); Stewart *et al.* 2007 (BT)
Water velocity (m/s)	0.22-0.55	-	0-0.22, 0.55-1.46	-	>1.46	Stewart *et al.* 2007 (BT)
Stream morphology	Main channel pools and riffles	Run	Side channel pools-riffles	Flat	Chutes, falls	Hagen 2000 (DV); Murray and Gadbury 2005 (DV+BT)

Note:
[1] Brackets denote species habitat use information from which HSI was derived from: DV = Dolly Varden; BT = bull trout; AC = Arctic char

Table 3.4 Overwintering Habitat

Physical Habitat	Overwintering Habitat					References/Notes[1]
	Excellent	Above Average	Average	Below Average	Unsuitable	
HSI Value	**1.00**	**0.75**	**0.50**	**0.25**	**0.00**	
Dominant substrate	Cobble-boulder	Gravel	-	Rock	Fines, debris, organic	Based on rearing substrate use [Stewart *et al.* 2007 (BT)] and use of submerged cover in form of boulders as reported by Heifetz *et al.* 1986 (DV)
Cover	Depth, cobble, boulder	Woody debris,	-	Undercut banks	-	Heifetz *et al.* 1986 (DV)
Depth-Range (m)	0.20-0.60	-	0.05 – 0.20, >0.60	-	<0.05	Derived from data observations of fish in fall or systems where ice cover was not present in winter. Bonneau and Scarnecchia 1998 (BT); Huusko *et al*. 2007 (Salmo spp.); Jakober *et al*. 2000 (BT)
Stream morphology	Deep pools, open areas with groundwater upwelling	Deep Pools	Deep run - glides	Riffles	-	Heifetz *et al.* 1986 (DV); Jakober *et al*. 2000 (BT)

Note:
[1] Brackets denote species habitat use information from which HSI was derived from: DV = Dolly Varden; BT = bull trout; AC = Arctic char

3.2 Fish Habitat

The following provides a summary of the fish habitat at the assessed reaches. Additional habitat details and pictures are provided in Appendix B. Water quality data for all the assessed reaches are provided in Table 3.5 and steam velocities in Table 3.6.

Table 3.5 Water Quality Data by Reach

Reach	Water Clarity	Water Temperature (°C)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (%)	Specific Conductivity (µs/cm)	pH
A-01	Clear	9.6	10.71	93.9	66.6	7.79
A-02	Clear	7.5	10.66	89.0	67.8	7.78
AR-02	Clear	8.6	10.38	89.0	68.0	7.64
AR-03	Clear	8.7	10.46	89.9	68.0	7.32
AR-07	Clear	7.0	10.61	87.4	66.7	7.22
PP-01	Clear	7.0	10.59	87.1	67.3	7.12
US-01	Clear	7.8	10.65	89.5	63.1	7.07
US-02	Clear	10.9	10.25	92.8	62.4	7.62
US-03	Clear	8.5	10.45	89.4	66.1	7.11
US-04	Clear	9.4	10.35	90.5	65.7	7.16

Table 3.6 Stream Velocities by Reach

Reach	Minimum m/sec	Maximum m/sec	Average m/sec
A-01	0.045	0.429	0.235
A-02	0.003	0.373	0.124
AR-02	0.005	0.487	0.202
AR-03	ND	ND	ND
AR-07	0.018	0.164	0.077
PP-01	ND	ND	ND
US-01	0.018	0.234	0.101
US-02	0.028	0.333	0.163
US-03	0.002	0.248	0.097
US-04	0.043	0.352	0.178

Note:
ND = No data collected

3.2.1 Downstream of AR-02 to Koojesse Inlet

Downstream of AR-02 to the mouth of the Apex River at the Koojesse Inlet, habitat transitions from a riffle to a steeper series of cascades and rapids; however, these features are unlikely to limit fish passage. At the mouth of the Apex there is a 2 m waterfall which is a barrier for fish migrating up the Apex River from Koojesse Inlet. There are no deep pools along the assessed reach between AR-02 and the mouth of the Apex River to provide overwintering habitat. Spawning and rearing habitat is limited or absent.

3.2.2 Reach AR-02

Channel width and wetted width varied from 12.0 m to 33.6 m with the greatest width at the downstream end of the reach and narrowest 25 m downstream from the start of the reach. Maximum depths ranged from 0.49 m at the upstream end of the reach to 2.5 m at the middle of the reach and then decreased to over 1 m in the downstream portion of the reach. Stream gradient ranged from one to four percent with the highest gradient 25 m downstream of the beginning of the reach and then leveling off to one percent for the downstream segment of the reach. The upstream segment of the reach is a mixture of glide and riffle habitat with pools present in the downstream segment of the reach and extend into Swimming Lake. Cobble was the dominant substrate for upstream half of the reach and transitioned to an increased percentage of boulders in the lower half of the reach, with boulder being the dominant substrate at the downstream end of the reach. The remaining substrate was a mixture of sand and large gravel. The banks throughout the reach were stable. Grass was the dominant riparian vegetation and provided little to no overhead cover. Instream cover was provided by boulder and cobble substrate.

Fish habitat was rated in the field as poor for spawning due to a lack of gravel but moderate for rearing due to the presence of boulders and cobble. There is overwintering potential at the lower end of the reach due to the presence of a pool. Fish passage was rated as good as no obstructions to migration were observed.

Habitat ratings using the HSI from Section 3.1 is presented in Table 3.7.

Table 3.7 HSI Ratings for AR-02

Physical Habitat Parameter	Spawning/Egg Incubation	Juvenile Rearing	Adult Foraging	Overwintering
Dominant substrate	0.25	0.75	1.0	1.0
Substrate size	ND	ND	ND	ND
Depth range	0	0	0.75	1.0
Instream cover	-	0.25	1.0	1.0
Gradient	-	0.75	-	-
Water velocity (m/s)	0.25	0.5	0.5	-
Stream morphology	0.5	0.75	1.0	1.0
HSI Ranking	0.25 (below average)	0.50 (average)	0.85 (above average)	1.0 (excellent)

Notes:
ND = No field data for Apex River
= Not used in HSI calculation

3.2.3 Between Reach AR-02 and Reach AR-03

The habitat between reaches AR-02 and AR-03 varies between a series of runs and pools. There is potential for overwintering in a pool (>2 m deep) immediately downstream of AR-03 that has good instream cover afforded by boulders. There are no barriers to migration and sufficient depth to provide good fish passage. Some small patches of large gravels could provide potential spawning areas for Arctic char.

3.2.4 Reach AR-03

Channel width varied from 21.1 m to 44.6 m with the widest section was in the upper portions of the reach and then tapering to the lowest width at the end of the reach. Wetted width ranged from 37.6 m to 21.1 m. Maximum depth ranged from 0.37 m to 0.75 m with the shallowest water depth in the upper section of the reach and deepest at the lower end. Stream gradient ranged from one to 5 percent with the lowest gradient in the upper section of the reach and steepest gradient at the lower end of the reach. The reach was a mixture of riffle and glide habitat. Cobble was the dominant substrate at the upper end of the reach followed by boulders. At 25 m downstream large gravel was the dominant substrate followed by sand but then changing again at 50 m downstream where cobble and boulders were again the dominant substrate. The banks throughout the reach were stable. The dominant riparian vegetation was grass although there were areas on the downstream section which were devoid of vegetation. Marginal overhead cover was provided by undercut banks. Instream cover was provided boulders.

Fish habitat was rated in the field as poor for most of the each but at the 25 m transect with the increased amounts of gravel spawning was rated as moderate. Overwintering potential was rated as low. Rearing habitat was rated as moderate while fish passage was rated as good.

Habitat ratings using the HSI from Section 3.1 is presented in Table 3.8.

Table 3.8 HSI Ratings for AR-03

Physical Habitat Parameter	Spawning/Egg Incubation	Juvenile Rearing	Adult Foraging	Overwintering
Dominant substrate	0.25	0.75	1.0	1.0
Substrate size	ND	ND	ND	ND
Depth range	0	0	1.0	0.5
Instream cover	-	0.25	0.75	1.0
Gradient	-	0.75	-	-
Water velocity (m/s)	ND	ND	ND	-
Stream morphology	0.75	0.75	0.75	0.25
HSI Ranking	0.33 (below average)	0.5 (average)	0.88 (above average)	0.69 (average)

Notes:
ND = No field data for Apex River
= Not used in HSI calculation

3.2.5 Between Reach AR-03 and A-02

There is good overwintering habitat between reaches AR-03 and A-02 which includes Swimming Lake with deep pools and cover provided from boulders. Shallow stretches between pools provide potential spawning habitat. There are no barriers to fish passage in this area. Upstream of Swimming Lake habitat is mostly riffle with a cobble/boulder substrate.

3.2.6 Reach A-02

Channel width varied from 18.4 m to 38.0 m with the narrowest section on the upstream portion of the reach and the widest at the center of the reach. Wetted width varied from 14.3 m to 27.7 m at the center of the reach. Maximum water depth varied from 0.38 m to 1.1 m at the center of the reach. Stream gradient was 4% at the upper section of the reach and then 3% for the remainder of the reach. Cobble was the dominant substrate throughout the reach followed by boulders, with smaller amounts of sand, large gravel and bedrock. Riffles was the dominant habitat type throughout the reach except for the center of the reach was primarily glide. Riverbanks were mainly stable for most of the reach except for the lower quarter of the reach where the banks were mostly unstable. Riparian vegetation was dominated by grasses except for the lower section which had no riparian vegetation. Instream cover was limited and provided predominantly by boulders.

Fish habitat for was rated in the field as poor for spawning and overwintering but moderate to good for rearing and fish passage.

Habitat ratings using the HSI from Section 3.1 is presented in Table 3.9.

Table 3.9 HSI Ratings for A-02

Physical Habitat Parameter	Spawning/Egg Incubation	Juvenile Rearing	Adult Foraging	Overwintering
Dominant substrate	0.25	0.75	1	1.0
Substrate size	ND	ND	ND	ND
Depth range	0	0	1	0.5
Instream cover	-	0.75	0.75	1
Gradient	-	0.75	-	-
Water velocity (m/s)	0.5	0.75	0.5	-
Stream morphology	0.5	0.75	1	0.25
HSI Ranking	0.31 (below average)	0.63 (average)	0.85 (above average)	0.69 (average)

Notes:
ND = No field data for Apex River
= Not used in HSI calculation

3.2.7 Between Reach A-02 and A-01

Immediately upstream of reach A-02 stream habitat alternates between riffle and run. Multiple large pools, some with depths over 2m provide potential over wintering habitat for fish. Sections with cascades and chutes could pose as barriers to fish during different flow periods. Shallow riffle sections could potentially become a passage barrier during low flows. No gravel beds were identified for potential spawning areas.

3.2.8 Reach A-01

Channel width varied from 35.0 m to 6.10 m with the narrowest section of the reach being 25 m downstream of the beginning of the reach and the widest being 75 m downstream of the start of the reach. Wetted width varied from 4.8 m to 29.0 m. Maximum water depth ranged from 0.25 m to an estimated 4.0 m in a pool located at the lower end of the reach. Stream gradient varied from 2% to 5 % throughout the reach. Substrate was dominated by cobble with lesser amounts of boulders, large and small gravel and sand. Dominant habitat is riffles followed by pools and glide. Stream banks were stable throughout the reach. Riparian vegetation was a mixture of grasses or no vegetation, providing no overhead cover. Instream cover available was estimated at 17% provided mainly by boulders.

Fish habitat was rated as poor for spawning, moderate for overwintering due to some small pools, moderate to good for rearing and good for fish passage.

Habitat ratings using the HSI from Section 3.1 is presented in Table 3.10.

Table 3.10 HSI Ratings for A-01

Physical Habitat Parameter	Spawning/Egg Incubation	Juvenile Rearing	Adult Foraging	Overwintering
Dominant substrate	0.25	0.75	1	1
Substrate size	ND	ND	ND	ND
Depth range	0	0	0.5	0.5
Instream cover	-	0.25	1.0	1
Gradient	-	0.75	-	-
Water velocity (m/s)	1	0.5	0.5	-
Stream morphology	1	0.75	1	1
HSI Ranking	0.56 (average)	0.50 (average)	0.80 (above average)	0.88 (above average)

Notes:
ND = No field data for Apex River
= Not used in HSI calculation

3.2.9 Between Reach A-01 and AR-07

There are no barriers to fish passage between reaches A-01 and AR-07. About 170m downstream of AR-07 there is a pool with depths over 1m which may provide overwintering habitat. Most of the section of the stream is composed of riffles and runs. There are some small patches of gravel providing potential spawning sites. Substrate is predominantly cobble and boulder between the two reaches. The section of stream immediately upstream of A-01 has good cover provided from large boulders.

3.2.10 Reach AR-07

Channel width varied from 47.0 m to 61.8 m with the widest section being at the upstream start of the reach. Wetted width varied from 55.1 m to 47.0 m. maximum water depth along the length of the reach was fairly consistent, ranging from 0.61 m to 0.79 m. Stream gradient ranged from 1% at the upper section of the reach increasing to 3% 25 m downstream and then 4% the remainder of the reach. The reach consisted entirely of riffle habitat. Substrate through the reach consisted of boulder and cobble with cobble being the most dominant substrate at the upper end of the reach and boulders being the most dominant for the remainder of the reach. The stream banks were all stable except the left bank at the downstream end of the reach which was moderately stable. Riparian vegetation consisted of grass and provided no overhead cover. Instream cover was limited and provided by the boulder substrate.

Fish habitat for spawning and overwintering was rated as none. Rearing habitat was rated as moderate for both rearing and fish passage.

Habitat ratings using the HSI from Section 3.1 is presented in Table 3.11.

Table 3.11 HSI Ratings for AR-07

Physical Habitat Parameter	Spawning/Egg Incubation	Juvenile Rearing	Adult Foraging	Overwintering
Dominant substrate	0.25	0.75	1	1
Substrate size	ND	ND	ND	ND
Depth range	0.5	0.75	1	0.5
Instream cover	-	0.25	0.75	1
Gradient	-	0.75	-	-
Water velocity (m/s)	1	0.75	0.75	-
Stream morphology	0.75	0.75	0.75	0.25
HSI Ranking	0.63 (average)	0.67 (average)	0.85 (above average)	0.69 (average)

Notes:
ND = No field data for Apex River
= Not used in HSI calculation

3.2.11 Between Reach AR-07 and PP-01

The 80m section between reaches AR-07 and PP-01 is a large pool with depths over 2 m. Overwintering habitat is very good with boulders providing good cover in the area. The bottom of the pool is mostly sand substrate with some cobble, large gravel, and boulders. There are no barriers to fish passage. There are no potential spawning areas in this area.

3.2.12 Reach PP-01

Channel width varied from 35.0 m, at 25 m downstream of the upper start of the reach to 52.0 m at the downstream end of the reach. Wetted width varied from 34.0 m to 50.0 m. Maximum depth ranged from 0.74 m to 1.78 m. Stream gradient was 3% at the upper end of the reach with the gradient being 1% for the remainder of the reach. Riffles is the dominant habitat type at the upstream end of the reach with the dominant habitat type being pool habitat from 25 m downstream and continuing throughout the rest of the reach. Substrate varied considerably from the upstream end of the reach to the downstream end with substrate at the upper end of the reach dominated by boulders (80%). At 25 m downstream large gravel was the dominant substrate type at 60% with a mixture of organics, small gravel, and boulders. At 50 m downstream substrate consisted mainly of cobble and boulders at 40% each, followed by sand and large gravel. At 75 m and 100 m downstream sand becomes the dominant substrate followed by large gravel, cobble and boulders. Stream banks throughout the reach were stable. Instream cover is provided primarily by depth of water and boulders where present. Riparian vegetation consisted of grasses and provided no overhead cover.

Fish habitat for spawning was rated as poor but good for overwintering, rearing and fish passage.

Habitat ratings using the HSI from Section 3.1 is presented in Table 3.12.

Table 3.12 HSI Ratings for PP-01

Physical Habitat Parameter	Spawning/Egg Incubation	Juvenile Rearing	Adult Foraging	Overwintering
Dominant substrate	0.5	0.25	1	1
Substrate size	ND	ND	ND	ND
Depth range	0	0	0.5	0.5
Instream cover	-	0.25	1	1
Gradient	-	0.75	-	-
Water velocity (m/s)	ND	ND	ND	-
Stream morphology	0.5	0.5	1	0.75
HSI Ranking	0.33 (below average)	0.35 (below average)	0.88 (above average)	0.81 (above average)

Notes:
ND = No field data for Apex River
= Not used in HSI calculation

3.2.13 Between Reach PP-01 and US-04

The habitat between reaches PP-01 and US-04 is composed mostly of a riffle with boulder substrate. There are some small glide sections with large and small gravels that provide spawning potential. There are no barriers to fish passage and no deeper pools to provide overwintering habitat.

3.2.14 Reach US-04

Channel width and wetted width varied from 10 m to 25.8 m with the narrowest section of the reach at the downstream end of the reach and the widest section 25 m downstream of the beginning of the reach. Maximum depth ranged from 0.44 m to 0.73 m. Stream gradient ranged from 1% to 2%. Habitat type was predominantly riffle with an area of flat water 25m downstream of the beginning of the reach. Cobble was the dominant substrate throughout the reach with varying amounts of sand large gravel and boulders. Stream banks were stable throughout the reach. Instream cover was limited and mainly provided by boulders and water depth. Riparian vegetation consisted of grasses and there was no overhead cover,

Fish habitat was rated as poor for spawning and overwintering, poor to moderate for rearing and good for fish passage.

3.2.15 Between Reach US-04 and US-03

Between reaches US-04 and US-03 there are several cascades and falls creating potential multiple barriers to fish passage. At the bottom of some of these sections there are deeper pools that provide potential overwintering habitat if fish can access them. No areas with potential spawning gravels were identified.

3.2.16 Reach US-03

Channel width and wetted width varied from 58.0 m at the start of the reach to 7.6 m at the end of the reach. Maximum depth varied from 1.3 m at the beginning of the reach and quicky becoming shallower with the minimum of depth 0.08 m 25 m downstream from the beginning of the reach and then gradually increasing in depth to 0.29 m at the end of the reach. Stream gradient was 1% on the upper sections of the reach and increases to 4% at the end of the reach. A pool was present at the beginning of the reach becoming glide habitat followed by riffles for the remainder of the reach. Boulders followed by sand was the dominant habitat at the beginning of the reach while cobble was dominant or co-dominant throughout the remainder of the reach. Smaller amounts of sand, large gravel and boulders were present throughout the reach. Stream banks were stable throughout the reach. Instream cover was provided by depth at the pool location and boulders throughout the reach. Riparian vegetation consisted of grasses and there was no overhead cover.

Fish habitat was rated as poor to moderate for spawning, overwintering, and rearing and good for fish passage.

3.2.17 Between Reach US-03 and US-02

Habitat immediately upstream of US-03 is a large pool with depths greater than 2m providing good overwintering habitat. Upstream of those pools the stream becomes a very braided section of riffles with cobble and boulder substrate. Upstream of the riffles is a series of cascades and waterfalls that are likely barriers to fish passage. Just downstream of US-02 is a large pool with depths over 1m which may provide overwintering habitat. The pool tail out has some sections of large and small gravels suitable for spawning.

3.2.18 Reach US-02

Channel width and wetted width varied from 9.10 m to 18.2 m with the narrowest sections of the reach being at the end and beginning of the reach and the widest section at the center of the reach. Maximum depth ranged from 0.30 m to 0.75 m with the deepest depth at the beginning of the reach and shallowest depth at 75 m downstream of the beginning of the reach. Stream gradient was 3% for most of the reach except at the end of the reach where is was 5%. The dominant habitat was riffles with varying sections of run, glide and pool habitat. Cobble was the dominant substrate throughout most of the reach except at 25 m downstream of the beginning of the reach where the dominant substrate was sand likely due to a pool at this location. The remaining substrate was a mixture of large gravel and boulders. Stream banks were stable throughout the reach. Instream cover was limited and provided by boulders in this reach. Riparian vegetation consisted of grasses and there was no overhead cover.

Fish habitat for spawning, rearing, and overwintering was rated as poor while fish passage was rated as good.

3.2.19 Between Reach US-02 and US-01

Between reaches US-02 and US-01 there are multiple pools with depths over 2m providing good overwintering habitat. On the pool edges and tail outs there are some gravel patches providing potential spawning areas. There are a series of cascades with step pools that are likely not tall enough to be a barrier to fish passage. Although at the top of this series of cascades and pools is a bedrock chute with water velocities up to 1.9 m/s which may act as a velocity barrier.

3.2.20 Reach US-01

Channel width was the narrowest at the upstream start of the reach and increased a maximum of 32.5 m at the downstream end of the reach. Wetted width varied similarly ranging from 5.8 m to 23.6 m. Maximum depth ranged from 0.96 m at the upstream start of the reach to 0.26 m at the downstream end of the reach. Stream gradient ranged from 3% to 5% with the dominant habitat throughout the reach being riffles. Boulders was the dominant substrate throughout the reach ranging from 60% to 80% of the substrate. Cobble was the next dominant substrate type ranging from 15% to 20% throughout the reach. Large gravel and sand were also present within the reach. The stream banks were stable throughout the reach. Instream cover was provided through the boulder substrate. Riparian vegetation was grass. There was minimal overhead cover (approximately 5%) provided by some undercut banks.

Fish habitat for spawning was rated as poor. Overwintering and rearing habitat were both rated as poor to moderate while fish passage was rated as good.

3.2.21 Comparison of HSI Ratings and Field Ratings by Biologist

A comparison of HSI ratings and field ratings by a qualified aquatic biologist is presented in Table 3.13 for the temporary pumping location (PP-01) and downstream reaches only as these reaches may be used for future monitoring purposes during periods of water diversion. Care must be used in interpreting results from the HSI model as it relies heavily on habitat features of Dolly Varden char and bull trout with only limited information for Arctic char. The model also may also not reflect preferred habitat features of smaller resident Arctic char as compared to larger anadromous Arctic char and Dolly Varden char or the larger bull trout. Much of the reported data used in the model also was for rivers in more southerly locations and may not be fully applicable to rivers in an Arctic tundra environment like the Apex River. Examples of these differences include the reference of root wads and woody debris in the rating criteria for instream cover in the HSI model while there are no root wads or woody debris in the Apex River due to the absence of trees and shrubs along the length of the river. Also, water depths used in the HSI model were lower (< 1.0m) to achieve a higher rating for overwintering than what was used in the field assessed ratings (> 1.0 m). In addition, there are gaps in the HSI model where data is not available thus making it difficult to determine the appropriate rating for those habitat features.

Differences in habitat ratings between the HSI model and field assessed ratings by the aquatic biologist mainly occur for the life history parameters of spawning and egg incubation, and overwintering although these differences were not large. Ratings of both approaches for rearing mainly similar for all reaches.

Table 3.13 Comparison of HSI Ratings and Field Ratings by a Qualified Aquatic Biologist

Reach	Spawning and Egg Incubation		Rearing		Adult Foraging		Fish Passage		Overwintering	
	HSI	Field	HSI	Field	HSI	Field	HSI	Field	HSI	Field
AR-02	Below Average to average	Poor	Average	Moderate	Above Average	NR	NR	Good	Excellent	Good
AR-03	Below average	Poor-moderate	Average	Moderate	Above average	NR	NR	Good	average	Poor
A-02	Below Average	Poor	Average	Moderate - good	Above average	NR	NR	Moderate-good	average	Poor
A-01	Average	Poor	Average	Moderate-good	Excellent	NR	NR	Good	Excellent	Moderate
AR-07	Below average	None	Average	Moderate	Above average	NR	NR	Moderate	Above average	None
PP-01	Average	Poor	Average	Good	Above average	NR	NR	Good	Average	Good

Note:
NR = Not rated

3.3 eDNA

Two of the five samples collected at US-01 detected eDNA from Arctic char which was 100% identical to the global reference database. No other species were detected. Metabarcoding was not successful for the remaining three eDNA samples. No eDNA was detected in the negative control filter. The detection of Arctic char DNA upstream of the pumping location indicated that Arctic char are present upstream of this location at the time of the assessment.

4 Summary

The Apex River is approximately eight km in length beginning at an unnamed lake to the north of the City of Iqaluit and flowing into Koojesse Inlet (Figure 1.1). The Apex River has a resident population of Arctic char based on a previous study (Nunami Stantec 2017). No other fish species are known to occur in the river. A waterfall at the mouth of the Apex River prevents fish from moving into the river from Koojesse Inlet.

A fish habitat assessment study was conducted in support of a monitoring program if supplementary water withdrawal for the Lake Geraldine Reservoir exceeds the allowable 10% instantaneous flow. A field survey was conducted between August 16 to August 20, 2022. Ten 100 m reaches were assessed four upstream of the temporary pumping location (PP-01), and five downstream of the temporary pumping location.

A HSI model was developed for Arctic char adapted from a HSI model for Dolly Varden char, developed by AMEX (2012). The HSI model for Arctic char relies heavily on data preferences for Dolly Varden char and bull trout due to the limited detailed habitat preferences of Arctic char available in the literature. There are limitations to the validity of the model as it is not specific to the Apex River, utilizes other species habitat preferences and the use of information from other geographic regions. Although there was a general agreement on rankings HSI model rankings were compared with field assessment rankings by an aquatic biologist, there were also some larger discrepancies especially in the ratings of overwintering habitat where the HSI model used lower favourable water depth for overwintering of fish based on requirements in more southerly geographic locations, which do not necessarily reflect requirements at the Apex River.

Water samples were collected at one site upstream of the temporary pumping location for the collection of eDNA to determine the potential for Arctic char upstream of the temporary pumping location. Analysis of the water samples indicated the potential presence of Arctic char at or above the sampling site. No other fish species were identified through the eDNA analysis.

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Appendix A NatureMetrics Report

FISH METABARCODING **RESULTS**

Order number:	NA-SO00135
Report number:	NM-YRX780
Company:	Stantec Consulting Ltd
Contact:	Doug Chiperzak
Project:	I144903261/502.100-CAO2-FishBsIn Study
Sample type:	Smith-Root filter
Date of report:	22-Nov-2022
Number of samples:	6

Thank you for sending your samples for analysis by NatureMetrics. Your samples have been metabarcoded following our eDNA survey - Fish pipeline. **A taxon-by-sample table of your samples is attached to this report (NM-YRX780.NA-SO00135.Fish.xlsx).** Each row in the table represents one taxon (OTU), shown with the lowest possible taxonomic assignment based on currently available reference data. Each column represents a sample, showing the proportion of sequence reads per detected OTU. Care should be taken in interpreting the numbers in terms of relative species abundance, but a high sequence proportion can be interpreted as lending greater confidence to a detection. This report contains biodiversity information that may be sensitive, particularly with respect to endangered or protected species. It is the responsibility of the client to ensure that due consideration is given to the data and that the information is shared in a responsible way.

Here we present an overview of the key results, followed by a more detailed report that starts with the taxonomic composition of the samples followed by a more detailed look at the steps taken to extract, amplify, sequence, and analyse your DNA. A glossary for terms in bold is provided at the end of the report to define key terms used within the report.

OVERVIEW OF YOUR RESULTS

- A total of 1 taxon was detected.
- Most abundant sequences: Arctic char (*Salvelinus alpinus*).
- Fish sequence data were obtained from 2 of 6 eDNA samples.

FULL REPORT

Sample composition

A total of 1 taxon was detected (**Table 1**). The taxon was 100% identical to a species in the global reference databases, and a species name is suggested.

The relative proportion of the sequences found in each of the samples is shown in **Figure 1** and **Table 1** and the diversity is summarised in **Table 2** and **Table 3**.

Arctic char (*Salvelinus alpinus*), which accounted for 100% of the total sequence reads, was the most abundant in terms of sequences.

High-quality vertebrate sequence data were obtained for 2 of the 6 eDNA samples. eDNA metabarcoding of fish was not successful for the remaining 4 samples, which failed to amplify despite troubleshooting. All negative controls behaved as expected.

Table 1 (attached separately). Taxon-by-sample table.

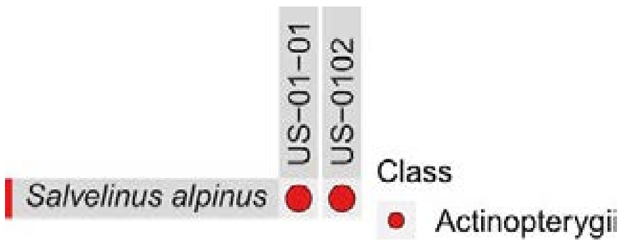

Figure 1. The proportion of the sequencing output allocated to the different species (rows) within each sample (columns). Each bubble per sample represents the proportion of DNA for each species for that sample. The size of the bubble is relative to the number of sequences from all species detected in that sample.

Table 2. Taxon richness among the samples.

Sample ID	Class	Order	Family	Genus	Taxa (Species)
US-01-01	1	1	1	1	1 (1)
US-0102	1	1	1	1	1 (1)

Table 3. The frequency of occurrence of all detected families. Numbers correspond to the number of taxa belonging to those families in those samples.

Class	Order	Family	US-01-01	US-0102	# samples
Actinopterygii	Salmoniformes	Salmonidae	1	1	2

METHODS

DNA from each filter was extracted using a commercial DNA extraction kit with a protocol modified to increase DNA yields. An extraction blank was also processed for the extraction batch. DNA was purified to remove PCR inhibitors using a commercial purification kit.

Comment: DNA yields were as expected.

Purified DNAs were amplified with PCR for a hypervariable region of the 12S rRNA gene to target fish as part of the eDNA survey - Fish pipeline. Our standard analysis includes 12 replicate PCRs per sample.

All PCRs were performed in the presence of both a negative control sample. Amplification success was determined by gel electrophoresis.

Comment: PCR reactions were successful for 2 of 6 samples. Electrophoresis bands were strong and of the expected size. Samples 'NC-01', 'US-01-03', 'US-01-04' and 'US-01-05' failed to amplify despite troubleshooting steps. Overall, 4-8 successful PCRs replicates were obtained for each of the 2 samples submitted for sequencing. No bands were observed on electrophoresis gels for the extraction blank or negative controls.

PCR replicates were pooled and purified, and sequencing adapters were added. Success was determined by gel electrophoresis.

Comment: All samples were successfully indexed, electrophoresis bands were strong and of the expected size. No repeat reactions were necessary.

Amplicons were purified and checked by gel electrophoresis, these were then quantified using a Qubit high sensitivity kit according to the manufacturer's protocol.

Comment: All amplicons were successfully purified.

All purified index PCRs were pooled into a final library with equal concentrations. The final library was sequenced using an Illumina MiSeq V3 kit at 10.5 pM with a 20% PhiX spike in.

Sequence data were processed using a custom bioinformatics pipeline for quality filtering, OTU clustering, and taxonomic assignment.

Comment: Negative controls were as expected. Very few sequences were discarded prior to dereplication, which is indicative of high-quality data with minimal PCR and sequencing errors. A total of 130,422 high-quality sequences, including 130,422 target sequences, were included in the final dataset.

Consensus taxonomic assignments were made for each OTU using sequence similarity searches against the NCBI nt (GenBank) reference database. Assignments were made to the lowest possible taxonomic level where there was consistency in the matches. Conflicts were flagged and resolved manually. Minimum similarity thresholds of 99%, 97%, and 95% were used for species-, genus- and higher-level assignments respectively. In cases where there were equally good matches to multiple species, public records from GBIF were used to assess which were most likely to be present in Canada.

Higher-level taxonomic identifications or multiple potential identifications were reported in cases that could not be resolved in this way.

The OTU table was then filtered to remove low abundance OTUs from each sample (<0.03% or <10 reads, whichever is the greater threshold for the sample). Unidentified, non-target, and common contaminant sequences were then removed.

Note that unidentified or misidentified taxa can result from incomplete or incorrect reference databases, and taxa may be missed due to low quality DNA, environmental contaminants, or the dominance of other species in the sample.

Please note that the abundance of taxa cannot be directly inferred from the proportion of total sequence reads. While the proportion of sequence reads is a consequence of abundance, it is also impacted by biomass, activity, surface area, condition, distance from the physical sample, primer bias, and species-specific variation in the genome.

Table 4. Sample information table.

Kit ID	Sample ID	Volume filtered	Date received
NAS-01-04248	NC-01	2000ml	20-Oct-22
NAS-01-04243	US-01-01	2000ml	20-Oct-22
NAS-01-04245	US-01-03	2000ml	20-Oct-22
NAS-01-04246	US-01-04	2000ml	20-Oct-22
NAS-01-04247	US-01-05	2000ml	20-Oct-22
NAS-01-04244	US-0102	2000ml	20-Oct-22

END OF REPORT

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Report issued by: **Thomas Shannon**

Contact: **team@naturemetrics.co.uk**

GLOSSARY

adapter	short, artificially synthesised nucleotide sequence which attaches to the ends of the target DNA or RNA sequences prior to sequencing. They are typically used to aid in attachment of the target sequence to other functional molecules/sequences.
amplicon	A DNA sequence which is the product of PCR amplification.
bioinformatics	An interface between genetics, computational biology, statistics, and programming in which DNA or other biological data is processed, analysed and integrated into research or communications.
bioinformatics pipeline	Refers to a data processing pipeline that takes the raw sequence data from high-throughput sequencing (often 20 million sequences or more) and transforms it into usable ecological data. Key steps for metabarcoding pipelines include quality filtering, trimming, merging paired ends, removal of sequencing errors such as chimeras, clustering of similar sequences into molecular Operational Taxonomic Units, and matching one sequence from each cluster against a reference database. The output is a OTU-by-sample table showing how many sequences from each sample were assigned to each OTU.
BMWP	Short for biological monitoring working party, an index that can be used to measure water quality by scoring the presence of aquatic invertebrate indicator taxa. The index is reliant on taxa that are less tolerant of polluted water bodies (e.g. Ephemeroptera, Plecoptera, Trichoptera).
BOLD	Barcode Of Life Database; a specialised database of eukaryote COI reference sequences.
contaminant sequences	The sensitivity of high-throughput sequencing of eDNA means that contamination is always a concern that needs to be minimised. The sources of contamination are threefold: Natural - Examples of natural contaminants include: frequent visitors to site, faecal discharge from predators, livestock, wastewater, and fishing bait. This type of contamination is typically unavoidable and very difficult to quantify. Sequences of this type are typically flagged and conservatively removed from the sequencing output. Typical contaminant species include cow, pig, dog, cat, sheep, etc. Sampling - Human contamination of sampling equipment can reduce the efficiency of the sequencing. This type of

contamination can be minimised by stringent contamination protocols, such as PPE.

Laboratory - Residual DNA can contaminate other samples processed at the same time in other labs. At NatureMetrics this is mitigated by a designated eDNA laboratory, strict decontamination procedures, negative controls, and good laboratory practices.

dereplication	The identification of unique sequences so that only one copy of each sequence is reported.
eBioAtlas	A global partnership between IUCN and NatureMetrics to map the world's biodiversity using DNA from water samples as a foundation for the Global Biodiversity Framework and to enable IUCN Red List Assessments.
eDNA	Short for 'environmental DNA'. Refers to DNA deposited in the environment through excretion, shedding, mucous secretions, saliva etc. This can be collected in environmental samples (e.g. water, sediment) and used to identify the organisms that it originated from. eDNA in water is broken down by environmental processes over a period of days to weeks. It can travel some distance from the point at which it was released from the organism, particularly in running water. eDNA is sampled in low concentrations and can be degraded (i.e. broken into short fragments), which limits the analysis options.
extraction blank	A DNA extraction with no sample added to assess potential contamination during the DNA extraction process.
gel electrophoresis	The process in which DNA is separated according to size and electrical charge via an electric current, while in a gel. The process is used to confirm the successful amplification of a specifically sized fragment of DNA.
high-throughput sequencing	Technology developed in the 2000s that produces millions of sequences in parallel. Enables thousands of different organisms from a mixture of species to be sequenced at once, so community DNA can be sequenced. Various different technologies exist to do this, but the most commonly used platform is Illumina's MiSeq. Also known as Next-Generation Sequencing (NGS) or parallel sequencing.
inhibitors/inhibition	Naturally-occurring chemicals/compounds that cause DNA amplification to fail, potentially resulting in false negative results. Common inhibitors include tannins, humic acids and other organic compounds. Inhibitors can be overcome by either diluting the DNA (and the inhibitors) or by additional cleaning of the DNA, but

dilution carries the risk of reducing the DNA concentration below the limits of detection. At NatureMetrics, inhibition is removed using a commercial purification kit.

invasive	Invasive species are defined using GRIIS (Global Register of Introduced and Invasive Species) which is a checklist of Introduced and Invasive species for each country. The IUCN describes an Introduced species as a species outside of its natural range and dispersal potential, and an Invasive species as an introduced species which becomes established in a habitat, is an agent of change or threatens native biological diversity.
IUCN Red List	The IUCN (International Union for the Conservation of Nature) is a global union of government and civil organisations that disseminates information to assist conservation. The IUCN Red List of Threatened Species is an inventory of the conservation status of over 100,000 species worldwide. The Red List evaluates data such as population trends, geographic range and the number of mature individuals in order to categorise species based on their extinction risk: Extinct (EX) - No individual of this species remains alive. Extinct in the Wild (EW) - Surviving individuals are only found in captivity. Critically Endangered (CE) - species faces an extremely high risk of extinction in the wild. e.g. Population size estimated at fewer than 50 mature individuals. Endangered (EN) - species faces a very high risk of extinction in the wild. e.g. Population size estimated at fewer than 250 mature individuals. Vulnerable (VU) - species faces a high risk of extinction in the wild. e.g. Population size estimated at fewer than 10,000 mature individuals and declining. Near Threatened (NT) - species is below the threshold for any of the threatened categories (CE, E, V) but is close to this threshold or is expected to pass it in the near future. Least Concern (LC) - species is not currently close to qualifying for any of the other categories. This includes widespread and abundant species. Data Deficient (DD) - There is currently insufficient data available to make an assessment of extinction risk. This is not a threat category - when more data becomes available the species may be recategorised as threatened.
Jaccard similarity index	This index is a calculation that compares two samples to see which taxa are shared and which are distinct. The higher the percentage,

	the more similar two samples are in their community composition.
metabarcoding	Refers to identification of species assemblages from community DNA using barcode genes. PCR is carried out with non-specific primers, followed by high-throughput sequencing and bioinformatics processing. Can identify hundreds of species in each sample, and 100+ different samples can be processed in parallel to reduce sequencing cost.
NCBI nt	National Centre for Biotechnology Information nucleotide database; a general reference database.
negative control	Used to determine whether PCR reactions are contaminated.
NMDS	Non-metric multidimensional scaling (NMDS) is a method that allows visualisation of the similarity of each sample to one another. The dissimilarity between each sample is calculated, taking into account shared taxa (Jaccard similarity index), and then configured into a 2D ordinal space that allows the similarity-based relationship between each sample to be plotted. Samples which are closer together are more similar to one another in terms of community composition, while samples which are further apart are less similar. This type of clustering analysis allows you to see if certain types of samples, for example, those from a particular habitat type, are more clustered together and therefore more similar to one another compared to other groups.
nucleotide	An individual unit of genetic material which, when strung together constitutes a DNA (or RNA) strand/sequence.
OTU	Operational Taxonomic Unit; similar sequences are clustered into OTUs at a defined similarity threshold. OTUs are approximately equivalent to species and are treated as such in our analyses. Species-level taxonomic assignments may or may not be possible, depending on the availability of reference sequences and the similarity between closely related species in the amplified marker. It may be possible to refine the taxonomic assignment for an OTU later as more sequences are added to reference databases.
PCR	Polymerase Chain Reaction; a process by which millions of copies of a particular DNA segment are produced through a series of heating and cooling steps. Known as an 'amplification' process. One of the most common processes in molecular biology and a precursor to most sequencing-based analyses.

positive control — Used to determine whether the PCR is working correctly.

primers — Short sections of synthesised DNA that bind to either end of the DNA segment to be amplified by PCR. Can be designed to be totally specific to a particular species (so that only that species' DNA will be amplified from a community DNA sample), or to be very general so that a wide range of species' DNA will be amplified. Good design of primers is one of the critical factors in DNA-based monitoring.

rarefaction curve — A plot showing the number of taxa as a function of the sequencing depth (number of reads). Rarefaction curves grow rapidly at first as common species are found then reach a plateau as only the rarest species remain to be detected. Rarefaction curves can provide an indication as to whether the species being studied have been comprehensively sampled.

rarefy — A normalisation technique which transforms the data to remove biases associated with uneven sampling depth (number of reads) across samples. The sampling depth of each sample is standardised to a specified number of reads (usually that of the sample with the lowest depth) by random resampling.

reference databases — Over time, the DNA sequences of many species have been compiled into publicly accessible databases by scientists from around the world. These databases serve as a reference against which unknown sequences can be queried to obtain a species identification. The most commonly accessed database is NCBI, which is maintained by the US National Institute of Health. Anyone can search for DNA sequences at https://www.ncbi.nlm.nih.gov.

richness — The total number of taxa within a sample.

rRNA — Ribosomal RNA.

SAC species — Typically the presence of these species potentially elevates the conservation status of a site to a Special Area of Conservation (SAC). Special Areas of Conservation (SACs) are strictly protected sites designated under the EC Habitats Directive.

sequence(s) — A DNA sequence is made up of four nucleotide bases represented by the letters A, T, C & G. The precise order of these letters is used to compare genetic similarity among individuals or species and to identify species using reference databases. In high-throughput sequencing analyses (e.g. metabarcoding), many identical copies of the same sequence are obtained for each species in the sample. The number of copies obtained per species is known as the number of sequence reads, and this is often -

although not always - related to the relative abundance of the species.

SILVA	SILVA is a database of small (16S/18S, SSU) and large subunit (23S/28S, LSU) ribosomal RNA sequences for all three domains of life (Bacteria, Archaea and Eukarya).
taxon (s.) / taxa (pl.)	Strictly, a taxonomic group. Here we use the term to describe groups of DNA sequences (OTUs) that are equivalent to species. We do not use the term species because we are unable to assign complete identifications to all of the groups at this time due to gaps in the available reference databases.
taxonomy	The branch of science concerned with classification of organisms. species (s./pl.) - A group of genetically similar organisms that show a high degree of overall similarity in many independent characteristics. Related species are grouped together into progressively larger taxonomic units, from genus to kingdom. Homo sapiens (human) is an example of a species. genus (s.) / genera (pl.) - A group of closely related species. Each genus can include one or more species. Homo is an example of a genus. family (s.) / families (pl.) - A group of closely related genera. Homo sapiens is in the Family Hominidae (great apes). order (s.) / orders (pl.) - A group of closely related families. Homo sapiens is in the Order Primates. class (s.) / classes (pl.) - A group of closely related orders. Homo sapiens is in the Class Mammalia. phylum (s.) / phyla (pl.) - A group of closely related classes. Homo sapiens is in the Phylum Chordata.
UKBAP species	UK Biodiversity Action Plan species have been identified as being the most threatened and requiring conservation action under the UK Biodiversity Action Plan.
UNITE	A ribosomal RNA database for identification of fungi.

Appendix B Site Summary Cards

Nunami Stantec Limited - Apex River Study 2022

Site AR-02: Apex River

UTM Location: 19V 526625 7068410 **Survey Date:** August 17, 2022
Legal Location: **Watercourse Class:**
Crew Initials: AB, CM **Restricted Activity Period:**

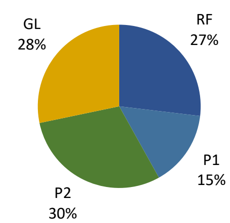
Physical Channel Transect Data

Transect # (Location)	**0**		**25**		**50**		**75**		**100**	
Channel Width (m)	17.6		12.0		27		18.6		33.6	
Wetted Width (m)	16.3		12.0		26.9		18.6		33.6	
Depth at LDB + 25% (m)	0.24		0.05		2.10		0.49		0.55	
Depth at LDB + 50% (m)	0.12		0.14		0.65		0.86		0.05	
Depth at LDB + 75% (m)	0.07		0.15		0.35		0.53		0.15	
Max. Depth (m)	0.49		0.87		2.5		1.14		1.08	
Gradient (%)	2		4		1		1		1	
Dominant Habitat Unit	GL		RF		GL		P1		P2	
Stream Bed										
Substrate (% of Transect Area) Organics	0		0		0		0		0	
Sand	20		10		15		10		5	
Small Gravel	0		0		0		0		0	
Large Gravel	10		5		10		10		5	
Cobble	60		80		65		40		20	
Boulder	10		5		10		40		70	
Bedrock	0		0		0		0		0	
Embeddedness	L		L		L		L		L	
Bank Measurements	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**
Bank Height (m)	0.23	0.25	0.37	0.20	0.19	0.43	0.28	0.25	0.53	0.25
Bank Slope (°)	80	80	70	80	60	70	80	80	80	80
Bank Stability	S	S	S	S	S	S	S	S	S	S
Dom. Bank Material	F	F	F	F	F	F	F	F	F	F
Subdom. Bank Material	O	O	O	O	O	O	O	O	O	BL
Dom. Riparian Veg.	G	G	G	G	N	G	G	G	G	G
Subdom. Riparian Veg.					G					N

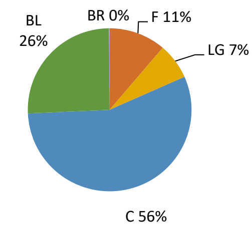
Habitat Inventory / Reach Data

Instream Cover (%):	6	Overhead Cover (%):	0
Dom. Instream Cover:	DC	Dom. Overhead Cover:	UC
Subdom. Instream Cover:	BL	Subdom. Overhead Cover:	
Maximum Depth (m)	-	Dom. Aquatic Veg. Type:	

Habitat Distribution



Substrate Composition



Water Quality Data

Time of Day (HH:MM):	07:26
Water Temperature (°C):	8.6
Dissolved Oxygen (mg/L):	10.38
Sp. Conductivity (µs/cm):	68.0
pH:	7.64
Turbidity (NTU):	0.00

Channel Characteristics

Pattern:	SI
Islands:	N
Bars:	SP
Coupling:	PC
Confinement:	FC
Flow Stage:	Moderate

Fish Habitat Assessment Ratings

	Forage Fish	**Coarse Fish**	**Sport Fish**
Spawning:	None	None	Poor
Overwintering:	None	None	Good
Rearing:	None	None	Moderate
Passage:	None	None	Good

P

Fish Sampling Data

Method	**Effort**	**Species**	**Efish Catch** (n)	**Trap Catch** (n)	**Efish CPUE** (#fish/100s)	**Trap CPUE** (#fish/hr)	**Rel. Abundance** (% of total)

Electrofisher Settings

Volts	Freq. (Hz)	Duty Cycle (%)	Dist. (m)

General Comments

Prepared by: CB Reviewed by: LA

Nunami Stantec Limited - Apex River Study 2022

Site AR-03: Apex River

UTM Location: 19V 526559 7068632 **Survey Date:** August 17, 2022
Legal Location: **Watercourse Class:**
Crew Initials: AB, CM **Restricted Activity Period:**

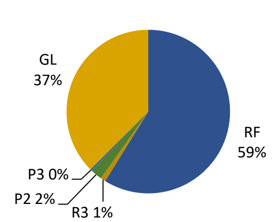
Physical Channel Transect Data

Transect # (Location)	**0**		**25**		**50**		**75**		**100**	
Channel Width (m)	37.6		44.6		32		27.1		21.1	
Wetted Width (m)	37.6		37.5		24.3		21.4		21.1	
Depth at LDB + 25% (m)	0.21		0.10		0.37		0.30		0.27	
Depth at LDB + 50% (m)	0.19		0.35		0.43		0.21		0.10	
Depth at LDB + 75% (m)	0.16		0.08		0.38		0.16		0.11	
Max. Depth (m)	0.37		0.63		0.63		0.58		0.75	
Gradient (%)	1		2		2		3		5	
Dominant Habitat Unit	RF		GL		GL		RF		RF	
Stream Bed										
Substrate (% of Transect Area) Organics	0		0		0		0		0	
Sand	10		20		5		5		5	
Small Gravel	0		10		0		0		0	
Large Gravel	10		60		5		5		10	
Cobble	60		10		75		45		65	
Boulder	20		0		15		45		20	
Bedrock	0		0		0		0		0	
Embeddedness	L		L		L		L		L	
Bank Measurements	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**
Bank Height (m)	0.16	0.16	0.28	0.10	0.20	0.19	0.37	0.37	0.21	0.48
Bank Slope (°)	80	70	80	30	90	90	70	90	80	90
Bank Stability	S	S	S	S	S	S	S	S	S	S
Dom. Bank Material	F	F	F	F	F	F	BL	F	BD	F
Subdom. Bank Material	O	O	O	O	O	O	F	O	BL	O
Dom. Riparian Veg.	G	G	G	G	G	N	G	G	N	G
Subdom. Riparian Veg.							N	N	G	

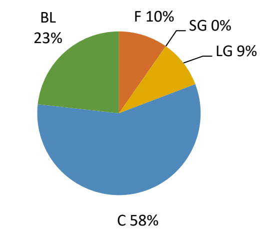
Habitat Inventory / Reach Data

Instream Cover (%):	11	Overhead Cover (%):	0
Dom. Instream Cover:	BL	Dom. Overhead Cover:	UC
Subdom. Instream Cover:	-	Subdom. Overhead Cover:	-
Maximum Depth (m)	-	Dom. Aquatic Veg. Type:	-

Habitat Distribution



Substrate Composition



Water Quality Data

Time of Day (HH:MM):	12:07
Water Temperature (°C):	8.7
Dissolved Oxygen (mg/L):	10.46
Sp. Conductivity (µs/cm):	68.0
pH:	7.32
Turbidity (NTU):	0.00

Channel Characteristics

Pattern:	IR
Islands:	N
Bars:	SP
Coupling:	PC
Confinement:	OC
Flow Stage:	Moderate

Fish Habitat Assessment Ratings

	Forage Fish	**Coarse Fish**	**Sport Fish**
Spawning:	None	None	Poor-moderate
Overwintering:	None	None	Poor
Rearing:	None	None	Moderate
Passage:	None	None	Good

P

Fish Sampling Data

Method	**Effort**	**Species**	**Efish Catch** (n)	**Trap Catch** (n)	**Efish CPUE** (#fish/100s)	**Trap CPUE** (#fish/hr)	**Rel. Abundance** (% of total)

Electrofisher Settings

Volts	Freq. (Hz)	Duty Cycle (%)	Dist. (m)

General Comments

Prepared by: CB Reviewed by: LA

Nunami Stantec Limited - Apex River Study 2022

Site A-02: Apex River

UTM Location: 19 V 526260 7069180 **Survey Date:** August 16, 2022

Legal Location: **Watercourse Class:**

Crew Initials: AB, CM **Restricted Activity Period:**

Physical Channel Transect Data

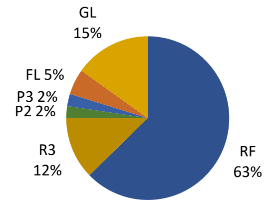
Transect # (Location)	0	25	50	75	100
Channel Width (m)	18.4	32.0	38	26.0	30.0
Wetted Width (m)	14.3	21.0	27.7	20.0	21.0
Depth at LDB + 25% (m)	0.24	0.36	0.79	0.31	0.33
Depth at LDB + 50% (m)	0.37	0.21	0.32	0.00	0.00
Depth at LDB + 75% (m)	0.40	0.18	0.11	0.19	0.37
Max. Depth (m)	0.71	0.38	1.1	0.69	0.77
Gradient (%)	4	3	3	3	3
Dominant Habitat Unit	RF	RF	GL	RF	RF
Stream Bed					
Substrate (% of Transect Area) – Organics	0	0	0	0	0
Sand	5	5	20	10	5
Small Gravel	0	0	0	0	0
Large Gravel	10	5	15	10	5
Cobble	60	40	30	60	40
Boulder	25	30	20	20	40
Bedrock	0	5	5	0	10
Embeddedness	L	L	L	L	L

Bank Measurements	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right
Bank Height (m)	0.31	0.10	0.32	0.30	0.34	0.17	0.38	0.30	0.40	0.35
Bank Slope (°)	70	30	80	70	90	60	90	70	45	30
Bank Stability	S	S	S	S	MS	S	US	S	US	US
Dom. Bank Material	F	BL	F	BL	F	F	F	F	F	F
Subdom. Bank Material	O	F	O	F	O	BD	O	BD	C	BD
Dom. Riparian Veg.	G	G	G	G	G	G	G	G	N	N
Subdom. Riparian Veg.	N	N	N	N	N	N	N	N	G	G

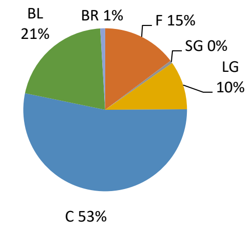
Habitat Inventory / Reach Data

Instream Cover (%):	2	Overhead Cover (%):	1
Dom. Instream Cover:	BL	Dom. Overhead Cover:	UC
Subdom. Instream Cover:	-	Subdom. Overhead Cover:	-
Maximum Depth (m)	-	Dom. Aquatic Veg. Type:	-

Habitat Distribution



Substrate Composition



Water Quality Data

Time of Day (HH:MM):	08:03
Water Temperature (°C):	7.5
Dissolved Oxygen (mg/L):	10.66
Sp. Conductivity (µs/cm):	67.8
pH:	7.78
Turbidity (NTU):	0.00

Channel Characteristics

Pattern:	ST
Islands:	O
Bars:	SP
Coupling:	PC
Confinement:	FC
Flow Stage:	Moderate

Fish Habitat Assessment Ratings

	Forage Fish	Coarse Fish	Sport Fish
Spawning:	None	None	Poor
Overwintering:	None	None	Poor
Rearing:	None	None	Moderate-Good
Passage:	None	None	Moderate-Good

Fish Sampling Data

Method	Effort	Species	Efish Catch (n)	Trap Catch (n)	Efish CPUE (#fish/100s)	Trap CPUE (#fish/hr)	Rel. Abundance (% of total)

Electrofisher Settings

Volts	Freq. (Hz)	Duty Cycle (%)	Dist. (m)

General Comments

Prepared by: CB Reviewed by: LA

Nunami Stantec Limited - Apex River Study 2022

Site A-01: Apex River

UTM Location: 19V 526548 7069946 **Survey Date:** August 16, 2022
Legal Location: **Watercourse Class:**
Crew Initials: AB, CM **Restricted Activity Period:**

Physical Channel Transect Data

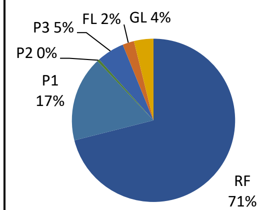
Transect # (Location)	**0**	**25**	**50**	**75**	**100**
Channel Width (m)	26.0	6.10	22	35.0	20.0
Wetted Width (m)	20.5	4.80	17.0	29.0	20.0
Depth at LDB + 25% (m)	0.60	0.42	0.60	0.14	0.48
Depth at LDB + 50% (m)	0.58	0.43	1.01	0.43	0.38
Depth at LDB + 75% (m)	0.32	0.25	1.46	0.37	0.43
Max. Depth (m)	0.98	1.15	1.6	0.66	4.00
Gradient (%)	2	5	3	3	4
Dominant Habitat Unit	P3	RF	P1	RF	RF
Stream Bed					
Substrate (% of Transect Area) – Organics	0	0	0	0	0
Sand	30	0	30	20	10
Small Gravel	10	0	0	5	0
Large Gravel	10	5	0	30	5
Cobble	20	90	50	20	5
Boulder	30	5	20	25	80
Bedrock	0	0	0	0	0
Embeddedness	L	N	L	L	L

Bank Measurements	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**
Bank Height (m)	0.38	0.09	0.72	0.72	0.14	0.18	0.13	0.23	0.32	0.41
Bank Slope (°)	80	15	90	45	20	45	20	70	70	70
Bank Stability	S	S	S	S	S	S	S	S	S	S
Dom. Bank Material	F	F	BL	C	C	F	F	F	F	F
Subdom. Bank Material	BL	BL	C	BL	F	O	SG	BL	BL	BL
Dom. Riparian Veg.	G	N	N	N	N	G	N	G	G	G
Subdom. Riparian Veg.		G			G		G			N

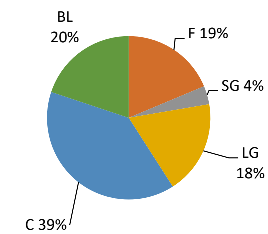
Habitat Inventory / Reach Data

Instream Cover (%):	17	Overhead Cover (%):	-
Dom. Instream Cover:	BL	Dom. Overhead Cover:	-
Subdom. Instream Cover:	DC	Subdom. Overhead Cover:	-
Maximum Depth (m)	-	Dom. Aquatic Veg. Type:	-

Habitat Distribution



Substrate Composition



Water Quality Data

Time of Day (HH:MM):	12:17
Water Temperature (°C):	9.6
Dissolved Oxygen (mg/L):	10.71
Sp. Conductivity (µs/cm):	66.6
pH:	7.79
Turbidity (NTU):	0.00

Channel Characteristics

Pattern:	IR
Islands:	I
Bars:	SP
Coupling:	DC
Confinement:	OC
Flow Stage:	Moderate

Fish Habitat Assessment Ratings

	Forage Fish	**Coarse Fish**	**Sport Fish**
Spawning:	None	None	Poor
Overwintering:	None	None	Moderate
Rearing:	None	None	Moderate-Good
Passage:	None	None	Good

Fish Sampling Data

Method	**Effort**	**Species**	**Efish Catch** (n)	**Trap Catch** (n)	**Efish CPUE** (#fish/100s)	**Trap CPUE** (#fish/hr)	**Rel. Abundance** (% of total)

Electrofisher Settings

Volts	Freq. (Hz)	Duty Cycle (%)	Dist. (m)

General Comments

Prepared by: CB Reviewed by: LA

Nunami Stantec Limited - Apex River Study 2022

Site AR-07: Apex River

UTM Location: 19V 525871 7070396 **Survey Date:** August 18, 2022
Legal Location: 00-00-000-00W4M **Watercourse Class:**
Crew Initials: AB, CM **Restricted Activity Period:**

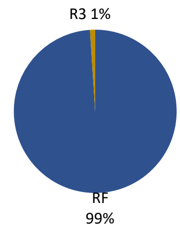
Physical Channel Transect Data

Transect # (Location)	**0**		**25**		**50**		**75**		**100**	
Channel Width (m)	61.8		53.0		58		47.0		50.5	
Wetted Width (m)	55.1		48.7		53.0		43.7		47.5	
Depth at LDB + 25% (m)	0.34		0.25		0.16		0.36		0.21	
Depth at LDB + 50% (m)	0.24		0.30		0.47		0.30		0.33	
Depth at LDB + 75% (m)	0.27		0.52		0.30		0.27		0.22	
Max. Depth (m)	0.62		0.79		0.74		0.61		0.72	
Gradient (%)	1		3		4		4		4	
Dominant Habitat Unit	RF		RF		RF		RF		RF	
Stream Bed										
Substrate (% of Transect Area): Organics	0		0		0		0		0	
Sand	0		0		0		0		0	
Small Gravel	0		0		0		0		0	
Large Gravel	0		0		5		0		0	
Cobble	60		30		15		10		20	
Boulder	40		70		80		90		80	
Bedrock	0		0		0		0		0	
Embeddedness	N		N		N		N		L	
Bank Measurements	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**
Bank Height (m)	0.18	0.28	0.27	0.18	0.27	0.10	0.25	0.21	0.22	0.17
Bank Slope (°)	60	45	50	70	70	60	90	45	60	80
Bank Stability	S	S	S	S	S	S	S	S	MS	S
Dom. Bank Material	F	F	F	F	F	F	F	F	F	F
Subdom. Bank Material	O	BL	O	BL	O	O	O	O	O	O
Dom. Riparian Veg.	G	G	G	G	G	G	G	G	G	G
Subdom. Riparian Veg.		N		N				N	N	

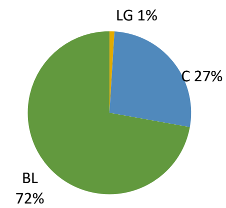
Habitat Inventory / Reach Data

Instream Cover (%):	6	Overhead Cover (%):	-
Dom. Instream Cover:	BL	Dom. Overhead Cover:	-
Subdom. Instream Cover:	-	Subdom. Overhead Cover:	-
Maximum Depth (m)		Dom. Aquatic Veg. Type:	-

Habitat Distribution



Substrate Composition



Water Quality Data

Time of Day (HH:MM):	07:19
Water Temperature (°C):	7.0
Dissolved Oxygen (mg/L):	10.61
Sp. Conductivity (µs/cm):	66.7
pH:	7.22
Turbidity (NTU):	0.00

Channel Characteristics

Pattern:	ST
Islands:	N
Bars:	SP
Coupling:	PC
Confinement:	FC
Flow Stage:	Moderate

Fish Habitat Assessment Ratings

	Forage Fish	**Coarse Fish**	**Sport Fish**
Spawning:	None	None	None
Overwintering:	None	None	None
Rearing:	None	None	Moderate
Passage:	None	None	Moderate

P

Fish Sampling Data

Method	**Effort**	**Species**	**Efish Catch** (n)	**Trap Catch** (n)	**Efish CPUE** (#fish/100s)	**Trap CPUE** (#fish/hr)	**Rel. Abundance** (% of total)

Electrofisher Settings

Volts	Freq. (Hz)	Duty Cycle (%)	Dist. (m)

General Comments

Prepared by: CB Reviewed by: LA

Nunami Stantec Limited - Apex River Study 2022

Site PP-01: Apex River

UTM Location: 19V 525736 7070513 **Survey Date:** August 18, 2022
Legal Location: 00-00-000-00W4M **Watercourse Class:**
Crew Initials: AB, CM **Restricted Activity Period:**

Physical Channel Transect Data

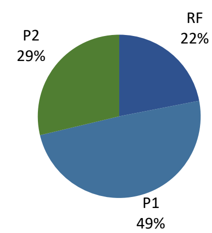
Transect # (Location)	**0**	**25**	**50**	**75**	**100**
Channel Width (m)	50.5	35.0	40	51.0	52.0
Wetted Width (m)	47.5	34.0	39.0	50.0	50.0
Depth at LDB + 25% (m)	0.43	0.43	0.78	1.00	1.20
Depth at LDB + 50% (m)	0.47	0.57	1.10	-	-
Depth at LDB + 75% (m)	0.39	0.70	1.33	1.55	1.17
Max. Depth (m)	1.43	0.74	1.6	1.78	1.38
Gradient (%)	3	1	1	1	1
Dominant Habitat Unit	RF	P2	P1	P1	P1
Stream Bed					
Substrate (% of Transect Area): Organics	0	10	0	0	0
Sand	0	0	20	70	55
Small Gravel	0	10	0	0	0
Large Gravel	0	60	10	10	10
Cobble	20	20	40	10	20
Boulder	80	0	30	10	15
Bedrock	0	0	0	0	0
Embeddedness	N	L	L	M	M

Bank Measurements	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**
Bank Height (m)	0.22	0.96	0.14	0.17	0.18	0.25	0.23	0.2	0.18	0.14
Bank Slope (°)	45	60	30	45	70	-	45	45	45	45
Bank Stability	S	S	S	S	S	S	S	S	S	S
Dom. Bank Material	F	F	F	F	F	F	F	F	F	F
Subdom. Bank Material	O	BL	O	BL	BL	BL	BL	O	O	O
Dom. Riparian Veg.	G	G	G	G	G	G	G	G	G	G
Subdom. Riparian Veg.	N	N	N	N		N	N	N	N	N

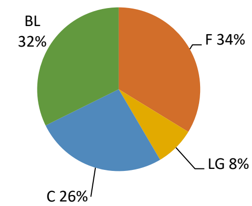
Habitat Inventory / Reach Data

Instream Cover (%):	61	Overhead Cover (%):	0
Dom. Instream Cover:	DC	Dom. Overhead Cover:	-
Subdom. Instream Cover:	BL	Subdom. Overhead Cover:	-
Maximum Depth (m)	-	Dom. Aquatic Veg. Type:	-

Habitat Distribution



Substrate Composition



Water Quality Data

Time of Day (HH:MM):	07:52
Water Temperature (°C):	7.0
Dissolved Oxygen (mg/L):	10.59
Sp. Conductivity (µs/cm):	67.3
pH:	7.12
Turbidity (NTU):	0.00

Channel Characteristics

Pattern:	SI
Islands:	N
Bars:	SP
Coupling:	DC
Confinement:	FC
Flow Stage:	Moderate

Fish Habitat Assessment Ratings

	Forage Fish	**Coarse Fish**	**Sport Fish**
Spawning:	None	None	poor
Overwintering:	None	None	good
Rearing:	None	None	good
Passage:	None	None	good

P

Fish Sampling Data

Method	**Effort**	**Species**	**Efish Catch** (n)	**Trap Catch** (n)	**Efish CPUE** (#fish/100s)	**Trap CPUE** (#fish/hr)	**Rel. Abundance** (% of total)

Electrofisher Settings

Volts	Freq. (Hz)	Duty Cycle (%)	Dist. (m)

General Comments

Prepared by: CB Reviewed by: LA

Stantec

Nunami Stantec Limited - Apex River Study 2022

Site US-04: Apex River

UTM Location: 19V 525371 7070950 **Survey Date:** August 20, 2022

Legal Location: **Watercourse Class:**

Crew Initials: AB, CM **Restricted Activity Period:**

Physical Channel Transect Data

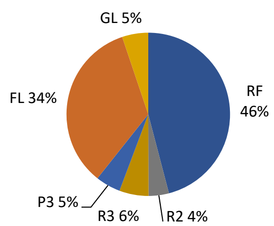
Transect # (Location)	**0**	**25**	**50**	**75**	**100**
Channel Width (m)	18.1	25.8	13	14.4	10.0
Wetted Width (m)	18.1	25.8	12.3	13.6	10.0
Depth at LDB + 25% (m)	0.55	0.10	0.27	0.12	0.32
Depth at LDB + 50% (m)	0.14	0.13	0.26	0.35	0.14
Depth at LDB + 75% (m)	0.15	0.25	0.17	0.10	0.20
Max. Depth (m)	0.71	0.53	0.44	0.73	0.71
Gradient (%)	2	1	2	2	2
Dominant Habitat Unit	RF	FL	RF	RF	RF
Stream Bed					
Substrate (% of Transect Area): Organics	0	0	0	0	0
Sand	20	20	10	10	10
Small Gravel	0	10	0	0	0
Large Gravel	10	25	10	10	10
Cobble	65	40	60	65	65
Boulder	5	5	20	15	15
Bedrock	0	0	0	0	0
Embeddedness	M	M	L	L	L

Bank Measurements	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**
Bank Height (m)	0.16	0.15	0.03	0.28	0.16	0.09	0.17	0.38	0.26	0.23
Bank Slope (°)	90	80	90	90	90	60	90	70	90	90
Bank Stability	S	S	S	S	S	S	S	S	S	S
Dom. Bank Material	F	F	F	F	F	F	F	F	F	F
Subdom. Bank Material	O	O	O	O	O	O	O	O	O	O
Dom. Riparian Veg.	G	G	G	G	G	G	G	G	G	G
Subdom. Riparian Veg.										

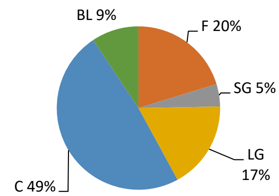
Habitat Inventory / Reach Data

Instream Cover (%):	2	Overhead Cover (%):	0
Dom. Instream Cover:	BL	Dom. Overhead Cover:	UC
Subdom. Instream Cover:	DC	Subdom. Overhead Cover:	-
Maximum Depth (m)	-	Dom. Aquatic Veg. Type:	-

Habitat Distribution



Substrate Composition



Water Quality Data

Time of Day (HH:MM):	11:54
Water Temperature (°C):	9.4
Dissolved Oxygen (mg/L):	10.35
Sp. Conductivity (µs/cm):	65.7
pH:	7.16
Turbidity (NTU):	0.00

Channel Characteristics

Pattern:	IR
Islands:	O
Bars:	MD
Coupling:	DC
Confinement:	OC
Flow Stage:	Moderate

Fish Habitat Assessment Ratings

	Forage Fish	**Coarse Fish**	**Sport Fish**
Spawning:	None	None	Poor
Overwintering:	None	None	Poor
Rearing:	None	None	Poor-moderate
Passage:	None	None	Good

P

Fish Sampling Data

Method	**Effort**	**Species**	**Efish Catch** (n)	**Trap Catch** (n)	**Efish CPUE** (#fish/100s)	**Trap CPUE** (#fish/hr)	**Rel. Abundance** (% of total)

Electrofisher Settings

Volts	Freq. (Hz)	Duty Cycle (%)	Dist. (m)

General Comments

Prepared by: CB Reviewed by: LA

Nunami Stantec Limited - Apex River Study 2022

Site US-03: Apex River

UTM Location:	19V 525419 7071445	**Survey Date:**	August 20, 2022
Legal Location:	00-00-000-00W4M	**Watercourse Class:**	
Crew Initials:	AB, CM	**Restricted Activity Period:**	

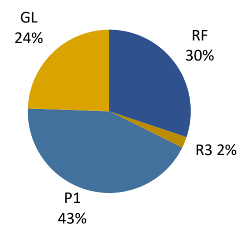
Physical Channel Transect Data

Transect # (Location)	**0**		**25**		**50**		**75**		**100**	
Channel Width (m)	58.0		54.5		27		24.2		7.60	
Wetted Width (m)	58.0		54.5		27.4		21.3		7.60	
Depth at LDB + 25% (m)	1.3		0.08		0.17		0.16		0.29	
Depth at LDB + 50% (m)	-		0.22		0.14		0.11		0.28	
Depth at LDB + 75% (m)	1.1		0.27		0.13		0.20		0.30	
Max. Depth (m)	1.59		0.58		0.34		0.43		0.92	
Gradient (%)	1		1		2		2		4	
Dominant Habitat Unit	P1		GL		RF		RF		RF	
Stream Bed										
Substrate (% of Transect Area) Organics	0		0		0		0		0	
Sand	30		20		10		20		10	
Small Gravel	0		0		0		0		0	
Large Gravel	10		10		10		20		10	
Cobble	10		40		40		40		40	
Boulder	50		30		40		20		40	
Bedrock	0		0		0		0		0	
Embeddedness	M		L		L				L	
Bank Measurements	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**
Bank Height (m)	0.29	0.06	0.31	0.13	0.17	0.08	0.23	0.11	0.62	0.51
Bank Slope (°)	80	45	80	80	90	45	90	20	80	60
Bank Stability	S	S	S	S	S	S	S	S	S	S
Dom. Bank Material	F	F	F	F	F	F	F	F	F	F
Subdom. Bank Material	O	O	O	O	O	O	O	O	BL	BL
Dom. Riparian Veg.	G	G	G	G	G	N	G	G	G	G
Subdom. Riparian Veg.		N		N					N	N

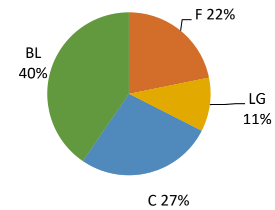
Habitat Inventory / Reach Data

Instream Cover (%):	42	Overhead Cover (%):	-
Dom. Instream Cover:	DC	Dom. Overhead Cover:	-
Subdom. Instream Cover:	BL	Subdom. Overhead Cover:	-
Maximum Depth (m)		Dom. Aquatic Veg. Type:	-

Habitat Distribution



Substrate Composition



Water Quality Data

Time of Day (HH:MM):	08:56
Water Temperature (°C):	8.5
Dissolved Oxygen (mg/L):	10.45
Sp. Conductivity (µs/cm):	66.1
pH:	7.11
Turbidity (NTU):	0.00

Channel Characteristics

Pattern:	IR
Islands:	N
Bars:	SD
Coupling:	DC
Confinement:	OC
Flow Stage:	Moderate

Fish Habitat Assessment Ratings

	Forage Fish	**Coarse Fish**	**Sport Fish**
Spawning:	None	None	poor-moderate
Overwintering:	None	None	Poor-Moderate
Rearing:	None	None	Poor-moderate
Passage:	None	None	Good

P

Fish Sampling Data

Method	**Effort**	**Species**	**Efish Catch** (n)	**Trap Catch** (n)	**Efish CPUE** (#fish/100s)	**Trap CPUE** (#fish/hr)	**Rel. Abundance** (% of total)

Electrofisher Settings

Volts	Freq. (Hz)	Duty Cycle (%)	Dist. (m)

General Comments

Prepared by: CB Reviewed by: LA

Nunami Stantec Limited - Apex River Study 2022

Site US-02: Apex River

UTM Location: 19V 525666 7072105 | **Survey Date:** August 19, 2022
Legal Location: 00-00-000-00W4M | **Watercourse Class:**
Crew Initials: AB, CM | **Restricted Activity Period:**

Physical Channel Transect Data

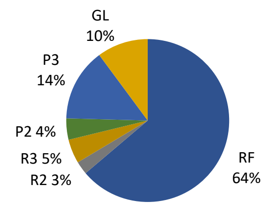
Transect # (Location)	**0**	**25**	**50**	**75**	**100**
Channel Width (m)	9.60	13.9	18	14.5	9.10
Wetted Width (m)	9.60	13.9	18.2	14.3	9.10
Depth at LDB + 25% (m)	0.40	0.39	0.13	0.16	0.14
Depth at LDB + 50% (m)	0.22	0.29	0.17	0.30	0.33
Depth at LDB + 75% (m)	0.16	0.35	0.36	0.25	0.11
Max. Depth (m)	0.75	0.52	0.50	0.30	0.56
Gradient (%)	3	3	3	3	5
Dominant Habitat Unit	R3	P3	GL	RF	RF
Stream Bed					
Substrate (% of Transect Area) – Organics	0	0	0	0	0
Sand	10	40	20	10	20
Small Gravel	0	0	0	0	0
Large Gravel	20	20	10	20	10
Cobble	65	30	65	60	75
Boulder	5	10	5	10	5
Bedrock	0	0	0	0	0
Embeddedness	L	M	L	L	L

Bank Measurements	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**
Bank Height (m)	0.35	0.14	0.13	0.10	0.14	0.10	0.14	0.09	0.23	0.22
Bank Slope (°)	90	80	90	90	90	30	90	60	90	90
Bank Stability	S	S	S	S	S	S	S	S	S	S
Dom. Bank Material	F	F	F	F	F	F	F	F	F	F
Subdom. Bank Material	O	O	O	O	O	O	O	O	O	O
Dom. Riparian Veg.	G	N	G	G	G	N	G	G	G	G
Subdom. Riparian Veg.										

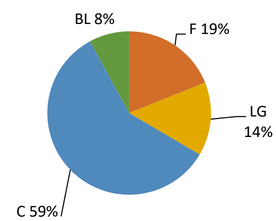
Habitat Inventory / Reach Data

Instream Cover (%):	1	Overhead Cover (%):	0
Dom. Instream Cover:	BL	Dom. Overhead Cover:	UC
Subdom. Instream Cover:	-	Subdom. Overhead Cover:	-
Maximum Depth (m)	-	Dom. Aquatic Veg. Type:	-

Habitat Distribution



Substrate Composition



Water Quality Data

Time of Day (HH:MM):	12:56
Water Temperature (°C):	10.9
Dissolved Oxygen (mg/L):	10.25
Sp. Conductivity (µs/cm):	62.4
pH:	7.62
Turbidity (NTU):	0.00

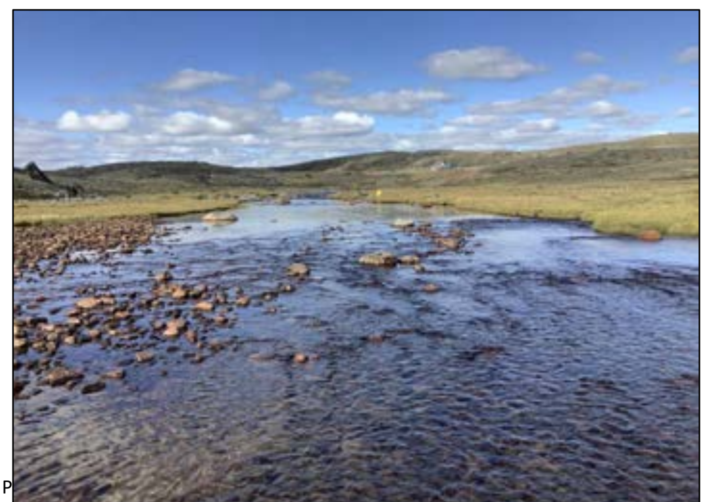
Channel Characteristics

Pattern:	ST
Islands:	N
Bars:	SP
Coupling:	DC
Confinement:	OC
Flow Stage:	Moderate

Fish Habitat Assessment Ratings

	Forage Fish	Coarse Fish	Sport Fish
Spawning:	None	None	Poor
Overwintering:	None	None	Poor
Rearing:	None	None	Poor
Passage:	None	None	Good

P



Fish Sampling Data

Method	**Effort**	**Species**	**Efish Catch** (n)	**Trap Catch** (n)	**Efish CPUE** (#fish/100s)	**Trap CPUE** (#fish/hr)	**Rel. Abundance** (% of total)

Electrofisher Settings

Volts	Freq. (Hz)	Duty Cycle (%)	Dist. (m)

General Comments

Prepared by: CB Reviewed by: LA

Nunami Stantec Limited -Apex River Study 2022

Site US-01: Apex River

UTM Location:	19V 525685 7072648	**Survey Date:**	August 19, 2022
Legal Location:		**Watercourse Class:**	
Crew Initials:	AB, CM	**Restricted Activity Period:**	

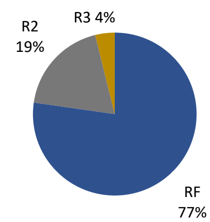
Physical Channel Transect Data

Transect # (Location)	**0**		**25**		**50**		**75**		**100**	
Channel Width (m)	5.80		10.9		6.9		16.0		32.5	
Wetted Width (m)	5.80		10.9		6.80		16.0		23.6	
Depth at LDB + 25% (m)	0.42		0.32		0.54		0.34		0.26	
Depth at LDB + 50% (m)	0.60		0.25		0.44		0.54		0.25	
Depth at LDB + 75% (m)	0.38		0.38		0.37		0.26		0.19	
Max. Depth (m)	0.96		0.69		0.87		0.91		0.26	
Gradient (%)	3		5		4		2		3	
Dominant Habitat Unit	RF		RF		R2		R2		RF	
Stream Bed										
Substrate (% of Transect Area) Organics	0		0		0		0		0	
Sand	10		10		10		10		0	
Small Gravel	0		0		0		0		0	
Large Gravel	0		10		5		0		0	
Cobble	15		20		15		20		20	
Boulder	75		60		70		70		80	
Bedrock	0		0		0		0		0	
Embeddedness	L		L		L		L		N	
Bank Measurements	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**
Bank Height (m)	0.30	0.36	0.31	0.18	0.20	0.33	0.38	0.31	0.41	0.20
Bank Slope (^{o})	90	90	80	90	90	80	80	80	90	45
Bank Stability	S	S	S	S	S	S	S	S	S	S
Dom. Bank Material	F	F	F	F	F	F	F	F	F	F
Subdom. Bank Material	O	O	O	O	O	O	O	O	O	O
Dom. Riparian Veg.	G	G	G	G	G	G	G	G	G	G
Subdom. Riparian Veg.									N	N

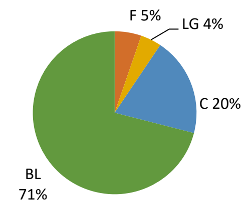
Habitat Inventory / Reach Data

Instream Cover (%):	21	Overhead Cover (%):	5
Dom. Instream Cover:	BL	Dom. Overhead Cover:	UC
Subdom. Instream Cover:	-	Subdom. Overhead Cover:	-
Maximum Depth (m)	-	Dom. Aquatic Veg. Type:	-

Habitat Distribution



Substrate Composition



Water Quality Data

Time of Day (HH:MM):	08:40
Water Temperature (^{o}C):	7.8
Dissolved Oxygen (mg/L):	10.65
Sp. Conductivity (µs/cm):	63.1
pH:	7.07
Turbidity (NTU):	0.00

Channel Characteristics

Pattern:	SI
Islands:	I
Bars:	SP
Coupling:	DC
Confinement:	OC
Flow Stage:	Moderate

Fish Habitat Assessment Ratings

	Forage Fish	Coarse Fish	Sport Fish
Spawning:	None	None	Poor
Overwintering:	None	None	Poor-moderate
Rearing:	None	None	Poor-moderate
Passage:	None	None	Good

P

Fish Sampling Data

Method	**Effort**	**Species**	**Efish Catch** (n)	**Trap Catch** (n)	**Efish CPUE** (#fish/100s)	**Trap CPUE** (#fish/hr)	**Rel. Abundance** (% of total)

Electrofisher Settings

Volts	Freq. (Hz)	Duty Cycle (%)	Dist. (m)

General Comments

Prepared by: CB Reviewed by: LA

APPENDIX E

Lake Geraldine Resupply 2022 Final Site Review November 3, 2022

Equipment Manifest (Pre-Mobilization)

NUNAMI STANTEC LIMITED

To:	Shane Turner Superintendent of Public Works/Water Works City of Iqaluit Eric Jacobsen President Tower Arctic Ltd.	From:	Matt Follett, M.A.Sc., P.Eng. Associate Civil Engineer Nunami Stantec Ltd.
File:	Lake Geraldine Emergency Resupply 2022	Date:	October 19, 2022

Reference: Lake Geraldine Emergency Resupply 2022 _ Equipment Manifest & Project Closeout

The following list summarizes the equipment returned following the project demobilization. If any items have been missed from this list, please make note of them in the rows provided at the end of the table and have all parties sign.

Item	Notes	Signoff (Initials)		
		City of Iqaluit	Nunami Stantec	TAL
Floating Pump Docks	These were used for the UNL pumping system and were purchased by the city. It is understood that these are located at the back of the Coke Plant.			
Operator Shack & Pump Control Room	UNL Shack & secondary building for pump controls. Controls, transformer, electrical components returned. Please confirm these have been placed outside the Coke Plant.		Isaac Freda	
3 Apex pumps & associated fish screens	It is understood that these are at the Coke Plant		Isaac Freda	
Manifolds	Apex river manifold. Outside of Coke Plant		Isaac Freda	
Flow Meters	3 x Apex are still attached to the Apex manifold outside of the Coke Plant.		Isaac Freda	
Hoses	The city owns 2 km of 4" flexible hose. It is understood that all hoses are in the green seacan outside of the Coke Plant.		Isaac Freda	
Apex Generator	The city-owned generator and associated seacan containment has been returned to outside of the Coke Plant.		Isaac Freda	

Reference: **Lake Geraldine Emergency Resupply 2022 _ Equipment Manifest & Project Closeout**

400mm HDPE	The uninsulated 400 mm HDPE used for the UNL portion of the project has been left on site near UNL.		Isaac Freda	
4" Flexible Hoses (GN-Owned)	TAL to pickup, layout, re-coil, and return flexible hoses from the GN to outside of the Apex warehouse. Hoses to be returned in good condition.		Isaac Freda	
Fuel Tanks	Apex Generator Fuel tanks (2) have been returned to outside of the Coke Plant.		Isaac Freda	
Add any additional equipment below				

This is a working document with expected updates as the project progresses.

Nunami Stantec Ltd.

Matt Follett, M.A.Sc., P.Eng.
Associate Civil Engineer - Nunavut

Phone: 613-223-1569
Matt.Follett@stantec.com

Final Site Review

To:	Amy Elgersma City of Iqaluit	From:	Erica Bonhomme Yellowknife, NT
File:	Lake Geraldine Emergency Resupply 2022	Date:	November 3, 2022

Reference: Lake Geraldine Emergency Resupply 2022_Final Site Review

1. General

I. This report will cover the work completed during the construction closeout phase/demobilization.

II. A site review was completed on Oct.03. At this time there was still material and equipment on site to be demobilized.

- **i.** The GN owned 4" hose was coiled up at set on pallets in one spot for the most part however it was still up the road very close to Unnamed Lake and would have to be brought back to the Apex warehouse. (Figure 1)
- **ii.** The seacans (staff room, generator, electrical/controls), as well as the fuel tanks for the generator at the Apex River were still on site. (Figure 5)
- **iii.** The 3 submersible pumps along with their associated fish screens were still in the Apex River. (Figure 3)
- **iv.** The Apex River pump manifold had been demobilized and brought to the coke plant. (Figure 7)
- **v.** There was still a large Caterpillar loader parked at Unnamed Lake as well as one at the Apex River site. (Figures 5, and 8)
- **vi.** The HDPE line at unnamed lake had yet to be capped. (Figure 9)
- **vii.** Some miscellaneous materials scraps, pallets, etc. are to be removed from site. (Figure 10)
- **viii.** The broken chain at the new road's gate had been fixed and locked

III. Once the required outstanding demobilization work was completed, we were unable to get out to site before a large snowfall had occurred in Iqaluit. This meant that the site was inaccessible, and a final review was not able to be completed safely.

IV. Fortunately, a representative from the City of Iqaluit was able to get out to site with a representative from Tower Ltd. To ensure the aforementioned outstanding items had been demobilized from site. The representative from the City of Iqaluit confirmed with Nunami Stantec that the tasks had been completed and that they were satisfied.

Reference: Lake Geraldine Emergency Resupply 2022_Final Site Review

V. A representative from the City of Iqaluit, Nunami Stantec, and Tower confirmed all materials and equipment had been returned to its proper place for winter storage while completing the demobilization manifests forms that all 3 parties signed-off on Oct.25, 2022.

VI. A representative from the GN (Emergency Preparedness Department) was notified of the return of the GN owned hoses to the Apex warehouse. A separate project closeout manifest form was presented to them regarding the placement and condition of the hoses upon return. The representative was satisfied with the return of the hoses.

2. Photos

Reference: Lake Geraldine Emergency Resupply 2022_Final Site Review

Figure 1: GN hoses rolled up and stacked on Pallets, still near Unnamed Lake site (Oct. 3)

Reference: Lake Geraldine Emergency Resupply 2022_Final Site Review

Figure 2: GN hoses placed at the Apex warehouse (Oct.19)

Reference: Lake Geraldine Emergency Resupply 2022_Final Site Review

Figure 3: Apex River site on Oct.3. Pumps still in the water.

Reference: Lake Geraldine Emergency Resupply 2022_Final Site Review

Figure 4: 3 Apex River pumps at the Coke Plant (Oct.19).

Reference: Lake Geraldine Emergency Resupply 2022_Final Site Review

Figure 5: Apex River site (Oct. 3). Three seacans still on-site.

Reference: Lake Geraldine Emergency Resupply 2022_Final Site Review

Figure 6: Apex River seacans outside the Coke Plant (Oct.19).

Reference: Lake Geraldine Emergency Resupply 2022_Final Site Review

Figure 7: Apex River pumps manifold outside the Coke Plant (Oct.19).

Reference: Lake Geraldine Emergency Resupply 2022_Final Site Review

Figure 8: Unnamed Lake site on (Oct.3).

Reference: Lake Geraldine Emergency Resupply 2022_Final Site Review

Figure 9: HDPE line at Unnamed Lake to be capped (Oct.3).

Reference: Lake Geraldine Emergency Resupply 2022_Final Site Review

Figure 10: Example of 1 of a few miscellaneous/scrap material piles to be removed from site (Oct.3).

Reference: Lake Geraldine Emergency Resupply 2022_Final Site Review

Nunami Stantec

Isaac Freda
P. Eng
Phone: Sender's Phone
Fax: Sender's Fax
Sender's Email

Attachment: Attachment

c. C.C.

APPENDIX F

Water Quality Results

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Certificate of Analysis

Stantec Consulting Ltd. (Ottawa)

2781 Lancaster Road, Suite 101
Ottawa, ON K2C 3G4
Attn: Matt Follett

Client PO:
Project: 144903261
Custody:

Report Date: 6-Sep-2022
Order Date: 30-Aug-2022

Order #: 2236155

This Certificate of Analysis contains analytical data applicable to the following samples as submitted:

Paracel ID	Client ID
2236155-01	Unnamed Lake UNL-01
2236155-02	Unnamed Lake UNL-02
2236155-03	Apex River APEX-01
2236155-04	Lake Geraldine LG-01

Approved By:

Dale Robertson, BSc
Laboratory Director

Analysis Summary Table

Analysis	Method Reference/Description	Extraction Date	Analysis Date
Ammonia, as N	EPA 351.2 - Auto Colour	1-Sep-22	1-Sep-22
Anions	EPA 300.1 - IC	31-Aug-22	31-Aug-22
E. coli	MOE E3407	31-Aug-22	31-Aug-22
Hardness	Hardness as CaCO3	31-Aug-22	31-Aug-22
Mercury by CVAA	EPA 245.2 - Cold Vapour AA	31-Aug-22	31-Aug-22
Metals, ICP-MS	EPA 200.8 - ICP-MS	31-Aug-22	31-Aug-22
pH	EPA 150.1 - pH probe @25 °C	31-Aug-22	31-Aug-22
Total Kjeldahl Nitrogen	EPA 351.2 - Auto Colour, digestion	31-Aug-22	6-Sep-22
Total Suspended Solids	SM 2540D - Gravimetric	31-Aug-22	1-Sep-22
Turbidity	SM 2130B - Turbidity meter	31-Aug-22	31-Aug-22

Certificate of Analysis

Client: Stantec Consulting Ltd. (Ottawa)

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Report Date: 06-Sep-2022

Order Date: 30-Aug-2022

Project Description: 144903261

Client ID:		Unnamed Lake UNL-01	Unnamed Lake UNL-02	Apex River APEX-01	Lake Geraldine LG-01
Sample Date:		29-Aug-22 10:00	29-Aug-22 10:15	29-Aug-22 10:30	29-Aug-22 11:00
Sample ID:		2236155-01	2236155-02	2236155-03	2236155-04
	MDL/Units	Water	Water	Water	Water
Microbiological Parameters					
E. coli	1 CFU/100mL	ND [1]	ND [1]	ND [1]	1
General Inorganics					
Ammonia as N	0.01 mg/L	<0.01	<0.01	<0.01	<0.01
Hardness	mg/L	21.0	21.4	33.7	15.3
pH	0.1 pH Units	7.5	7.5	7.6	7.3
Total Suspended Solids	2 mg/L	<2	<2	<2	<2
Total Kjeldahl Nitrogen	0.1 mg/L	0.1	0.1	0.1	0.2
Turbidity	0.1 NTU	0.2	0.2	0.1	0.5
Anions					
Bromide	0.1 mg/L	<0.1	<0.1	<0.1	<0.1
Chloride	1.0 mg/L	<1.0	<1.0	<1.0	<1.0
Fluoride	0.1 mg/L	<0.1	<0.1	0.1	<0.1
Nitrate as N	0.1 mg/L	<0.1	<0.1	<0.1	<0.1
Nitrite as N	0.05 mg/L	<0.05	<0.05	<0.05	<0.05
Phosphate as P	0.2 mg/L	<0.2	<0.2	<0.2	<0.2
Sulphate	1.0 mg/L	3.3	3.3	8.3	2.0
Metals					
Mercury	0.1 ug/L	<0.1	<0.1	<0.1	<0.1
Aluminum	1 ug/L	7	6	54	12
Antimony	0.5 ug/L	<0.5	<0.5	<0.5	<0.5
Arsenic	1 ug/L	<1	<1	<1	<1
Barium	1 ug/L	2	2	2	1
Beryllium	0.5 ug/L	<0.5	<0.5	<0.5	<0.5
Boron	10 ug/L	<10	<10	<10	<10
Cadmium	0.1 ug/L	<0.1	<0.1	<0.1	<0.1
Calcium	100 ug/L	7080	7210	10900	4730
Chromium	1 ug/L	<1	<1	<1	<1
Cobalt	0.5 ug/L	<0.5	<0.5	<0.5	<0.5
Copper	0.5 ug/L	0.6	<0.5	0.7	0.9
Iron	100 ug/L	<100	<100	<100	<100
Lead	0.1 ug/L	<0.1	<0.1	<0.1	<0.1
Magnesium	200 ug/L	802	827	1570	859
Manganese	5 ug/L	<5	<5	<5	11
Molybdenum	0.5 ug/L	<0.5	<0.5	<0.5	<0.5

Certificate of Analysis

Client: **Stantec Consulting Ltd. (Ottawa)**

Client PO:

Report Date: 06-Sep-2022

Order Date: 30-Aug-2022

Project Description: 144903261

	Client ID:	Unnamed Lake UNL-01	Unnamed Lake UNL-02	Apex River APEX-01	Lake Geraldine LG-01
	Sample Date:	29-Aug-22 10:00	29-Aug-22 10:15	29-Aug-22 10:30	29-Aug-22 11:00
	Sample ID:	2236155-01	2236155-02	2236155-03	2236155-04
	MDL/Units	Water	Water	Water	Water
Nickel	1 ug/L	<1	<1	<1	<1
Potassium	100 ug/L	197	201	199	172
Selenium	1 ug/L	<1	<1	<1	<1
Silver	0.1 ug/L	<0.1	<0.1	<0.1	<0.1
Sodium	200 ug/L	751	744	980	724
Strontium	10 ug/L	11	11	19	11
Thallium	0.1 ug/L	<0.1	<0.1	<0.1	<0.1
Tin	5 ug/L	<5	<5	<5	<5
Titanium	5 ug/L	<5	<5	<5	<5
Tungsten	10 ug/L	<10	<10	<10	<10
Uranium	0.1 ug/L	<0.1	<0.1	<0.1	<0.1
Vanadium	0.5 ug/L	<0.5	<0.5	<0.5	<0.5
Zinc	5 ug/L	<5	<5	<5	<5

Method Quality Control: Blank

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Bromide	ND	0.1	mg/L						
Chloride	ND	1.0	mg/L						
Fluoride	ND	0.1	mg/L						
Nitrate as N	ND	0.1	mg/L						
Nitrite as N	ND	0.05	mg/L						
Phosphate as P	ND	0.2	mg/L						
Sulphate	ND	1.0	mg/L						
General Inorganics									
Ammonia as N	ND	0.01	mg/L						
Total Suspended Solids	ND	2	mg/L						
Total Kjeldahl Nitrogen	ND	0.1	mg/L						
Turbidity	ND	0.1	NTU						
Metals									
Mercury	ND	0.1	ug/L						
Aluminum	ND	1	ug/L						
Antimony	ND	0.5	ug/L						
Arsenic	ND	1	ug/L						
Barium	ND	1	ug/L						
Beryllium	ND	0.5	ug/L						
Boron	ND	10	ug/L						
Cadmium	ND	0.1	ug/L						
Calcium	ND	100	ug/L						
Chromium	ND	1	ug/L						
Cobalt	ND	0.5	ug/L						
Copper	ND	0.5	ug/L						
Iron	ND	100	ug/L						
Lead	ND	0.1	ug/L						
Magnesium	ND	200	ug/L						
Manganese	ND	5	ug/L						
Molybdenum	ND	0.5	ug/L						
Nickel	ND	1	ug/L						
Potassium	ND	100	ug/L						
Selenium	ND	1	ug/L						
Silver	ND	0.1	ug/L						
Sodium	ND	200	ug/L						
Strontium	ND	10	ug/L						
Thallium	ND	0.1	ug/L						
Tin	ND	5	ug/L						
Titanium	ND	5	ug/L						
Tungsten	ND	10	ug/L						
Uranium	ND	0.1	ug/L						
Vanadium	ND	0.5	ug/L						
Zinc	ND	5	ug/L						
Microbiological Parameters									
E. coli	ND	1	CFU/100mL						

Certificate of Analysis
Client: Stantec Consulting Ltd. (Ottawa)
Client PO:

Report Date: 06-Sep-2022
Order Date: 30-Aug-2022
Project Description: 144903261

Method Quality Control: Duplicate

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Bromide	0.11	0.1	mg/L	0.26			NC	10	
Chloride	ND	1.0	mg/L	ND			NC	10	
Fluoride	ND	0.1	mg/L	ND			NC	10	
Nitrate as N	ND	0.1	mg/L	ND			NC	10	
Nitrite as N	ND	0.05	mg/L	ND			NC	10	
Phosphate as P	ND	0.2	mg/L	ND			NC	10	
Sulphate	ND	1.0	mg/L	324			NC	10	
General Inorganics									
Ammonia as N	ND	0.01	mg/L	ND			NC	18	
pH	7.3	0.1	pH Units	7.3			0.5	3.3	
Total Suspended Solids	2.0	2	mg/L	2.0			0.0	10	
Total Kjeldahl Nitrogen	ND	0.1	mg/L	0.33			NC	16	
Turbidity	0.2	0.1	NTU	0.2			0.0	10	
Metals									
Mercury	ND	0.1	ug/L	ND			NC	20	
Antimony	ND	0.5	ug/L	ND			NC	20	
Arsenic	ND	1	ug/L	ND			NC	20	
Barium	1.6	1	ug/L	1.8			14.0	20	
Beryllium	ND	0.5	ug/L	ND			NC	20	
Boron	ND	10	ug/L	ND			NC	20	
Cadmium	ND	0.1	ug/L	ND			NC	20	
Calcium	7050	100	ug/L	7080			0.5	20	
Chromium	ND	1	ug/L	ND			NC	20	
Cobalt	ND	0.5	ug/L	ND			NC	20	
Copper	0.51	0.5	ug/L	0.55			7.6	20	
Iron	ND	100	ug/L	ND			NC	20	
Lead	ND	0.1	ug/L	ND			NC	20	
Magnesium	831	200	ug/L	802			3.6	20	
Manganese	ND	5	ug/L	ND			NC	20	
Molybdenum	ND	0.5	ug/L	ND			NC	20	
Nickel	ND	1	ug/L	ND			NC	20	
Potassium	213	100	ug/L	197			8.0	20	
Selenium	ND	1	ug/L	ND			NC	20	
Silver	ND	0.1	ug/L	ND			NC	20	
Sodium	867	200	ug/L	751			14.3	20	
Strontium	11	10	ug/L	11			2.9	20	
Thallium	ND	0.1	ug/L	ND			NC	20	
Tin	ND	5	ug/L	ND			NC	20	
Titanium	ND	5	ug/L	ND			NC	20	
Tungsten	ND	10	ug/L	ND			NC	20	
Uranium	ND	0.1	ug/L	ND			NC	20	
Vanadium	ND	0.5	ug/L	ND			NC	20	
Zinc	ND	5	ug/L	ND			NC	20	
Microbiological Parameters									
E. coli	ND	1	CFU/100mL	ND			NC	30	BAC14

Method Quality Control: Spike

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Bromide	1.24	0.1	mg/L	0.26	98.6	80-120			
Chloride	10.3	1.0	mg/L	ND	103	80-120			
Fluoride	1.08	0.1	mg/L	ND	108	80-120			
Nitrate as N	1.03	0.1	mg/L	ND	103	80-120			
Nitrite as N	1.09	0.05	mg/L	ND	109	80-120			
Phosphate as P	5.15	0.2	mg/L	ND	103	70-130			
Sulphate	9.91	1.0	mg/L	ND	99.1	75-125			
General Inorganics									
Ammonia as N	0.203	0.01	mg/L	ND	81.3	81-124			
Total Suspended Solids	22.0	2	mg/L	ND	110	75-125			
Total Kjeldahl Nitrogen	1.88	0.1	mg/L	ND	93.8	81-126			
Metals									
Mercury	2.53	0.1	ug/L	ND	84.3	70-130			
Aluminum	62.2	1	ug/L	6.8	111	80-120			
Arsenic	42.7	1	ug/L	ND	85.2	80-120			
Barium	44.3	1	ug/L	1.8	85.1	80-120			
Beryllium	46.8	0.5	ug/L	ND	93.6	80-120			
Boron	47	10	ug/L	ND	91.3	80-120			
Cadmium	47.0	0.1	ug/L	ND	94.1	80-120			
Calcium	16900	100	ug/L	7080	97.7	80-120			
Chromium	52.6	1	ug/L	ND	104	80-120			
Cobalt	54.1	0.5	ug/L	ND	108	80-120			
Copper	48.4	0.5	ug/L	0.55	95.6	80-120			
Iron	2510	100	ug/L	ND	99.3	80-120			
Lead	47.0	0.1	ug/L	ND	93.9	80-120			
Magnesium	11500	200	ug/L	802	107	80-120			
Manganese	52.9	5	ug/L	ND	102	80-120			
Molybdenum	49.1	0.5	ug/L	ND	97.9	80-120			
Nickel	49.8	1	ug/L	ND	99.3	80-120			
Potassium	11200	100	ug/L	197	110	80-120			
Selenium	50.5	1	ug/L	ND	101	80-120			
Silver	45.4	0.1	ug/L	ND	90.7	80-120			
Sodium	11500	200	ug/L	751	107	80-120			
Strontium	59	10	ug/L	11	96.9	80-120			
Thallium	45.6	0.1	ug/L	ND	91.2	80-120			
Tin	45.0	5	ug/L	ND	89.4	80-120			
Titanium	59.2	5	ug/L	ND	118	80-120			
Tungsten	50.5	10	ug/L	ND	101	80-120			
Uranium	51.8	0.1	ug/L	ND	104	80-120			
Vanadium	52.4	0.5	ug/L	ND	105	80-120			
Zinc	49	5	ug/L	ND	97.9	80-120			

Qualifier Notes:

Sample Qualifiers :

1 : A2C - Background counts greater than 200

QC Qualifiers :

BAC14 A2C - Background counts greater than 200

Sample Data Revisions

None

Work Order Revisions / Comments:

None

Other Report Notes:

n/a: not applicable
ND: Not Detected
MDL: Method Detection Limit
Source Result: Data used as source for matrix and duplicate samples
%REC: Percent recovery.
RPD: Relative percent difference.
NC: Not Calculated

Paracel ID: 2236155

PARACEL LABORATORIES LTD

Paracel Order Number (Lab Use Only)	Chain Of Custody (Lab Use Only)
2236155	

Client Name: Stantec / City of Iqaluit	Project Ref: 144903261	Page _ of _	
Contact Name: Matt Follett	Quote #: Stantec MSA 2020-2023-DW	Turnaround Time	
Address: ~~108-C Noble House, Iqaluit~~. Ottawa, ON	PO #:	☐ 1 day	☐ 3 day
	E-mail: matt.follett@stantec.com erica.bonhomme@stantec.com	☐ 2 day	☑ Regular
Telephone: 613-223-1569		Date Required: 2022-09-02	

☐ REG 153/04 ☐ REG 406/19 | Other Regulation

☐ Table 1 ☐ Res/Park ☐ Med/Fine | ☐ REG 558 ☐ PWQO

☐ Table 2 ☐ Ind/Comm ☐ Coarse | ☐ CCME ☐ MISA

☐ Table 3 ☐ Agri/Other | ☐ SU - Sani ☐ SU - Storm

☐ Table ___ | Mun: Northern Health

For RSC: ☐ Yes ☐ No | ☑ Other: Public Health Prot.

Matrix Type: S (Soil/Sed.) GW (Ground Water) SW (Surface Water) SS (Storm/Sanitary Sewer) P (Paint) A (Air) O (Other)

Required Analysis

	Sample ID/Location Name		Matrix	Air Volume	# of Containers	Date	Time	Ammonia as N	Anions full scan	CBOD	Chloride	E. Coli	General Water Quality	Hardness	Mercury	Metals - full scan	pH	Total K-N	TSS	Turbidity
1	Unnamed Lake	UNL-01	SW		7	08/29/22	10:00	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
2	Unnamed Lake	UNL-02	SW		7	08/29/22	10:15	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
3	Apex River	APEX-01	SW		7	08/29/22	10:30	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
4	Lake Geraldine	LG-01	SW		7	08/29/22	11:00	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
5																				
6																				
7																				
8																				
9																				
10																				

Comments: Revised CoC			Method of Delivery: Canadian North
Relinquished By (Sign): [signature]	Received By Driver/Depot:	Received at Lab: [signature]	Verified By: [signature]
Relinquished By (Print): Matt Follett, M.A.Sc., P.Eng.	Date/Time:	Date/Time: Aug 30 2022 1440	Date/Time: Aug 30 2022 1500
Date/Time: August 29, 2022	Temperature: °C	Temperature:	pH Verified: ☑ By:

Chain of Custody (Blank).xlsx Revsion 4.0

Paracel ID: 2236155

PARACEL LABORATORIES

Laurent Blvd.
rio K1G 4J8
1947
aracellabs.com
abs.com

Paracel Order Number: 2236155

Chain Of Custody
Ontario Drinking Water Samples

№ 17189

Client Name: Stantec	Project Ref: 1449	Waterworks Name: City of Iqaluit	Samples Taken By:	
Contact Name: Matt follett	Quote #:	Waterworks Number:	Name: matt follett	
Address: Iqaluit, NU	PO #:	Address:	Signature: [signature]	
After Hours Contact: Matt	E-mail: matt.follett@stantec.com		Page ___ of ___	
Telephone: 613-223-1569	Fax:	Public Health Unit:	Turn Around Time Required: ☐ 1 day ☐ 2 day ☐ 3 day ☐ 4 day	

Samples Submitted Under: (Indicate ONLY one)
☐ ON REG 170/03 ☐ ON REG 319/08 ☐ Private Well
☐ ON REG 243/07 ☒ Other:

Have LSN forms been submitted to MOE/MOHLTC?: ☐ Yes ☐ No ☒ N/A

Are these samples for human consumption?: ☒ Yes ☐ No

All information must be completed before samples will be processed.

Sample Type: R = Raw ; T = Treated ; D = Distribution; P = Plumbing
Source Type: G = Ground Water; S = Surface Water
Reportable: Requires AWQI reporting as per Regulation - Y = Yes; N = No

Required Analyses

	LOCATION NAME	SAMPLE ID	Sample Type: R/T/D/P	Source Type: G / S	Reportable: Y / N	Resample	SAMPLE COLLECTED DATE	SAMPLE COLLECTED TIME	# of Containers	Free/Combined Chlorine Residual mg/L	Standing / Flushed: S/F (REG 243)	Total Coliform/E. Coli	HPC	Lead	THM			
1	~~UNL-01~~ Unnamed Lake	UNL-01	R	S	N	N	08/29/22	10 Am	7									
2	Apex River	APEX-01	R	S	N	N	08/29/22	10:30AM	7									
3	Lake Geraldine	LG-01	R	S	N	N	08/29/22	11:00 AM	7									
4	Unnamed Lake	UNL-02	R	S	N	N	08/29/22	10:15Am	7									
5																		
6																		
7																		
8																		
9																		
10																		

Comments: Call matt follett @ 1-613-223-1569 prior to processing

Method of Delivery: Canadian North

Relinquished By (Sign):	Received By Driver/Depot:	Received at Lab: [signature]	Verified By: [signature]
Relinquished By (Print):	Date/Time:	Date/Time: Aug 30 2022 14:40	Date/Time: Aug 30 2022 1506
Date/Time:	Temperature: °C	Temperature: 6.9 °C	pH Verified: ☒ By: [initials]

APPENDIX D

APEX RIVER SUPPLEMENTAL PUMPING NON-TECHNICAL EXECUTIVE SUMMARY

ᐅᐃᒍ D – ᓂᐊᕐᑯᖕᒎᑎᐅᑉ ᑰᖕᒐᓂᑦ ᐃᒥᑦᓴᒥᑦ ᒥᓪᓗᐊᕐᓂᖅ
ᐊᖏᔪᖅᑲᐅᑎᓄᑦ ᐅᓂᒃᑳᑦᓴᑦ ᐱᓪᓗᐊᑕᖏᓐᓂᑦ

ᒪᓕᑦᑐᒍ ᐃᒥᓕᕆᔪᓐᓇᐅᑎ ᓚᐃᓴ 3AM-IQA1626 ᐊᓯᒃᕿᐅᑎ 4, ᑐᐊᕕᕐᓇᑐᒃᑯᑦ ᐊᓯᒃᕿᐅᑎ 7, ᐊᒻᒪ ᐃᖃᓗᓕᕆᔩᒃᑯᑦ ᒪᓕᒐᖓᑎᒍᑦ ᐱᔪᓐᓇᐅᑎ 22-HCAA-02043 (DFO 2022: ᐃᐊᕝᐊᐃᐊᐃᒃᑯᑦ (FAA) ᐱᑎᑦᓯᓚᐅᕐᓯᒪᔪᑦ ᓄᓇᓕᐸᐅᔭᐃᑦ ᐃᖃᓗᐃᑦ (ᓄᓇᓕᐸᐅᔮᒃᑯᑦ), ᓄᓇᓕᐸᐅᔮᒃᑯᑦ ᒥᓪᓗᐊᕈᓐᓇᓕᓚᐅᖅᑐᑦ ᐃᒥᕐᒥᒃ ᐊᐅᔭᖓᓂ 2022 ᐃᒥᖅᑕᖅᑐᑎᒃ ᐃᒥᖅᑕᕕᒻᒧᑦ ᒥᓪᓗᐊᖅᑕᐅᓗᓂ ᐃᒥᖅ ᓂᐊᕐᑯᖕᒎᑎᐅᑉ ᑰᖕᒐᓂᑦ. ᒪᓕᑦᑐᒍ ᑐᐊᕕᕐᓇᖅᑐᒃᑯᑦ ᐊᓯᒃᕿᐅᑎ 7, ᓄᓇᓕᐸᐅᔮᒃᑯᑦ ᐱᔪᓐᓇᐅᑎᖃᓕᓚᐅᖅᑐᑦ ᐃᒥᖅᑕᕈᓐᓇᖅᑐᑎᒃ ᐊᑎᖃᕐᑎᑦᑐᒥᑦ ᑕᑯᕐᒥᑦ - ᓄᓇᓕᐸᐅᔮᒃᑯᓂᑦ ᐱᓕᕆᐊᖑᓚᐅᕐᑎᑦᑐᖅ ᑭᓯᐊᓂ ᓄᓇᓕᐸᐅᔮᒃᑯᑦ ᐃᒥᖅᑕᕈᓐᓇᓚᐅᕐᒪᑕ ᓂᐊᕐᑯᖕᒎᑎᐅᑉ ᑰᖕᒐᓂᑦ (ᐊᓯᒃᕿᐅᑎᒃᑯᑦ 4). ᑕᒪᓐᓇ ᐱᓪᓗᒍ, ᐅᓂᒃᑳᓕᐅᕆᐊᑐᓚᐅᕈᓐᓃᖅᑐᑦ ᒪᓕᑦᑐᒍ ᐊᓯᒃᕿᐅᑎ 7 ᐊᑐᖅᑕᐅᒋᐊᑐᓚᐅᕐᒋᒪᑕ 2022-ᒥ.

2022 ᐃᒥᖅᑕᕐᓂᐅᓚᐅᖅᑐᖅ ᒥᓪᓗᐊᓂᒃᑯᑦ ᐱᓕᕆᐊᑦᓴᖅ ᐱᔭᕇᖅᑕᐅᓚᐅᖅᑐᖅ ᐊᑯᓐᓂᖏᓐᓂ ᐃᐳᕈ 30, 2022 (ᐱᒋᐊᕈᑎᒥᑦ ᑲᑎᒪᓂᖄᖅᑐᑎᒃ) ᐊᒻᒪ ᐋᑦᑐᐸ 19, 2022 (ᐱᓕᕆᔪᓐᓃᕐᓂᖅ). ᐱᓕᕆᐊᑦᓴᐃᑦ ᐊᒻᒪ ᖃᓄᐃᓕᐅᕈᓰᑦ ᐱᔭᕇᖅᑕᐅᓯᒪᔪᑦ ᐱᖃᓯᐅᔾᔨᔪᑦ:

- ᐱᓕᕆᔾᔪᑎᖃᕆᐊᕐᓂᖅ ᓱᓇᒃᑯᑖᓂᑦ ᐊᒻᒪ ᒪᑭᒪᑎᑦᓯᔾᔪᑎᓂᑦ ᓂᐊᕐᑯᖕᒎᑎᐅᑉ ᑰᖕᒐᓂᑦ ᒥᓪᓗᐊᕐᕕᐅᓂᐊᖅᑐᒥᑦ;
- ᐋᖅᑭᑦᓯᐃᓂᖅ ᒥᓪᓗᐊᕈᑎᑦᓴᓂᑦ, ᑲᖖᒫᑎᑦᓯᔾᔪᑎᖏᓐᓂᑦ, ᐊᒻᒪ ᐅᐃᒍᔭᐅᓗᑎᒃ ᓂᐊᕐᑯᖕᒎᑎᐅᑉ ᑰᖕᒐᓄᑦ ᒥᓪᓗᐊᕈᑎᑦᓴᑦ;
- ᐱᔭᕇᖅᑕᐅᓂᖓ ᐃᖃᓗᒃᓴᒫᖅ ᐊᒻᒪ ᐃᖃᓗᒃᕕᐅᒪᖖᒫᖅ ᖃᐅᔨᓴᕐᓂᖅ, ᐃᖃᓗᖏᓐᓂᑦ ᐊᒻᒪ ᐃᓂᖏᓐᓂᑦ ᖃᐅᔨᓴᐃᓇᕐᓂᖅ ᐊᒻᒪ ᑰᓂᖓᓂᑦ ᓂᐊᕐᑯᖕᒎᑎᐅᑉ ᑰᖕᒐᓂᑦ;
- ᐋᖅᑭᑦᓯᐃᓂᖅ ᐊᒻᒪ ᐊᐅᓚᑦᑎᒋᐊᕐᓂᖅ ᒥᓪᓗᐊᕈᑎᓂᑦ ᓂᐊᕐᑯᖕᒎᑎᐅᑉ ᑰᖕᒐᓂᑦ;
- ᐊᐅᓚᑕᐅᓂᖓ ᐃᒥᐅᑉ ᓂᐊᕐᑯᖕᒎᑎᐅᑉ ᑰᖕᒐᓂᑦ ᐃᒥᖅᑕᕕᒻᒧᑦ;
- ᐃᑲᔪᕐᓯᐃᔾᔪᑎᓂᑦ ᐱᓕᕆᔾᔪᑎᖃᕐᓂᖅ ᓱᕐᓗ ᐅᐊᔭᒨᖅᑐᓄᑦ, ᒪᑭᒪᑎᑦᓯᔾᔪᑎᓄᑦ, ᐅᕐᓴᐃᔾᔪᑎᓄᑦ, ᐊᒻᒪ ᖃᐅᑕᒫᑦ ᖃᐅᔨᓴᐅᑎᖏᓐᓂᑦ; ᐊᒻᒪ
- ᐱᓕᕆᔾᔪᑎᖃᕈᓐᓃᕐᓂᖅ ᓱᓇᒃᑯᑖᓂᑦ ᐊᒻᒪ ᒪᑭᒪᑎᑦᓯᔾᔪᑎᓂᑦ (ᐊᓯᖏᓐᓂᑦ ᐋᖅᑭᑦᓯᒪᐃᓐᓇᓂᐊᖅᑐᑦ ᓱᓪᓗᓐᓕᑦ).

ᐃᒥᑦᓴᒥᑦ ᒥᓪᓗᐊᕐᓯᓂᖅ ᓂᐊᕐᑯᖕᒎᑎᐅᑉ ᑰᖕᒐᓂᑦ ᐃᒥᖅᑕᕕᒻᒧᑦ ᐱᔭᕇᖅᑕᐅᓚᐅᖅᑐᖅ ᐊᑯᓐᓂᖏᓐᓂ ᔪᓂ 12 ᐊᒻᒪ ᓯᑉᑎᐱᕆ 19, 2022. ᑲᑎᑦᑐᒍ ᐃᒪᖓᓄᑦ ᐃᒥᕐᒥᒃ 444,390 m³ ᐃᒥᖅᑕᕕᒻᒨᕆᐊᓚᐅᖅᑐᑦ. ᖃᐅᑕᒫᑦ ᒥᓪᓗᐊᖅᑕᖅ ᐃᒥᖅ ᐃᒪᖓᐅᓚᐅᖅᑐᖅ 14,541 m³ ᔪᓂ 16-ᒥ, 2022. ᒥᓪᓗᐊᖅᑕᐅᕙᓚᐅᖅᑐᑦ ᖃᐅᑕᒫᑦ ᑎᑎᖅᐸᓚᐅᖅᑕᖏᑦ ᑳᑐᕋᑎᒍᑦ ᐱᓕᕆᔨᐅᕝᕕᐊ ᒥᓪᓗᐊᕕᐅᕙᒃᑯᐊ ᐊᒻᒪ ᓄᓇᓕᐸᐅᔮᒃᑯᑦ ᖃᐅᔨᒪᔨᑕᕐᒥᑦ ᓴᒋᐊᓕᖓᓂᑦ ᑭᒡᒐᖅᑐᐃᔨᒧᑦ ᐱᓕᕆᐊᖑᕙᑦᑐᒃ ᖃᐅᔨᓴᖅᑕᐅᕙᑦᑐᒃ ᐊᒻᒪ ᖃᐅᔨᓴᖅᑕᐅᖏᓐᓇᖅᑐᒃ ᐱᓕᕆᐊᖃᕐᓂᖏᓐᓂᑦ ᓇᓗᓇᐃᕐᓯᒪᓪᓗᒃ ᒪᓕᑦᑕᐅᕙᒃᑲᓗᐊᕐᒪᖔᑕ ᒪᓕᒐᐃᑦ ᑎᑎᕋᕐᓯᒪᔪᑦ ᓚᐃᓴᒥ.

ᐃᒥᑦᓴᒥᑦ ᒥᓪᓗᐊᕐᓯᓂᒥᑦ ᐱᓕᕆᐊᑦᓴᖅ ᐱᔭᕇᖅᑕᐅᓚᐅᖅᑐᖅ ᒪᕐᕈᐃᓕᖕᒐᓪᓗᓂ. ᒥᓪᓗᐊᕐᓯᓂᖅ ᓯᕗᓪᓕᖅ 1 ᐊᑐᖅᑕᐅᓚᐅᖅᑐᖅ ᐊᑯᓐᓂᖏᓐᓂ ᔪᓂ 12 ᐊᒻᒪ ᓯᑉᑎᐱᕆ 12 ᐊᒻᒪ ᒪᓕᓚᐅᖅᑐᑦ ᒪᓕᒋᐊᓕᖕᓂᑦ ᓇᓗᓇᐃᔭᕐᓯᒪᔪᓂᑦ ᐊᓯᒃᕿᐅᑎ 4. ᒥᓪᓗᐊᕐᓯᓂᖅ ᑐᓪᓕᐊ 2 ᐊᑐᖅᑕᐅᓚᐅᖅᑐᖅ ᐊᑯᓐᓂᖏᓐᓂ ᓯᑉᑎᐱᕆ 13 ᐊᒻᒪ ᓯᑉᑎᐱᕆ 19 ᐊᒻᒪ ᒪᓕᓚᐅᖅᑐᑎᒃ ᒪᓕᒋᐊᓕᖕᓂᑦ ᐊᓯᒃᕿᐅᑎ ᐊᒻᒪ ᐃᒪᓕᕆᔨᒃᑯᑦ ᒪᓕᒐᖏᑎᒍᑦ ᐱᔪᓐᓇᐅᑎᒃᑯᑦ (FAA). ᒥᓪᓗᐊᓚᐅᖏᑦᑐᑦ ᐊᑯᓐᓂᖏᓐᓂ ᔪᓚᐃ 10 ᐊᒻᒪ ᔪᓚᐃ 23, 2022 ᑰᓗᐊᓚᐅᕈᓐᓃᕐᓂᖓᓄᑦ ᓂᐊᕐᑯᖕᒎᑎᐅᑉ ᑰᖕᒐ. ᒥᓪᓗᐊᓂᒃᑯᑦ 2 ᓇᓗᓇᐃᕐᓯᓚᐅᖅᑐᑦ ᐅᓗᕆᐊᓇᖅᑐᓂᑦ ᐊᓯᒃᓲᓚᐅᕐᒋᑦᑐᑦ, ᐸᕝᕕᓴᓚᐅᕐᒋᑦᑐᑦ, ᐊᒻᒪ ᓱᕋᐃᓚᐅᕐᒋᑦᑐᑦ ᐃᖃᓗᒃᕚᓂᑦ ᓂᐊᕐᑯᖕᒎᑎᐅᑉ ᑰᖕᒐᓂᑦ ᒥᓪᓗᐊᑎᓪᓗᒋᑦ ᒪᓕᑦᑐᑎᒃ ᐃᒪᓕᕆᔩᒃᑯᑦ ᒪᓕᒐᖏᓐᓂᑦ. ᑕᒪᓐᓇ ᐱᓪᓗᒍ, ᐃᖃᓗᓕᕆᔪᓂᑦ ᐅᕝᕙᓘᓐᓃᑦ ᐃᓂᖏᓐᓂᑦ ᒪᓕᒐᖏᓐᓂᑦ ᐊᑐᕆᐊᑐᖏᑦᑐᑦ ᖃᓄᐃᒍᑎᖃᕐᓂᕈᑎᒃ ᒪᓕᒋᐊᓕᖕᓂᑦ.

APPENDIX E

LONG-TERM WATER OPTIONS ANALYSIS REPORT

NUNAMI STANTEC LIMITED

Comparative Evaluation of Sylvia Grinnell River and Unnamed Lake as Long-Term Water Supply for City of Iqaluit

Final

December 6, 2022

Prepared for:

City of Iqaluit

Prepared by:

Nunami Stantec Ltd.

COMPARATIVE EVALUATION OF SYLVIA GRINNELL RIVER AND UNNAMED LAKE AS LONG-TERM WATER SUPPLY FOR CITY OF IQALUIT

This document entitled Comparative Evaluation of Sylvia Grinnell River and Unnamed Lake as Long-Term Water Supply for City of Iqaluit was prepared by Nunami Stantec Ltd. ("Nunami Stantec") for the account of City of Iqaluit (the "Client"). Any reliance on this document by any third party is strictly prohibited. The material in it reflects Nunami Stantec's professional judgment in light of the scope, schedule and other limitations stated in the document and in the contract between Nunami Stantec and the Client. The opinions in the document are based on conditions and information existing at the time the document was published and do not take into account any subsequent changes. In preparing the document, Nunami Stantec did not verify information supplied to it by others. Any use which a third party makes of this document is the responsibility of such third party. Such third party agrees that Nunami Stantec shall not be responsible for costs or damages of any kind, if any, suffered by it or any other third party as a result of decisions made or actions taken based on this document.

Prepared by ______________________________
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(signature)

Walter Orr, P.Eng.

Approved by ______________________________
(signature)

Erica Bonhomme, P.Geo.

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Executive Summary

The City of Iqaluit has been studying options for expanding its capability to provide a long-term water supply for its growing population. Based on the Iqaluit Water Storage Pre-Feasibility Study (EXP 2020), the City's population is currently approximately 9,000 residents, and could grow to 24,000 by the year 2050 under a high growth scenario. The City's water supply, Lake Geraldine, has for several years been inadequate on its own to address the City's water demands, which are approximately 400 litres per person per day (Lpcd). The City has previously commissioned several studies to identify options for additional supply and storage to address its future water needs, including studies of the Sylvia Grinnell River, Apex River, and Unnamed Lake.

This report provides a comparison of Sylvia Grinnell River and Unnamed Lake as the primary options for the City's long term water supplies, including a discussion on how the Apex River can contribute. The evaluation criteria were organized under three main categories: Technical, Economic, and Environmental. Within each of these, the following were considered:

Capacity	Pumping during summer (open-water) only, or also during winter
Supply	Can the source meet predicted quantities in the short term (2026) and in the long term (2050)
Accessibility	Infrastructure to access Sylvia Grinnell or Unnamed Lake, such as roads, power, pipeline, and pumps
Implementation	Constructability, O&M complexity, and asset security
Costs	Capital, operational, and life cycle
Environmental / Socio-cultural	Biophysical and socio-cultural environments, regulatory approvals, land use planning, and consultation results and requirements

The evaluation determined that:

1. SGR could be a sustainable supply for a population of 24,000, however, it would require an additional storage reservoir as it can only be used during open-water season.
2. UNL by itself could be a sustainable supply up to a population of 17,000 (with additional supply potential from Apex River). UNL does not require an additional reservoir as it, in itself, is a functioning reservoir.

The pumping scenario reviewed for SGR indicates that a three-month pumping regime would be used during open water. Because of the elevation increase from SGR to Lake Geraldine, this is paired with additional pumping requirements. The additional pumping requirements add cost and O&M requirements.

We consider that the optimal pumping scenario for UNL is to continuously resupply Lake Geraldine from UNL. That recommendation will require further analysis during detailed design to optimize pumping and other operational details. Required equipment and controls will also be determined later in design. UNL has minimal pumping requirements and could potentially generate power. While continuous pumping is optimal for the UNL system and would not require an additional reservoir ($65M), winter operations may present risk to the City. As such, it has been requested to move forward with three-month, summer operation of the UNL system and additional reservoir.

The estimated costs for SGR and UNL are summarized below:

	Sylvia Grinnell River	Unnamed Lake
Capital	$32.5M + $65M	$15M + $65M
Power, O&M	$1M, $300k	-$150k, $150k

SGR optimal concept indicates that intake Site B with a pipeline route towards the airport runway then overland be selected. For UNL, at the pre-conceptual level, considering the minor differences in cost between Options 1 and 2, we suggest that both pipeline routing options remain considered for UNL until detailed topography is evaluated during design.

Consultation determined a preference for development of the UNL option as SGR is an active and important cultural resource.

Abbreviations

City	City of Iqaluit
DFO	Department of Fisheries and Oceans
HP	Horsepower
km	kilometre
KWH	Kilowatt Hours
L	litre
LGHC	Lake Geraldine Headwater Creek
m	metre
Nunami Stantec	Nunami Stantec Ltd.
NWB	Nunavut Water Board
s	Second
SGR	Sylvia Grinnell River
UNL	Unnamed Lake

1.0 INTRODUCTION

1.1 PURPOSE AND SCOPE OF EVALUATION

The City of Iqaluit (the “City”) has been studying options for expanding its capability to provide a long-term water supply for its growing population. Based on the Iqaluit Water Storage Pre-Feasibility Study (EXP 2020), the City’s population is currently approximately 9,000 residents, and could grow to 24,000 by the year 2050 under a high growth scenario. The City’s water supply, Lake Geraldine, has for several years been inadequate on its own to address the City’s water demands, which are approximately 400 litres per person per day (Lpcd). The City has previously commissioned several studies to identify options for additional supply and storage to address its future water needs, including studies of the Sylvia Grinnell River, Apex River, and Unnamed Lake.

Nunami Stantec Limited (Nunami Stantec) was retained by the City to complete a comparative evaluation of the Sylvia Grinnell River (SGR) and Unnamed Lake (UNL) as options for supplemental long-term water supply based on available reports and information. This report presents the outcomes of this evaluation. This report’s scope includes engineering and environmental considerations associated with obtaining and conveying supplemental water from supply (SGR or UNL) to storage (Lake Geraldine and/or a new reservoir as discussed in EXP 2020). In all cases, the evaluation assumes that Lake Geraldine remains the primary source of water for the City. This report relies on and does not include evaluation of storage nor supply as reported on by others, and the findings are limited by the assumptions and limitations made in these other reports, as identified in the following section.

1.2 PREVIOUS STUDIES

This evaluation of the SGR and UNL benefits from and relies on studies and information previously presented in the following reports:

- Iqaluit Water Storage Pre-Feasibility Study (EXP 2020)
- Water Balance Assessment for Unnamed Lake – Modelling Report (Golder 2021)
- Options Evaluation for Raw Water Supplementation from the Sylvia Grinnell River (Nunami Stantec 2018)
- Conceptual Design Advancement for Raw Water Supplementation from the Sylvia Grinnell River (Nunami Stantec 2019a)
- Unnamed Lake Fish and Fish Habitat Assessment Technical Report (WSP 2021)
- Iqaluit DFO Bathymetric Lake Surveys (Tetra Tech 2019)

These previous studies have provided information to enable an evaluation of the SGR and UNL supply concepts. An additional pre-concept level description of UNL as a water source has been developed by

Nunami Stantec specifically to benefit this evaluation (see Appendix A). A summary description of the concepts is provided in the following sections.

1.3 FORECAST WATER DEMAND

As discussed in the Iqaluit Water Storage Pre-Feasibility Study (EXP, 2020), using the high growth rate for population projections, the City of Iqaluit is expected to have a population of 10,800 people by 2026. Based on a raw water consumption rate to be 400 Lpcd, the raw water demands for the City of Iqaluit in 2026 are estimated to be 4,320 m^3/d, or 1,576,800 m^3 per year. Under the high growth scenario (3.38%) as defined in the Iqaluit General Plan (2015) and further described in EXP (2020), the City is expected to have a population of 24,000 people by 2050. Based on a raw water consumption rate to be 400 Lpcd, raw water demand in 2050 may be as high as 9,600 m^3/d, or 3,500,000 m^3 per year. Under a medium growth scenario (2.87%) Iqaluit may have a population of 20,500 people by 2050, with 8,200 m^3/d, or 3,000,000 m^3 per year. The City has requested that this report consider the high growth scenario for this evaluation.

This report uses these projections to complete the evaluation of raw water supply options to year 2050, with a general discussion provided of water source considerations for a planning window of 75 years into the future.

2.0 DESCRIPTION OF OPTIONS EVALUATED

Two general options for water supply are evaluated, with variations described in the text. The Sylvia Grinnell (SGR) and Unnamed Lake (UNL) options are generally illustrated in Figure 2.1**.**, with “New Lake” referring to the reservoir discussed in EXP (2020). These two options occur within two separate watersheds: UNL is a sub-watershed within the larger Apex River watershed; the SGR occurs within the Sylvia Grinnell watershed. The Lake Geraldine reservoir is within a smaller watershed between the two. Figure 2.2 shows the three referenced watershed and sub-watersheds.

Figure 2.1 Overview of SGR and UNL Options

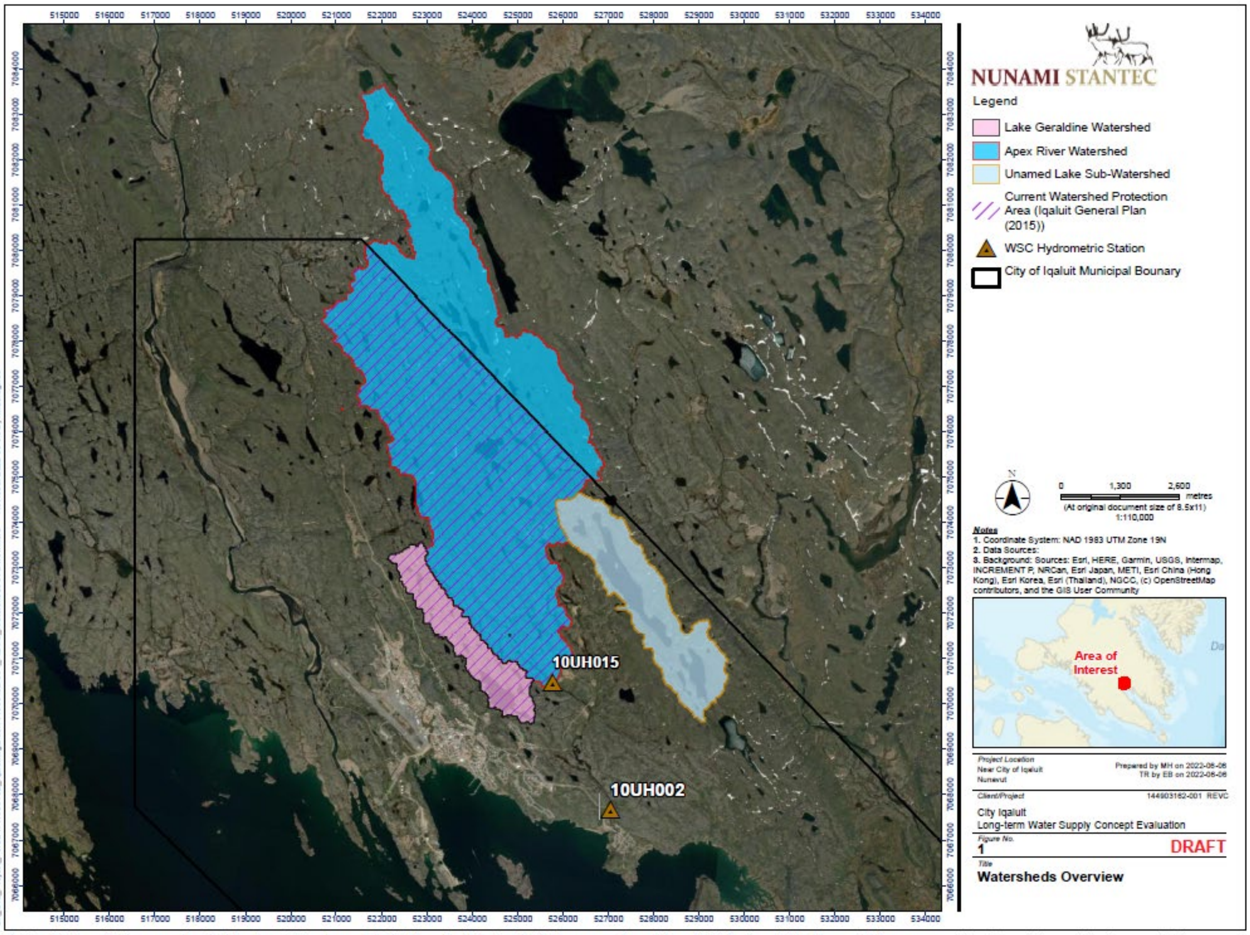


Figure 2.2 Lake Geraldine, Apex River and Unnamed Lake Watersheds

2.1 SYLVIA GRINNELL RIVER OPTION

The SGR option includes supplemental water supply from the SGR and conveyance to Lake Geraldine Reservoir and the New Lake (Figure 2.1). The SGR supply consists of a wet well intake operated seasonally, and a pipeline system that moves water uphill to the headwaters of Lake Geraldine.

2.1.1 Sylvia Grinnell River Intake

Nunami Stantec's report *Options Evaluation for Raw Water Supplementation from the Sylvia Grinnell River* (Nunami, 2018) compared five possible river intake site locations. Following that report, two sites were selected for further evaluation as possible intake locations. The selected sites included Site A and Site B. Site A was located near the end of the airport runway and Site B was located approximately 2 kilometres (km) upstream from there. While more costly, Site B was found to have a lower level of design and operational risk than Site A. Site B was therefore considered in this evaluation.

Site B is a run located on a pronounced outside bend of the river channel. The left (north) bank at Site B is actively eroding and would require stabilization for any infrastructure placed at this site; however, a bedrock outcrop is present downstream. The outcrop provides some limit to the progression of erosion at left bank and downcutting of the river channel.

The Site B intake concept involves a protruding bank structure that takes advantage of the bank's natural geometry and the access platform of the protruding wall structure can be placed well above the estimated flood and ice elevations (see Figure 2.3). As a result, there is no need for separate screen chamber and wet well infrastructure and there is opportunity for the instrumentation building to be placed on top of the wet well to serve as a combined instrumentation and mechanical building. The building and wet well would be accessed using the gravel pad formed by the protruding wall structure

The concept uses concrete to form the wall of the protruding structure. Pending sub-surface conditions, the wall could be formed of sheet pile, or an alternate material that can resist ice forces. The structure would require a suitable foundation. Selection of the wall material would be dependent upon geotechnical investigation and foundation design as part of preliminary engineering.

The intake chamber is incorporated into the structure with maintenance access provided by a manhole. The chamber is abutted to the wall and has an opening to the river that is fitted with two 2 metre (m) x 1 m intake screens. The screens, trash rack and any protective plates could be raised and lowered along slotted guides using the davit shown on the concept drawings.

A submersible style pump was deemed the most appropriate for use at Site B and it would be lowered into the wet well and secured to the discharge pipe seasonally. At the end of each annual withdrawal window the pump would be removed from the wet well for winterization and protection against possible ice formation in the well.

The Site B geometry has the added benefit of the hydraulic control provided by the bedrock outcrop located approximately 50 m downstream. The hydraulic control provided by the bedrock outcrop provides added assurance to the hydraulic stability of the site at low flow. In this geometry, the Site B protruding wall structure is not overtopped by flood events and though ice scars were not seen during the site visit in 2018, it is expected that this structure would not be overtopped by ice.

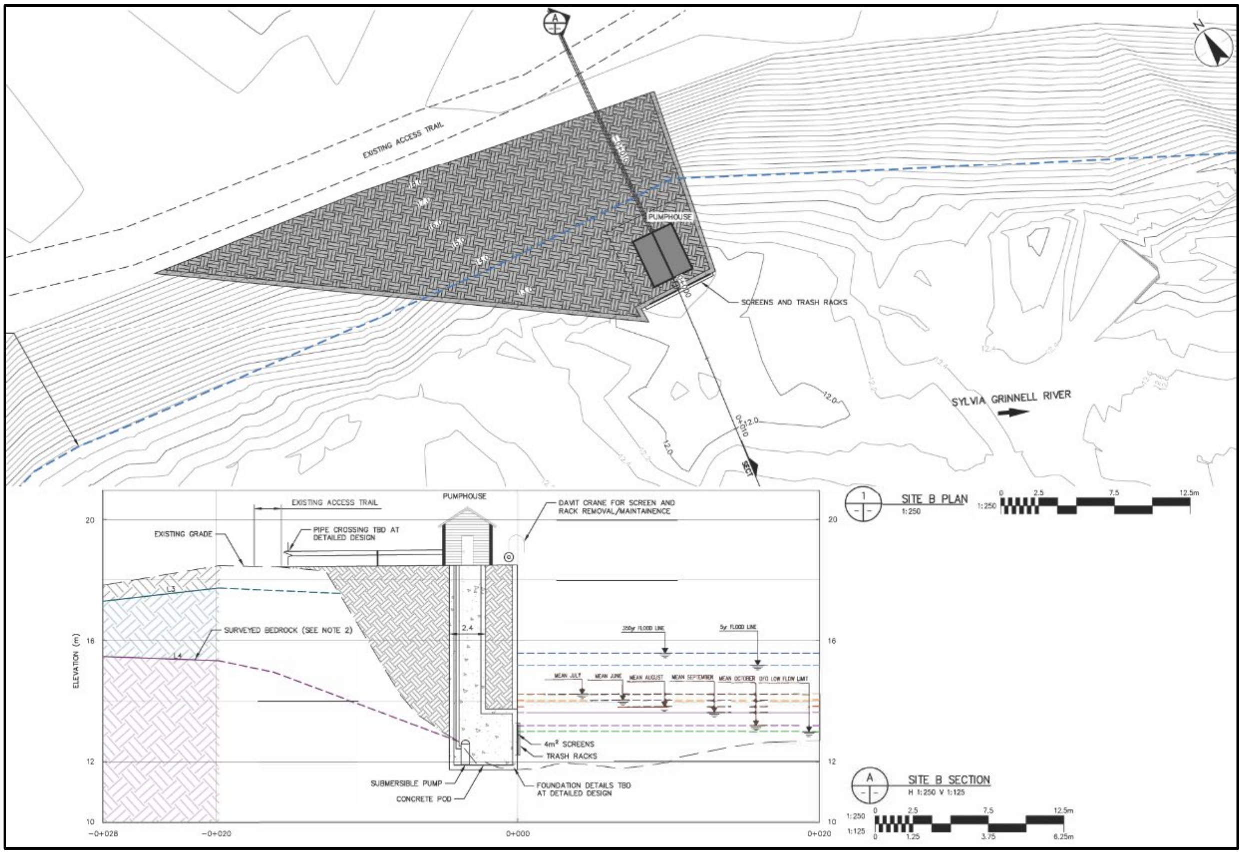


Figure 2.3 SGR Concept Intake Site B (from Stantec 2019)

The protruding wall structure puts the intake screens into the channel’s thalweg as shown by bathymetric survey. Hydraulic modeling results show that have the screens placed in this location would allow for withdrawals at the shoulders of the open water season (June and October), if conditions permit, and would also allow withdrawals in flows as low as those permitted by Fisheries and Oceans Canada (DFO) for withdrawal specific to this location.

The Site B concept considered maintenance requirements related to screen clogging, sediment accumulation in the wet well, seasonal operation, and preliminary measures to protect against ice floes or jams that might occur at the intake site. The screen face and trash racks at Site B could also be designed with some provision for ice resistance but there would be residual risk of damage over winter and the screens should be removed as part of winterizing. The Site B intake can also be designed with an air bubbler or air scour system to reduce the frazil ice build-up on the intake screens should the City wish to have the intake operational in the late fall season and prior to complete freeze-up of the river.

2.1.2 Sylvia Grinnell Pipeline Routing

Site B is located approximately 12 m above sea level (asl), with Lake Geraldine located at about 95 m asl, with topography generally sloping uphill from Site B towards Lake Geraldine, although there are many high and low points between Site B Lake Geraldine.

Pipeline routing from Site B was originally presented as two options, Route B and Route BA. Using information from a Light Detection and Ranging (LiDAR) topographic survey (partially completed, to date), two optimal routes from Intake Site B to Lake Geraldine were identified in the concept design.

Route B follows a less direct path to Lake Geraldine Headwater Creek (LGHC), east from the intake site past Upper Base to discharge. Route BA follows a path from the intake site at approximately 30 m above sea level (asl), downstream along the river edge toward the end of the airstrip, where it then routes uphill through the North 40 and Plateau subdivisions to LGHC at an elevation of approximately 110 m asl. Route BA was selected as the optimal route and used in this evaluation, and is the route shown in Figure 2.1. Routing to a “New Lake” reservoir was not identified at the time of the study.

2.1.3 Sylvia Grinnell Resupply Scenario

Resupply from Sylvia Grinnell River would include annual withdrawal when flows are more than 30% of the river’s mean annual discharge, which generally, but not necessarily continuously, occurs from June to October. Water would be transferred to supplement (top up) both Lake Geraldine and the New Lake during the open-water season. There would be no resupply from the SGR during winter. All over-winter supply would have to be stored within these two reservoirs.

2.2 UNNAMED LAKE

The UNL option includes supplemental water supply from UNL and conveyance to Lake Geraldine Reservoir and/or the New Lake (Figure 2.1). The UNL supply consists of a permanent intake to be operated either year-round or seasonally, and a pipeline system that moves water downhill to Lake Geraldine or the New Lake.

2.2.1 Unnamed Lake Intake

The intake at UNL would be comprised of a pumphouse on the west shore and a raw water line extending out into the lake and running along the lakebed to the withdrawal location. At the withdrawal location, the pipe would be screened with an orb type screen(s) with the pipe and screen affixed to an anchor block or pile footing to keep it in place and above the lakebed. The screens must be sized in accordance with DFO code of practice for end of pipe fish screening for the type of fish anticipated to be present. Environmental deoxyribonucleic acid (eDNA) samples taken from the lake (WSP 2021) identified the presence of arctic char, but no other fish, though Ninespine stickleback have potential to be present. Arctic char and Ninespine stickleback both have a subcarangiform mode of swimming and under the code of practice, a screen area of 0.51 m^2 would be required for a withdrawal rate of 50 litres per second (L/s) to prevent entrainment and impingement. This screen area can be accommodated with a single drum type orb screen with openings no larger than 2.54 mm, in accordance with the code. The screens would also be fitted with an air scour that is operated by an airline running in parallel with the raw water line and connected to a compressor at the pumphouse. The air scour can be run continuously in winter to mitigate frazil or in bursts to control biofouling.

The withdrawal should occur in an area of the lake that is deep enough to accommodate the screens without risk of entrainment of lake sediment from being too close to the bottom; or damage from ice, or the entrainment of frazil from being too near the surface. The screens contemplated in this pre-concept and should be placed no less than 2 m from the lakebed. The screens should have at least a minimum of 2 m of water above them to accommodate ice thickness however Nunami Stantec has recommended a minimum of 4 m in the pre-concept configuration (see Appendix A). Totaling these assumed values suggests the intake should be in a minimum of 8 m of water. Bathymetry of the lake bottom (Tetra Tech 2019) suggests the maximum depth in UNL is 22 m and there are a several areas in UNL where the recommended 8 m depth is exceeded. Based on desktop review of the bathymetry, Nunami Stantec recommends that the intake withdraw from the deeper portions of the lake located around the location of 7072500N 527400E Zone19. The pumphouse would be located on shore near this location. This assumption served the basis for pipeline and access road routing for the pre-concept.

2.2.2 Unnamed Lake Pipeline Routing

Unnamed Lake is located approximately 3.5 km northeast of Lake Geraldine. It is located approximately 200 m above sea level (asl), with Lake Geraldine located at about 95 m asl, with topography generally sloping towards Lake Geraldine. The Apex River runs between these lakes, creating a topographic valley. In the limited analysis of routing options, a general approach to routing has been taken, which would require further optimization based on detailed topographic information prior to detailed design. In this approach, two routes from UNL to Lake Geraldine have been identified; one running from the intake location along the northwest side of UNL, running directly into either Lake Geraldine or New Lake, and a second running from the intake location along the south western side of UNL, running past the current Apex River supplementary pumping program location[1], to the New Lake or Lake Geraldine. To compensate for future route grade optimization, 30% has been added to the length of each of these pipelines in the costing analysis.

The assumed discharge locations are to locations within Lake Geraldine that are accessible by the Water Treatment Plant (WTP intake), as estimated from bathymetric data. This would be further confirmed during detailed design.

[1] The Apex River supplementary pumping program currently transfers water from the Apex River to Lake Geraldine Reservoir during summer months.

2.2.2.1 UNL Pre-Concept Pipeline Routing – Option 1

Option 1 for pipeline routing consists of a pipeline running from the intake location (central UNL) past the northwest side of UNL directly to Lake Geraldine at a location accessible by the current WTP intake. This discharge location would feed Lake Geraldine directly without requiring any modifications to the current WTP intake structure. Following this path, the pipeline would generally move water downgradient from 200 m asl at UNL to about 95 m asl at Lake Geraldine. This route Option 1 is shown in Figure 2.1.

Alternatively, the pipeline could terminate at the New Lake, requiring construction of additional infrastructure to transfer water from New Lake to Lake Geraldine on an as-needed or continuous basis.

2.2.2.2 UNL Pre-Concept Pipeline Routing – Option 2

Option 2 for pipeline routing consists of a pipeline running from the intake in the central region of UNL past the western side of UNL to eastern side of Lake Geraldine. This discharge location would feed either into the New Lake, or Lake Geraldine directly at a location that remains accessible by the current WTP intake as based upon bathymetric data. Following this path, the pipeline would generally move water downgradient from 200 m asl at UNL to about 95 m asl at Lake Geraldine. This route was selected as it generally aligns with the current pipeline route from the Apex River to Lake Geraldine installed and in use seasonally for supplemental pumping from the Apex River, allowing integration of this additional sources if needed (further discussed in Section 3.1.

2.2.3 Updated Unnamed Lake Resupply Scenarios

Since the completion of the UNL Concept Memo, Nunami Stantec has prepared some additional pumping and flow scenarios as requested by the City. Based upon the pipeline routing options from UNL to Lake Geraldine described in Section 2.2.2, pumping and flow conditions have been analyzed based upon three flow conditions:

1. Year-round Resupply

   Year-round resupply represents the lowest required flow rate. For this condition, it is estimated that a continuous pump rate of 937 USGPM (59 L/s) is required to meet the 2050 additional water demand. A continuous resupply will not require additional water storage near Lake Geraldine if provided from UNL. Continuous resupply treats UNL as a reservoir, where water is drawn during all seasons. Freeze protection in the pipeline will be needed.

2. 5-Month Resupply

   To meet the 2050 additional water demands, it is estimated that resupply over five months will require a resupply (pump) rate of 2,219 USGPM (140 L/s). Additional over-winter storage (New Lake) will be required. It is worth noting that the 5-month resupply option will be required to include some freeze protection engineering similar to the year-round option, as early spring and late fall may experience sub-zero temperatures.

3. Summer-only Resupply.

   To meet the estimated 2050 additional water demands, it is estimated that a summer-only (3-month) resupply will require a resupply rate of 3,698 USGPM (233 L/s). Additional over-winter storage (New Lake) will be required.

3.0 EVALUATION

This section presents the results of a comparative evaluation of the SGR and UNL supplementation options based on criteria previously used in the *Conceptual Design Advancement for Raw Water Supplementation from the Sylvia Grinnell River* (Nunami Stantec 2019a) and others as relevant to this study. The following criterial are used:

- Capacity
- Supply
- Accessibility and Routing
- Implementation
- Costs
- Environmental and Socio-Cultural

3.1 CAPACITY

Capacity is used to describe the amount of water available from each water supply source, as based on available reports including Golder (2021) and Nunami Stantec (2018). As discussed by Golder (2021), the average annual outflows from Lake Geraldine are estimated to be 829,754 m^3 (2,273 m^3/d), which represents the annual regeneration of Lake Geraldine and the supplemented approximate self-sustaining water supply volume for the City.

3.1.1 Open Water vs. Winter Supply

Open water season refers to the period of time when the water source is without ice cover. In Iqaluit, this period can last up to five months each year, however, it has been shown to be as short as three months. As based on the Sylvia Grinnell studies, water can only be taken from the SGR during the open water season due to flows that are too low in the winter. At UNL, though some volume is lost due to ice formation, water can be withdrawn year-round. As such, SGR supply is considered open water only and UNL supply is available year-round

3.1.2 Sylvia Grinnell River Capacity

The SGR conceptual report (Nunami Stantec 2019a) considers a withdrawal rate of 233 litres per second (L/s) during a three month (90 day) open water season. Assuming this flow is available within regulatory flow limits (10% instantaneous flow when flows are greater than 30% mean annual discharge, MAD), the SGR will be able to provide 1,811,808 m^3, which is generally less than 2% of its flow. This satisfies the future requirement for the City's predicted demand; however, this water will not be able to be captured during winter conditions. To store and make this water available after the conclusion of the open water pumping season and over the winter, an additional holding reservoir is likely to be required (New Lake). Additional storage is discussed in EXP (2020).

3.1.3 Unnamed Lake Capacity

A water balance assessment of UNL was prepared in March 2021 (Golder, 2021). That study assumed that water from UNL is withdrawn to top up lake Geraldine over a four-week period prior to freeze up. The report found that "under current climate conditions, the UNL supplementation has the potential to be a feasible additional water supply for the City of Iqaluit."

According to Golder (2021), the average annual outflows from UNL are estimated to be 1,591,928 m^3 (4,361 m^3/d) based on the limited available data. For the purposes of the pre-concept description (Appendix A) it was assumed that all of the outflow from UNL as estimated by Golder (2021) is available for use (supplementation). While this amount would not reflect the available volumes on an annual basis, it approximates potentially available water once other lake variables are accounted for (for example, lake evaporation). Nunami Stantec acknowledges that additional work is required to provide additional confidence to the hydrology of UNL; however, the volumes presented in Golder (2021) will be used throughout this report as the amount of available water for use, annually, from UNL and Lake Geraldine.

The UNL water balance study (Golder 2021) assumed that UNL's outlet channel invert elevation is at 202.1 m. Stage-storage curves for each of UNL's three sub-basins were provided in that study and suggest that there is a total volume of 5,534,000 m^3 in UNL during open water, and at the point where no outflow occurs from the lake (e.g at freeze-up or at 'full supply level'). Golder assumed that ice thickness on UNL ranges between 1.3 m and 1.8 m under current climate. For the purposes of the pre-concept, Nunami Stantec conservatively used an ice thickness of 1.8 m. This translates to an under ice water elevation of 200.3 m. Referring to the stage-storage curves provided in Golder 2021, and summing them to capture total volume, but omitting abandonment of sub-basins from the drawdown, this results in a total minimum under ice volume in UNL of 4,252,000 m^3. This is nearly four times the volume of water available in winter than what can be stored in Lake Geraldine.

3.1.4 Additional Capacity of Apex River

The amounts reported for UNL do not include additional capacity that may be available from the Apex River, which is currently being used for temporary supplementation. While not included in the evaluation, the Apex River at a location 1 km upstream of the bridge on the Road to Nowhere (which is upstream of the confluence of UNL outflows) provides additional potential summer capacity to the UNL option, as most of the Apex River is hydrologically separate from the UNL sub-watershed (see Figure 2.2). Based on an analysis of 37 years of historical data collected at Water Survey of Canada station 10UH002 between 1973 and 2021 (data were not available in 1984 and from 1996 to 2005), scaled to the pumping location (now WSC location 10UH015), between 6,800,371 m^3 and 36,333,915 m^3 of additional water was available annually from the Apex River during unfrozen conditions using an unrestricted withdrawal scenario (all water taken from the river). Additional scenarios were evaluated to reflect fixed pumping rates (see Table 3.1). The methods, analysis and limitations of this study are further described in a memo provided as Appendix B.

Table 3.1 Water Available in Apex River (scaled to 10UH015) 1973-2021 Under Different Pump Scenarios (refer to Appendix B)

Statistics	Period of Record (days)	Unrestricted Pumping Scenario (m^3)	Pumping Scenario-50 L/s (m^3)	Pumping Scenario-100 L/s (m^3)	Pumping Scenario-200 L/s (m^3)
Average	141	17,697,765	543,183	1,054,989	2,005,389
Minimum	64	6,800,371	276,480	552,960	1,088,640
Maximum	225	36,333,915	747,360	1,451,520	2,782,080

3.1.5 Capacity Summary

To summarize, the following will be used as sustainable amounts that can be withdrawn from SGR, UNL, and Lake Geraldine.

- Annual potential withdrawal from SGR: 1,811,808 m^3 (20,131 m^3/d), for 90 days only
- Annual overflow from UNL: 1,591,928 m^3 (4,361 m^3/d)
- Annual regeneration from Lake Geraldine: 829,754 m^3 (2,273 m^3/d)

3.2 SUPPLY

Supply describes the ability of the source option to supply the additional volume of potable water needed to supplement the Lake Geraldine Reservoir source during the high growth scenario up to year 2050 as defined in the Iqaluit General Plan (2015) and further described in EXP (2020). This evaluation report will look at the available annual supply from UNL, as well as the pumping rate scenario used within the Sylvia Grinnell River concept report.

Lake Geraldine currently has a capacity of 1,680,500 m^3 (4,600 m^3/d), of which 1,100,000 m^3 is accessible during winter months due to ice formation and only when the reservoir is full prior to freeze up. The calculations for winter months, considered conservatively to be from October to May, do not consider any inflows from precipitation or runoff (Nunami Stantec, 2019b).

3.2.1 Required Additional Annual Supply 2050

As discussed in the Iqaluit Water Storage Pre-Feasibility Study (EXP, 2020), using the high growth rate for population projections, the City is expected to have a population of 24,000 people by 2050. Based on a raw water consumption rate to be 400 L per person per day, future demands are estimated to be 9,600 m^3/d. This is important data when considering the potential future supplemental water source. Based on this projected daily demand, the evaluation described herein considers an annual raw water demand requirement of 3,500,000 m^3 by 2050. Between October and May, or 8 months (242 days), the predicted 2050 over winter demand equates to a required raw water demand of 2,323,200 m^3 during this period. This means that Lake Geraldine will have a shortfall of about 1,223,200 m^3 by 2050 (or population of 24,000) during winter months. Considering the projected annual demand, the required amount of water to supplement future needs of Iqaluit would be about 1,820,000 m^3, or 4,990 m^3/d (915 USGPM). This amount does not take into consideration supply contingency for unforeseen demand (water line breakage, fire suppression, etc.).

3.2.2 Required Additional Annual Supply 2026

As discussed in the Iqaluit Water Storage Pre-Feasibility Study (EXP, 2020), using the high growth rate for population projections, the City of Iqaluit is expected to have a population of 10,800 people by 2026. Based on a raw water consumption rate of 400 Lpcd, 2026 demands are estimated to be 4,320 m^3/d. Based on this projected daily demand, the evaluation described herein considers an annual raw water demand requirement of 1,576,800 m^3 by 2026. Between October and May, or 8 months (242 days), the predicted 2026 over winter demand equates to a required raw water demand of 1,045,440 m^3 during this period. This means that Lake Geraldine has the capacity to supply water to the City (assuming the reservoir is full before freeze up) to 2026 (or population of 10,800) during winter months, not taking into account any allowance for unforeseen demand (water line breakage, fire suppression, etc.). Supplementation from Apex River, as has been carried out since 2019, will likely still be required to maximize volume in Lake Geraldine prior to freeze-up.

3.2.3 Climate Change Resilience

Climate resilience is a term that is becoming commonplace when discussing both social and economic futures. It is often used when describing the frequency and impact of extreme weather events, such as abnormal temperatures, precipitation events (rain, snow, droughts), wildfires, and sea level rises on planned and existing infrastructure, and adaptations that are needed to increase resilience to such events that will become more intense or less predictable as climate changes.

The Canadian Arctic is vulnerable to climate change. The cryosphere is a term is used to describe parts of the Earth that contain frozen oceans, glaciers, permafrost, and land with seasonal snow cover. Climate change is resulting in rising global temperatures and cryosphere temperatures are increasing at a faster rate than other parts of the world. This is directly resulting in periods shorter seasons of snow cover and sea ice, retreating glaciers, and permafrost degradation or disappearance.

The City has been observing recurring annual changes in temperature, precipitation, and permafrost degradation. The impact of permafrost degradation is costly for the City, affecting many components of the built environment. Foundations of buildings that rely on piling systems within permafrost are settling, buried infrastructure (water and sanitary piping systems) are settling and ground stability is being reduced. By encompassing resilient infrastructure design and replacement (i.e. flexible connections at access vaults), some defense can be offered to reduce the risk of expensive repairs and unintentional water demand increases due to line breaks and leaks.

Some specific climate change related considerations for long-term water supply may include:

1. Road Design

Roads will be required to access the intake locations and various parts of the designs. It is important that road construction be considerate of a sensitive sub surface environment and temperature. Constructing roads should minimize and disturbance to permafrost and completed in such a way to encourage permafrost migration within the road structure. Material placement and drainage are also important considerations to any road in the arctic.

2. Foundation Design

Foundations of any infrastructure (i.e. pumping stations and intake houses) should be considerate of changing subsurface conditions. The decision on best foundation design will be considered during future design by a structural engineer and complimented with adequate site drainage.

3. Pipe Placement

How the pipe is fixed will become important. If placed on the ground, avoid lateral shifting, appropriate lateral location staple design should be considerate of changing ground conditions. Considerations should be given to type and size of material and depth of penetration. Drainage must be considered to ensure pipeline does not impeded the overland flow.

If pipes are placed on pipe stands, base preparation will become very important to minimize movement of the pipe stands.

Covering the pipes with granular material in a berm would provide the greatest protection to the pipes from temperature and shifting forces, though would cost the highest amount. Depending on the selected route, berming of material over the pipelines should be considered.

4. Drainage Planning

Flash spring melting or high precipitation events are increasingly being observed. Future design must consider overall site drainage and changes in overland drainage patterns to minimize erosion and damage to infrastructure. This will involve careful consideration of engineered drainage pathways.

5. Source Integrity

The water sources considered in this study may be affected by changing permafrost conditions, such that potential for changes to basin or channel morphology will need to be considered in detailed design to mitigate for potential water loss. Changing permafrost conditions also have potential to affect water quality.

6. Alternate Water Sources

Climate extremes may be expressed with high and low temperatures and precipitation and potentially changes to local hydrology. The need to evaluate alternate water sources as a response to climate change over a longer planning horizon should be evaluated as the project is implemented.

Detailed designs of the water supply system (pumping infrastructure, pipeline, etc.) must consider a changing Arctic climate.

3.3 ACCESSIBILITY AND ROUTING

Accessibility of the source options will be described with respect to roads, power, pipeline, and pumping requirements. This section aims to describe possible scenarios for construction and operation access for SGR and UNL.

3.3.1 Roads

3.3.1.1 Road Access to Sylvia Grinnell River

As described in the conceptual report, the SGR scenario recommends an intake location at “Site B” and a pipeline route shown as the blue line in Figure 2.1. The pipeline route runs from Intake Site B south along the riverbank generally in a southeast direction, past and alongside the north side of the runway before heading generally east towards Lake Geraldine. A blue dashed line shows an additional pipeline route from LGHC to New Lake (per EXP 2020) anticipated to be required as part of the SGR supply option. See further discussion on this in Section 3.1.2.

The north side of the runway is accessible with existing roads used to access the Sylvia Grinnell Territorial Park. Additional access to the intake site would be required by extending and upgrading this access to permit maintenance at the intake site. The concept considers an instrumentation building adjacent to the existing trail that appears to be providing access to the Water Survey Canada station and informal all-terrain (ATV) access up the Sylvia Grinnell River. Conceptually, this access trail would be upgraded so the required operations and maintenance traffic can reach the intake and pumphouse in summer months, with room to maneuver to complete any maintenance or equipment replacement. A service road or trail will also be required between existing subdivision roads (North 40 and Plateau subdivisions) and from the intake site past the eastern side of the runway and as the pipeline approaches LGHC. Approximately 5.15 km of new road and trail could be required. The estimate of probable cost includes a rough cost for upgrading the required access trails. It should be noted that this cost will be refined as design advances.

While access is required for intake and pumping stations, it should be noted that a full access road is not required to run along the entire length of pipeline, however, trails would be required for maintenance.

3.3.1.2 Road Access to Unnamed Lake

A temporary trail was constructed between the Road to Nowhere (near the Iqaluit Shooting Range) and UNL as part of the 2019 Emergency Supplementary Pumping Program. Utilizing UNL as a permanent part of the City’s potable water supply system will require roads to be engineered, constructed, and maintained for potentially year-round operations. Pumping stations at stages along this pipeline route will not be required. As a result, a road or trail along the UNL pipelines would not be required for maintenance purposes.

The UNL pre-concept identifies two pipeline routes, as Options 1 and 2. Both options are shown on Figure 2.1 in green. The general route of the existing temporary road will suffice to support both options, with an additional portion of road required to reach the central portion of UNL where the intake is most likely to be located. The road requirements are approximately 3,200 m. Further analysis and design will be required to understand optimal routes for grading and drainage, with respect to topography.

3.3.2 Pumping Stations and Power Requirements

3.3.2.1 Sylvia Grinnell River Pumping Stations and Power Requirements

Nunami Stantec has selected the summer only open-water withdrawal rate of 233 L/s to provide adequate resupply of Lake Geraldine over a three-month period of July, August, and September.

An intake pumphouse will be required, as discussed within the concept report, with two pumps required for the selected pipeline route. Head and frictional losses contribute to a higher pressure within the system. It is good practice where possible that each additional booster pump be coupled with an atmospheric tank or drain to prevent unsafe conditions within the pipeline. An atmospheric tank, or a break pressure tank, is one possible solution to provide pressure relief in the pipe as water is pumped to a higher elevation. During the selection of pumps, a 63 m^3 atmospheric tank could be used to release pressure at stages within the pipeline route. If this option is selected for detailed design, the number of required tanks would be one less than the required number of pumps. In a situation requiring only one pump, no atmospheric tank would be needed. The need for pressure release has also been included within the estimate of probable cost.

The SGR concept report has identified a 500 mm pipeline size (as will be discussed in the subsequent section), a required pressure of 1,792 kPA, two pumps, one atmospheric tank, and a design pump horsepower of 700 horsepower (hp), as two 320 hp pumps. While a larger pipe size is paired with a higher construction cost, it has lower pumping operational costs.

Power poles and an access road will need to be constructed at the intake site and along the pipeline for booster and pumping station operation and maintenance. These have been included in the estimate of probable cost. There is partial power access near the airport runway; however, upgrades are expected to be required.

3.3.2.2 Unnamed Lake Pumping Stations and Power Requirements

The UNL plan will not require interim pumping stations to lift the water to Lake Geraldine as there is a net elevation loss along the pipeline route. The only pumping requirements of the UNL to Lake Geraldine system for the continuous resupply scenario will be to pump the water out of UNL. The elevation loss (static head) from UNL to Lake Geraldine is -107 m. At an assumed flow rate of 59 L/s (937 USGPM), the total dynamic head (TDH), which considers the frictional loss and static head, is -105.3 m. Converting this to pressure, the TDH is -147.9 psi (1,019.7 kPA).

The hydraulic power required to convey this water is -68.9 hp, with the negative sign indicates that power could be generated by the water flow downhill for this system. In theory, this system could continuously generate about 44.8 hp of electrical power with use of a micro hydro plant, assuming 65% efficiency, and result in about $146,000 in annual power earnings. Feasibility of the installation of a micro hydro plant will need to be evaluated further at concept level, however, it is mentioned here to illustrate the potential optimal pumping dynamics of the UNL to Lake Geraldine system.

For the “continuous resupply” pre-conceptual resupply scenario (see Appendix A), the start up power requirements can be either fulfilled by use of a generator or direct grid connection with power poles. Since the pumping requirements for this concept are minimal, a generator located near the intake pump would likely be suitable.

As noted in the previous section the operation of the continuous flow pipeline could potentially produce more power than is needed for pumping out of the lake. Thus power could only be required on startup, making a generator or batteries a viable option rather than grid power.

For the “bulk resupply” pre-conceptual resupply scenario (see Appendix A), power requirements are much greater. A permanent grid power connection would be recommended, although a generator would also be possible.

To demonstrate the pumping requirements from UNL to Lake Geraldine, the following scenarios have been analyzed. Note that pumps types discussed here are for comparison purposes and not intended to be viewed as preliminary design equipment selection.

1. Year-round Resupply;

   Resupply rate of 937 USGPM (59 L/s) applied

2. 5-Month Resupply

   Resupply rate of 2,219 USGPM (140 L/s) applied

3. Summer-only Resupply.

   Resupply rate of 3,698 USGPM (233 L/s) applied

Figure 3.1 compares pump curves for each of the resupply scenarios using different pumps and pipeline sizes 200 – 400 mm.

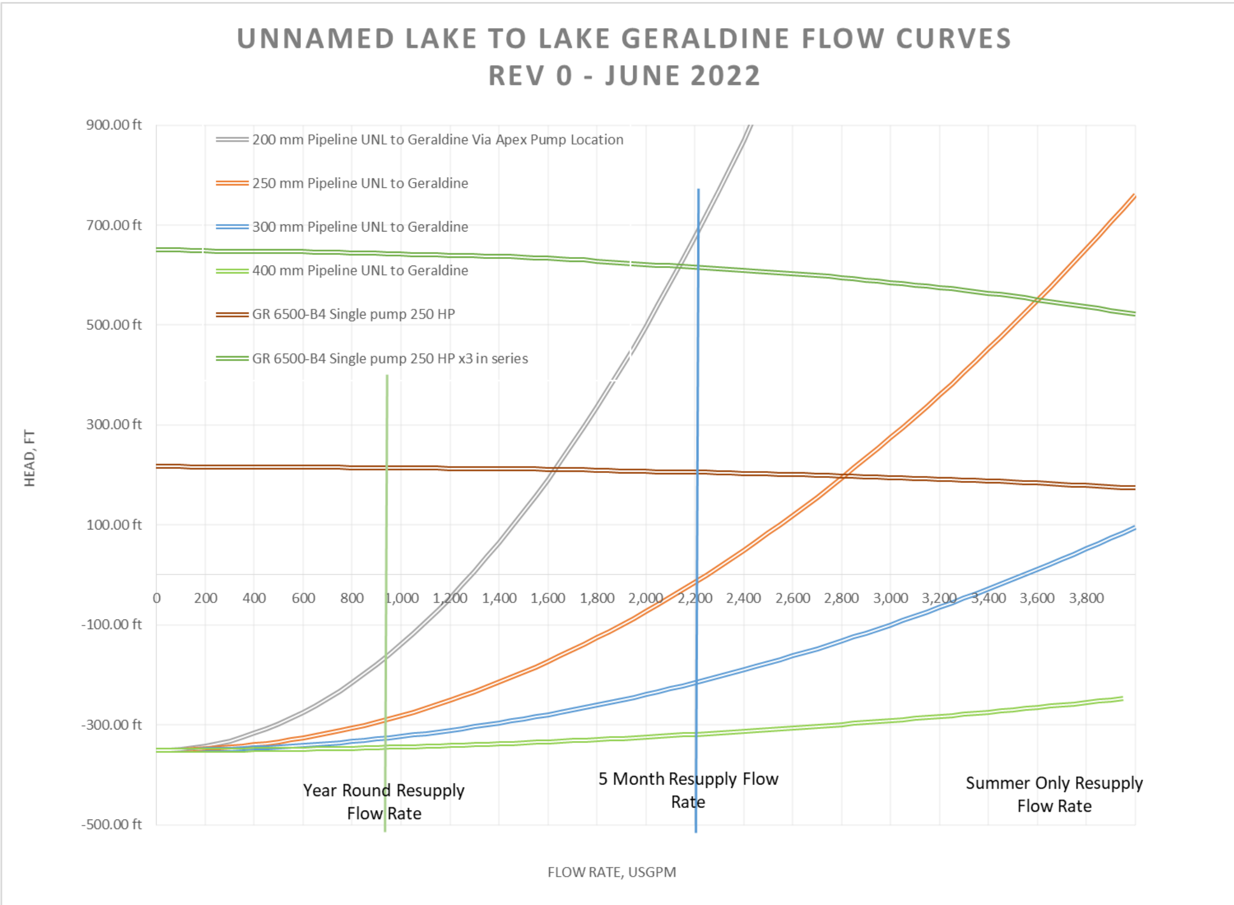


Figure 3.1 Hypothetical Pump Curve for UNL Operations

3.3.3 Pipeline

3.3.3.1 Sylvia Grinnell River Pipeline Route

A suitable pipeline design will run primarily above-ground from a pumping station at the selected intake location to the LGHC, with potential need to extend to a New Lake. As discussed in the previous sections, year-round withdrawal was not considered feasible, so the pipeline design considered only summer withdrawal. The pipe will consist of fused, uninsulated high-density polyethylene (HDPE) pipe. Buried sections will be required at road crossings and to avoid interference with existing infrastructure at the North 40 and Plateau subdivisions.

From the intake site, the pipeline route runs south past the east side of the runway and bordering the airport lands between the asphalt plant and the quarry. Where applicable, the pipeline has been offset from the river to accommodate the 30 m federal reserve on navigable waters.

The 500 mm diameter pipeline will span a total length of 6,500 - 7,500 m across craggy terrain to the discharge at Lake Geraldine Headwater Creek (LGHC). Running north of the airport lands, this option is easily accessed through Kudlik yards and along access roads north of Federal Road. The pipeline continues along Qaqqamiut Street toward Upper Base and running behind the residential housing on the Plateau toward LGHC.

High and low points can be smoothed with a cut and fill plan during detailed design, however, not eliminated. As a result, staged pumping and drains will be required to ensure that adequate pressure and relief can be maintained. The elevation gain from the intake site to LGHC is about 125 m.

3.3.3.2 Unnamed Lake Pipeline Route

UNL is located approximately 3.5 km northeast of Lake Geraldine. The topography generally slopes down from UNL to Lake Geraldine, but the Apex River runs between these lakes, creating a topographic valley. In the limited analysis of routing options, a general approach to routing has been taken, which would require optimization with detailed topography prior to detailed design. In this approach, two conceptual routes from UNL to Lake Geraldine have been identified; one running from the intake location along the northwest side of UNL to directly into Lake Geraldine, and a second running from the intake location along the western side of UNL directly to Lake Geraldine. To compensate for future route optimization, 30% was added to the length of each of these pipelines in the costing analysis.

The assumed discharge locations are within Lake Geraldine and would be accessible by the Water Treatment Plant (WTP intake), as estimated from bathymetric data. This can be further confirmed during detailed design.

Option 1 for pipeline routing consists of a pipeline running from the intake location (central UNL) past the northwest side of UNL directly to Lake Geraldine at a location accessible by the current WTP intake. This discharge location would feed Lake Geraldine directly without requiring any modifications to the current WTP intake structure. Following this path, the pipeline would generally flow down from 202 m asl at UNL to about 95 m asl at Lake Geraldine.

Option 2 for pipeline routing consists of a pipeline running from the intake in the central region of UNL past the western side of UNL to eastern side of Lake Geraldine. This discharge location would feed Lake Geraldine directly at a location that remains accessible by the current WTP intake as based upon bathymetric data. Following this path, the pipeline would generally flow down from 202 m asl at UNL to about 95 m asl at Lake Geraldine. This route was selected as it generally aligns with the current pipeline route from the Apex Supplemental Pumping infrastructure, and would be intersected by the New Lake, if constructed at the location proposed by EXP (2020).

The pipeline length for Option 1 is about 4,700 m and 4,050 m for Option 2. For each of these, as mentioned, a 30% contingency onto the length has been added as an optimal route will be selected at a concept level design with detailed topography analysis. As such, this pre-concept report will consider the pipeline length for Option 1 as 6,100 m and 5,300 m for Option 2.

With the continuous resupply scenario, a 300 mm insulated HDPE pipe was applied to the concept. The pipe can be placed either directly on the ground surface or buried in a bermed area. Heat tracing, while it could be included for recovery following emergency shut down periods, would not be required for normal operation under the continuous flow system. As mentioned, ideal routing would be selected using detailed topography during the subsequent design phases.

3.4 IMPLEMENTATION

3.4.1 Constructability

By identification of major construction activities, constructability is considered at this project phase as topics needed to be addressed to manage risks to the project during subsequent design phases. While this section does not address every detail, it is expected to form the basis of risk and constructability through detailed design. Road, trails, intake, and pipeline can be constructed in a single construction season; however, careful planning must be done to ensure the contractor is awarded the job with adequate time to get materials shipped on the first sealift. Materials and equipment have had a recent shift in lead times and may require pre-ordering up to or more than 90 days in advance of the first sealift delivery cut off, which is usually in early June. To avoid potential delays, one option might be that the contractor may be awarded the work a year before construction is expected to ensure the materials are waiting in Iqaluit for the following construction year or the City could choose to procure long lead items directly. This is not likely required for HDPE and granular materials, however, building materials and mechanical equipment may have a longer lead time requirement.

3.4.1.1 Sylvia Grinnell River Constructability

Intake construction will require a temporary cofferdam to isolate the workspace within the river channel. The isolation could comprise bulk bags wrapped in poly sheeting, rock and earth fill with riprap or other means of providing a sealed enclosure from behind which the workspace can be dewatered. Cofferdams should be installed and all instream work completed during low water periods to reduce risk of overtopping. The timing of cofferdam installation and removal would need to consider fisheries objectives and instream work windows.

Detailed topographic information is available for most parts along the SGR concept; however, detailed design will need to be completed to understand drainage and overall quantity and type of granular material required. As with any project, the quantity of materials should be specified to ensure stockpiles are ready at the time of construction. Given our current understanding of terrain conditions, substantial amounts of materials will be required. While some access exists to the north side of the runway, additional road will need to be constructed to the intake site. Trails for construction could be used as maintenance trails. Trails will need to be constructed to ensure access is available at booster pumping stations for maintenance.

As mentioned, the pipeline routing will be confirmed with detailed topographic information during detailed design. The optimal route would not require a permanent maintenance road; however, it will likely require a temporary construction path for installation. Insulated HDPE pipe is readily available; however, it does have a longer lead time and must be ordered in advance of the construction season. This material should be ordered such that it arrives to Iqaluit on the first sealift of the season. Construction trails can be prepared to ease access for installation. As was done for previous emergency resupply projects, contractors are able to fuse HDPE pipe and drag into location with equipment. Where this is not possible, temporary access trails can be constructed to allow for larger equipment to get to location. Fusing the pipe can be done in a central location and the fused segments dragged to location, or the fusing equipment can be moved relatively easily along the pipeline route. Any local contractor will understand the constructability challenges upon review of the designed site plan. Additional equipment and time may lead to an increase in cost.

Power requirements for operation can be in the form of a direct grid connection or from a diesel generator. The long-term road must be in place prior to installation of power poles if this option is selected. Adequate distance from SGR (minimum 30 m) and secondary containment will be required for placement of fuel storage or a generator. If a generator and fuel storage is chosen (including use for redundancy and backup), it is recommended to be ordered in advance of the first sea lift such that it arrives in Iqaluit in July. However, if grid power is chosen to power the system, backup diesel power systems are not recommended as this would substantially increase the cost of the system used only during summer months. Failure in the grid power line could be fixed during the summer season.

Sylvia Grinnell River will require some security to ensure this remains a protected water supply. The trail along the river is currently utilized by many community members, with cabins located north of the intake site. Development of a permanent road to the intake site will likely lead to increased activity in the area. It will not be possible to limit activities along the river, as it is an important cultural feature running through a territorial park. Signage and fencing may be required in various areas, as well as some potential limits to future use of the land.

The number of contractors expected to bid on this is limited, due to the remoteness of the site.

3.4.1.2 Unnamed Lake Constructability

The road to UNL will require detailed topographic information to delineate drainages courses to allow the installation of adequate drainage control. Also, the overall quantity and type of granular material should be specified to ensure stockpiles are ready at the time of construction. Given the current understanding of terrain conditions, substantial amounts of materials will be required. The temporary trail, built for the Lake Geraldine Resupply 2019 project, while in relatively good condition at this time, was not constructed using any detailed design for drainage or material quality and built mostly of locally sourced material. This trail is not suitable for long-term use and maintenance; however, the route generally meets the pre-conceptual design requirements and will be suitable to provide access during construction of the long-term road. In addition to that, the Road to Nowhere (RTN) bridge may be in poor condition with limitations to load weights and use of the bridge. If UNL is developed into detailed design, further review of RTN bridge will be required to determine if remedial action is required.

As mentioned, the pipeline routing will be confirmed with detailed topographic information during detailed design. The optimal route does not require a maintenance road; however, it will likely require a temporary construction path for installation. Once the route is selected, borrow sources for gravel can be considered. Construction of the long-term road is recommended before installation of the pipeline. Insulated HDPE pipe is readily available; however, it does have a longer lead time and must be ordered in advance of the construction season. This material should be ordered such that it arrives to Iqaluit on the first sealift of the season. Construction trails can be prepared to ease access for installation. As was the case with previous emergency resupply projects, contractors are able to fuse HDPE pipe and drag into location with equipment. Where this is not possible, temporary access trails can be constructed to allow for larger equipment to get to location. Fusing the pipe can be done in a central location and the fused segments dragged to location, or the fusing equipment can be moved relatively easily along the pipeline route. Any local contractor will understand the constructability challenges upon review of the designed site plan. Additional equipment and time may lead to an increase in cost.

To construct the intake at UNL, access to the central part of the lake will be required. The temporary road from 2019 does not run to this exact location so additional road construction will be required prior to installation of the intakes and supporting structures (i.e. generator room, site office). Construction would require a barge to lower pre-cast footings to the lake bottom and to pull the water line to the withdrawal location. Installation of the screen would then be done from the barge and all work would be coordinated using divers. The screen and its flange do not weigh too much and could be serviced using a smaller vessels with divers if necessary. There may be opportunity to use helicopters for the installation in place of a barge.

Power requirements for operation can be in the form of a direct grid connection or from a generator. The long-term road must be in place prior to installation of power poles if this option is selected. Adequate distance from UNL (minimum 30 m) and secondary containment will be required for placement of any diesel fuel storage or the generator. If a generator and fuel storage is required, it is recommended to be ordered in advance of the first sea lift such that it arrives in Iqaluit in July.

UNL will require some security to ensure this remains a protected water supply. As access to the area becomes easier by way of a road, so does community interest in recreational pursuits. The temporary 2019 road has already brought interest to UNL and an increase in activities (i.e. camping and ATV use) has been observed. Signage and fencing will likely be required in various areas.

3.4.2 Operation and Maintenance

3.4.2.1 Sylvia Grinnell River O&M Complexity

The SGR concept considered maintenance requirements related to screen clogging, sediment accumulation in the wet well, seasonal operation, and preliminary measures to protect against ice floes or jams that might occur at the intake site.

A potential disadvantage of the general arrangement of this concept is that the wet well approaches 6 m deep. Any sediment build-up in the wet well would likely need to be removed using a hydrovac truck. At this depth (6 m) it may be difficult for a hydrovac to remove the sediment. It is possible that the site could be graded down 1 to 2 m to create a shallower wet well. However, any lowering of the proposed infrastructure would have to be evaluated against potentially exposing the infrastructure to flood flows and/or ice and debris. A potential lowering of the wet well access for sediment removal using a hydrovac, should be further reviewed during preliminary design.

The screen face and trash racks could be designed with some provision for ice resistance but there would be residual risk of damage over winter. The City may wish to remove the screens at the end of the withdrawal season, prior to freeze-up and replace them with solid steel plates. Removing the screens would prevent them from being damaged by ice, and the steel plates would provide some protection to the structure and the intake chamber. The intake concept includes a removable davit for screen and trash rack removal. The davit also facilitates the removal of the screens for cleaning as part of regular maintenance. Regular cleaning of sediment, debris and biological fouling will help to maintain the flow rate across the screen and maintain overall system performance.

The general arrangement allows for access during spring break-up. Should the City wish to pursue beginning withdrawal during ice break-up, then consideration for leaving the screens in throughout winter should be included in preliminary engineering design.

The intake can be designed with an air bubbler or air scour system to reduce the likelihood of frazil ice build-up on the intake screens. Teflon coated screens and trash racks can also reduce frazil build-up. Because withdrawal is planned for the open water season, we have not included provision for frazil management in the concept, but mitigation measures like those mentioned above, could be further considered in preliminary engineering.

While effort to minimize low and high points within the pipeline during routing selection shall be made, low point drains and air releases will inevitably be required. The current semi-permanent pipeline from Apex River to Lake Geraldine currently requires walking the pipeline periodically during startup and shutdown, however, no engineered trail has been constructed for this and contractors complete this on foot. ATV trails could be considered along the pipeline route to provide ease of access for pipeline route inspection and low point drain operation. During any shut down when water is drained from the system low point drains may be operated. This is true during end of pumping season shutdown and for any other O&M purposes.

This pipeline does not need to be insulated nor does heat need to be added during operations as operation will only occur during the summer season.

This system requires large pumps and pipe to move water from the Sylvia Grinnell River to the new storage reservoir near Lake Geraldine. These pumps will need to be regularly maintained and annually serviced.

3.4.2.2 Unnamed Lake O&M Complexity

Operation and maintenance complexity is largely dependent on the selected resupply scenario. For Resupply Scenario 1, bulk period resupply periods, the line will be required to be drained after each use. If a generator is used to supply power, all fuel should be removed from site and the equipment during each shut down period. Roads must be maintained throughout the entire winter as late winter pumping may be required as demands increase. Any planned shutdowns must be timed adequately to ensure pipes with water do not freeze.

Resupply Scenario 2 of continuous supply will also require carefully timed shutdowns for maintenance and road maintenance. The site must be kept clear of snow as with any municipal building or infrastructure.

While effort to minimize low and high points within the pipeline during routing selection shall be made, low point drains and air releases will inevitably be required. The current semi-permanent pipeline from Apex River to Lake Geraldine currently requires walking the pipeline periodically during startup and shutdown, however, no engineered trail has been constructed for this and contractors complete this on foot. ATV trails could be considered along the pipeline route to provide ease of access for pipeline route inspection and low point drain operation.

During any shut down when water is drained from the system low point drains may be operated. This is true during end of pumping season shutdown and for any other O&M purposes, unless year-round operations are selected.

This pipeline does not need to be insulated nor does heat need to be added during operations if “summer-only” operation is selected. If 5-month or year-round operation is selected, the system will require an insulated pipe and heat injection into a recirculated water.

The UNL pipeline system will have minimal pumping requirements, largely only the low rate pumping required to fill the line before flow startup. These could be dealt with via small diesel or electric pump.

3.4.2.3 Automation & Security

Automatic controls should be in place, including alarms, so City operations can be alerted of any problems resulting from low flow conditions. Thermal analysis will be included during the detailed design to determine alarm setpoints. SCADA system design will certainly be part of detailed design.

Watershed protection must be carefully considered, which may include some trail gates and fencing where possible. In addition to that, security cameras within and around the pumping facilities can be considered.

3.5 COSTS

3.5.1 Capital Costs

Based on the identified site conditions, anticipated intake types, and pipeline options with associated infrastructure (i.e., access roads, power, pumping stations), Nunami Stantec has developed a Class 5 (AACE No.18R-97) estimate of probable infrastructure costs. This has been completed for both SGR and UNL options. To permit comparison, the unit prices have been normalized to match the 2019 estimate from SGR concept report. Construction costs are summarized in Table 3.2 and operations costs are summarized in Table 3.3.

Table 3.2 Estimate of Probable Cost Summary

COST ITEM	SYLVIA GRINNELL RIVER CONCEPT	UNNAMED LAKE PRE-CONCEPT
	Route BA	All Resupply Scenarios
DESIGN, PERMITTING, CONSTRUCTION SUPERVISION	$3M	$1.5M
GENERAL REQUIREMENTS (MOB/DEMOB, ECO PLAN AND ENV. MONITORING, UTILITIES COORDINATION)	$0.16M	$0.16M
SITE PREPARATION	$0.07M	$0.07M
INTAKE (INCLUDING PUMPHOUSE AND EQUIP.)	$3.7M	$1M
BOOSTER PUMPS, PUMPHOUSES, AND TANKS	$1M - $1.8M	$0.4M
POWER SUPPLY, ROAD, AND PIPE	$11-20M	$9-9.5M
SUB-TOTAL (NO CONTINGENCY)	$25M	$10.5-11.5M
TOTAL CONSTRUCTION COSTS (INCL. 30% CONTINGENCY)	$32.5M	$13.5-15M
COST OF ADDITONAL STORAGE	+$65M	$0-$65M

It should be noted that the SGR option requires additional storage to be constructed, though not all UNL options require this. The cost of additional storage (New Lake) has been added based on EXP (2020). The permitting cost does not include potential compensation or offsetting that may be required as a result of harmful alteration destruction or degradation (HADD) of fish habitat, which would be determined based on a review by Fisheries and Oceans Canada (DFO) of the final design of the selected options (see Section 3.6). This cost would apply to either option.

3.5.2 Operational Cost

The operational cost estimated as part of this assignment estimates power consumption (or generation), annually.

Table 3.3 O&M and Power Costs

ANNUAL POWER COST	SYLVIA GRINNELL RIVER CONCEPT	UNNAMED LAKE PRE-CONCEPT
POWER REQUIREMENTS	Power required = 700 hp Power consumed = 1,916,747 KWh Annual cost > $1,000,000	Power required = -69.60 hp Generation potential = 45.24 hp Power generated = 295,245 KWh Annual earnings = $148,000
O&M COSTS[1]	$300,000	$150,000

1. A broad estimate to include pump maintenance, road clearing, etc. To be confirmed following design and selection of equipment.

3.6 ENVIRONMENTAL & SOCIO-CULTURAL

This criterion reflects the considerations associated with advancing an option within the biophysical and socio-cultural environment and includes consideration of environmental regulatory approvals that may be required.

3.6.1 Biophysical Environment

3.6.1.1 Fish and Fish Habitat

Both the SGR and UNL options have potential to impact fish and fish habitat (HADD). The SGR is known to be a recreational and Indigenous fishery, with Arctic char being the primary harvested species. As reported in Nunami Stantec (2018), Arctic char use the SGR throughout the year for migration, overwintering, spawning, and rearing. The intake site is unlikely to provide overwintering habitat but may have some desirable habitat during certain times of year. Winter withdrawal from the SGR has been deemed not feasible due to low flow conditions (Nunami Stantec 2018). To remain protective of fish, withdrawals during the open water season (June to September) are limited to 10% of the instantaneous flow when flows are above 30% of the mean annual discharge in accordance with DFO (2013). Using this limitation, the design withdrawal rate of 0.233 m^3/s would take no more than 2% of the expected flows during July to September, as based on historical data, and therefore have low risk of effects to fish. There would be some habitat loss associated with the construction of intakes at both sites, with the SGR option leading to greater potential of a HADD and Fisheries Authorization being required.

The UNL option has considerations for fish and fish habitat as based on the need to install a new intake, and to withdraw water during winter when the lake is ice-covered. The available under-ice volume in UNL is estimated between 4.2 and 4.7 million m^3 (Appendix A and Tetra Tech 2019). For protection of fish, DFO applies a protocol to limit under-ice withdrawal to 10% of the available volume. In summer, withdrawals should meet the ecological flow needs of connected waterbodies. A proposed winter withdrawal of up to 1.2 million m^3 may exceed the 10% under-ice withdrawal that is protective of fish, triggering the need for additional study and authorization when withdrawals approach this volume. In any season, water withdrawal from UNL will reduce or eliminate outflows from UNL to the downstream Apex River. The reduction in flows is not immediately quantifiable but may exceed 10% of the total flow of the Apex River from time to time, triggering the need for additional study and/or authorization by DFO.

Of note is that this report does not discuss ongoing or complementary supplementation from the Apex River at its current location during the open water season, which is upstream of the confluence of the UNL outflow with Apex River. Taking water from the Apex River when available may mitigate potential effects to fish in UNL by reducing the withdrawal amounts needed in winter.

3.6.1.2 Terrain, Soils and Permafrost

The conceptual overland pipeline routes traverse hilly and rocky terrain with consideration of several wetlands and drainage areas. The SGR option may require some cut and fill sections. Both routes will require construction of a new road or upgrade to existing roads. Both options are located in an area of continuous permafrost. Granular material requirements and considerations of constructing and operating in permafrost will need to be considered in design. Granular (and rock) material is generally understood to be available within the City municipal boundaries.

3.6.1.3 Wildlife and Species at Risk

Both options require development in new areas, which has potential to disturb habitats for migratory birds, game birds and large and small mammals. Both options have potential to impact species at risk, including rare plants. Both options are currently considered comparable in terms of their potential impacts to wildlife and species at risk. Further study of potentially impacted habitats of species at risk should be completed as project planning advances for a selected option.

3.6.2 Socio-cultural Environment

3.6.2.1 Traditional and Recreational Land Use

The SGR option is located adjacent to the Sylvia Grinnell River, which is a popular area for seasonal and year-round camping by Iqalummiut, including Inuit families. Use of the area is currently unregulated. The placement of a new intake and pipeline in the river may locally impact traditional and recreational land use. The UNL area is not used commonly for recreational activities and is not believed to be used for traditional activities. The routing of pipelines for both options may impede access to traditional or recreational land use areas or create safety or security risks in certain areas. The potential impacts to, and mitigations for impacts to traditional and recreational land use should be considered as planning advances for a selected option and should be informed by consultation and engagement activities.

3.6.2.2 Heritage Resources

A portion of the UNL option was previously assessed for heritage resources during the 2019 emergency supplementation project. This included assessment and recording of heritage resources along the access road from Apex River to UNL, borrow sources and semi-permanent pipeline from Apex River to Lake Geraldine. Additional heritage resources assessment would need to be completed at all areas proposed to be disturbed by either option. This report makes no comment on heritage resources potential of either option, though potential may be correlated with traditional land use. Generally, impacts to heritage resources are mitigable and can be considered in later stages of planning, as further informed by field studies and consultation and engagement.

3.6.3 Community Engagement

The following stakeholders may have interest in one or both of the supply options being considered:

- Amaruq Hunters and Trappers Association
- Qikiqtani Inuit Association – Community Lands and Resources Committee
- Residents of the City of Iqaluit
- Iqaluit Joint Planning and Management Committee

The City of Iqaluit (supported by Nunami Stantec) has held several engagement meetings with stakeholders on water supply options, including the Sylvia Grinnell River, Apex River and Unnamed Lake since 2018. A summary of engagement meetings is provided in Table 3.4.

Table 3.4 Summary of Engagement Meetings on Water Supply Options

Date	Stakeholder	Type of Engagement	Topics Discussed
September 6, 2018	Amaruq HTA	Board Meeting	Sylvia Grinnell source and intake options
February 7, 2019	Amaruq HTA	Board Meeting	Update on water supplementation studies; short-term water licence amendment to withdraw water from Apex River
July 4, 2019	Amaruq HTA	Letter	Ongoing planned studies of Unnamed Lake
July 30, 2019	QIA	Individual Meeting	Information about ongoing and planned projects to be sent to QIA for information
May 16, 2022	Amaruq HTA	Board Meeting	Update on evaluation of UNL and SGR water supply options
May 17, 2022	Nunavut Parks representative of NJMPC	In-person Meeting	SGR supply option

Date	Stakeholder	Type of Engagement	Topics Discussed
May 23, 2022	QIA Planning representative	MS Teams Meeting	Update on evaluation of UNL and SGR water supply options
June 9, 2022	QIA Lands Administration and CLARC Coordinator	MS Teams Meeting	Overview of supply options being considered; discussion on further need to engage QIA and CLARC

3.6.3.1 What We Heard

During engagements since 2018, the Amaruq HTA has been firmly and consistently opposed to installing permanent infrastructure for water withdrawal within the Sylvia Grinnell River. They have raised concerns about potential effects to fish and fish habitat from installing water intakes and from pumping operations. These are not concerns related to the amount of water to be taken. They are concerns rooted deeply in the culture and traditional practices of Inuit who use the river and the surrounding area.

By contrast, the Amaruq HTA has encouraged the City to evaluate Unnamed Lake as a potential source, as well as other lakes further upstream in the Apex River (referred to as Crazy Lake and Long Lake) so as not to take all the water from any single lake. The small fish [“*nutiblik”*] present in the Apex River are not harvested by Inuit. The Amaruq HTA raised the need to maintain access to snowmobile trails and that pipelines need to be clearly marked.

QIA has responsibility for administering Inuit-owned lands. As the project does not directly impact IOL, QIA has asked to remain informed of the project. QIA would need to be further consulted if there were to be impacts to Inuit rights, such as impacts to hunting, fishing or trapping. This could potentially be a confounding consideration for the SGR supply option.

There were generally no concerns raised around potential impacts to Sylvia Grinnell Park from creating new access or pipeline for the SGR option.

3.6.4 Regulatory Engagement and Approvals

Supplementation from either the SGR or UNL will require approval and/or authorizations from the Nunavut Water Board, GN Department of Health and Fisheries and Oceans Canada Other organizations that may have an interest include Crown-Indigenous Relations and Northern Affairs Canada – Water Resources Division, Government of Nunavut –Department of Environment and Department of Culture and Heritage.

A screening by the Nunavut Impact Review Board will be required as per the Nunavut Planning and Project Assessment Act. To support applications for approval, the City will need to engage with Amaruq Hunters and Trappers Association (HTA), Qikiqtani Inuit Association, Parks Management Committee (SGR Option) and residents of Iqaluit.

To support applications for approval, the City will need to engage with Amaruq Hunters and Trappers Association, Qikiqtani Inuit Association, and residents of Iqaluit. As both supply options (UNL and SGR) are within the municipal boundaries of the City of Iqaluit, community consultation is expected to be a key aspect of the regulatory review process. Some consultation has already occurred with the HTA for the SGR option. We understand that the HTA's current preference is to not utilize SGR as a long-term water supply, but to consider UNL.

The construction and operation of a new intake site, pipeline and associated infrastructure for water withdrawal and conveyance is anticipated to require review, approvals and/or authorizations from:

- Nunavut Planning Commission (NPC) and Nunavut Impact Review Board (NIRB) (Screening)
- Fisheries and Oceans Canada (Request for Review / Fisheries Act Authorization)
- Nunavut Water Board (amendment to municipal type A water licence)
- Government of Nunavut Department of Health (source water quality)
- Government of Nunavut Economic Development and Transportation – Iqaluit International Airport Division (for SGR option)
- NAV Canada (land use application), for SGR option
- Nunavut Department of Culture and Heritage – approval of Archaeological Assessment

Neither option encroaches upon the Sylvia Grinnell Territorial Park.

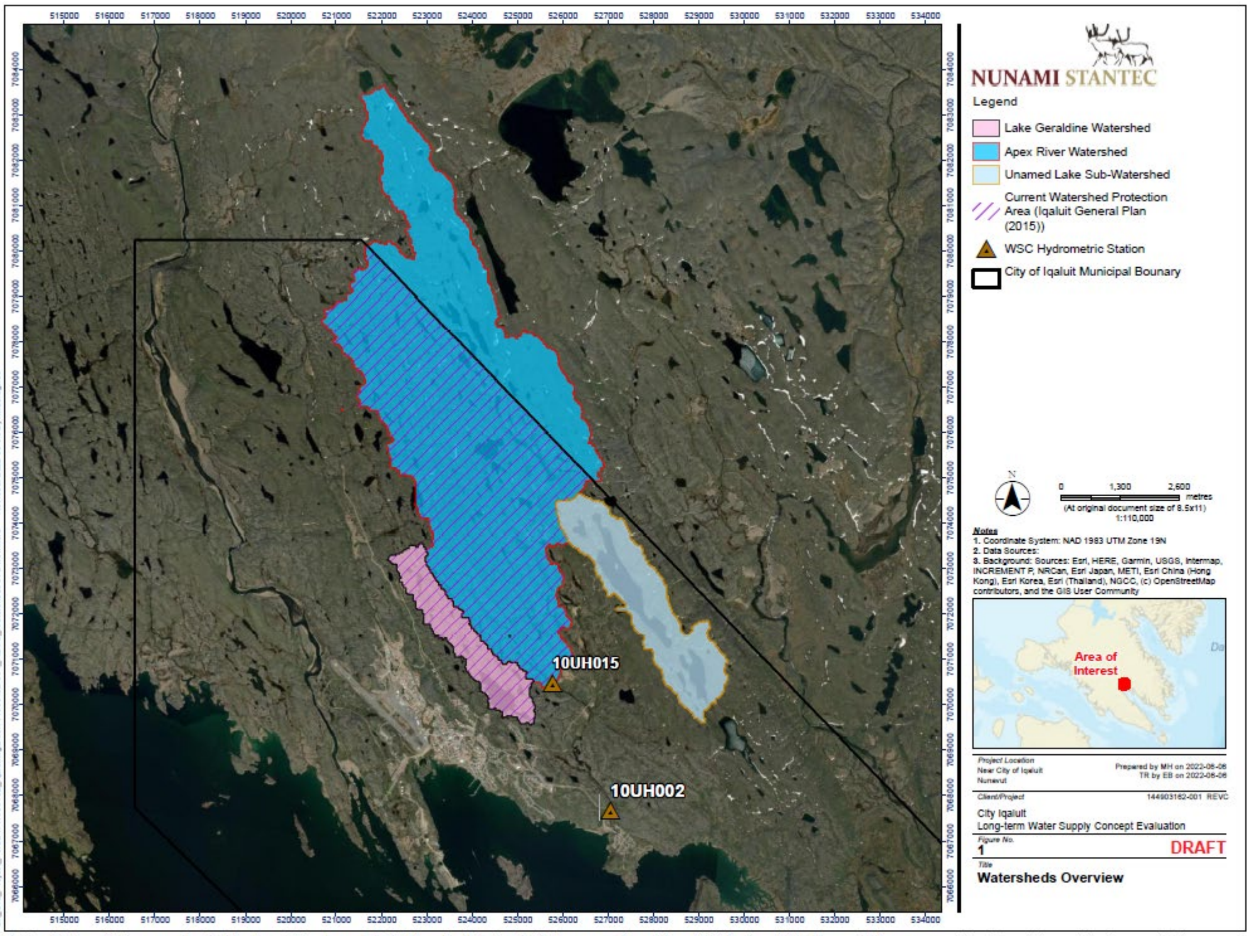
The City of Iqaluit will need to consider amending the Zoning by-law to add watershed protection to the UNL watershed, and to potentially extend existing protection of the Apex River watershed to beyond the municipal boundary, if the Apex River additional supply is considered further (beyond the scope of this report). Figure 3.1 shows the extend of current watershed protection areas within the municipal boundary and the full extent of the Apex River watershed, including the Unnamed Lake sub-watershed.

Additional fields studies that may be required to support regulatory approvals include:

- Further validation of the water balance model for UNL
- Water quality profile including sediment quality in UNL
- Fisheries study (gill netting) of UNL
- Archaeological assessment of the road and pipeline route
- Evaluation of presence of species at risk

A key aspect of the regulatory review process for UNL is expected to be the water balance, to confirm the sustainability of the supply.

Figure 3.2 Watersheds and Existing Watershed Protection Areas



3.6.4.1 NPC/NIRB Screening

The requirements to obtain an authorization from one or more regulators or agencies of the federal or territorial government for the project triggers the requirement for a NIRB screening of the proposed project under the provisions of the Nunavut Agreement and Nunavut Planning and Project Assessment Act. This process requires submission of a project proposal to the NPC first, then a more detailed project proposal to NIRB, including a description of the project works and activities, evidence of engagement with affected communities, and a preliminary assessment of impacts of the project on the environment. The outcome of this public screening is a determination by the NIRB whether the project can proceed to permitting, or whether additional review is required. The NPC/NIRB screening for this project should be expected to take approximately 4 months and is coordinated with the Nunavut Water Board's process.

3.6.4.2 Amendment to City of Iqaluit Water Licence

The City of Iqaluit currently holds a type "A" water licence issued by the Nunavut Water Board (NWB). The licence permits water withdrawal from specified sources and up to specified amounts. The withdrawal of more than 300 m^3 water per day from a new source – the SGR or UNL and diversion to Lake Geraldine, requires approval by the NWB and an amendment to the licence in accordance with the Nunavut Waters Regulations. An application for such amendment requires that the application supporting documents include detailed design drawings accompanied by updates to the compliance monitoring program and environmental protection plans as applicable. The NWB's process to amend a type A water licence begins after a NIRB screening process concludes the project proposal can proceed to licensing. The NWB's process to amend a type A water licence includes a public technical review and requires a public hearing to be held. The NWB review process should be expected to take approximately 12 months.

3.6.4.3 Fisheries Act Authorization

For the SGR option, a Fisheries Act Authorization may be required due to instream works related to the proposed water intake structure and local importance of the Sylvia Grinnell River fishery. A Fisheries Act Authorization may be required for the UNL option due to the potential for water withdrawal to exceed 10% of the under-ice volume of UNL and for withdrawals to affect downstream flow. To initiate this process, a Request for Review is submitted to DFO to start a file number, and to confirm whether an Authorization will be required. A Request for Review by DFO typically takes 6-8 weeks for a decision whether an Authorization is required. If an Authorization is required under Section 35(2) of the Fisheries Act an application for Authorization is required to be submitted to DFO. The application also requires the submission of an Offsetting Plan and letter of credit. DFO prefers that offsetting be completed prior to construction of a project, however this sometimes can be waived and the offsetting can be conducted at the same time as project construction. DFO has 60 days to respond whether the application is complete. Once DFO considers the application to be complete they have 90 days to decide on whether the Authorization is approved or denied. Depending on the circumstances (generally information requirements) the timelines can be stopped and restarted. Both the Authorization and Offsetting Plan require engagement with affected communities and Indigenous groups to identify potential offsetting measures and then to confirm the offsetting measured to be used. DFO participates in this process to confirm the identified offsetting options area suitable. The amount of offsetting would be based on the degree of serious harm that is likely to occur and is usually transformed into square meters of habitat. Offsetting would require an engineered design which would require a field survey of the area to be offset to inform the engineering design. Preparing and obtaining an Authorization should be expected to take approximately 6 –12 months.

3.6.4.4 Department of Health

As both source options are new raw potable water sources, water quality testing must be conducted to confirm the water is suitable as a raw water supply. The Territorial Medical Health Officer issues approval to use a source as a raw water supply based on a review of results of water quality analyses. Based on experience from the 2019 supplementation from UNL, it is a suitable potable water source based on surface water samples. Additional water testing should be completed along a depth profile, and testing of mercury in sediment should be completed and compared against applicable guidelines at the time. No data is available for Sylvia Grinnell River.

3.6.4.5 Airports and NAV Canada Approval

The City of Iqaluit Airport Authority has jurisdiction over developments conducted on airport lands, and Transport Canada has authority to approve certain types of developments within Airport Zoning Regulations (4,000 m radius of airport). A review of the proposed development against these authorities' requirements is completed by the Airports Division and by NAV Canada. Drawings showing the location and all dimensions of infrastructure are required to be provided.

3.7 SCHEDULE

Table 3.5 provides a high level conceptual schedule from design to in-service of supply options, which can be applied to both options. The schedule does not reflect timelines associated with modifications to alter storage.

Table 3.5 Conceptual Schedule for In-service of Supply Options

Development Stage	2023	2024	2025	2026	2027
Field Studies and Design					
Engagement					
Permitting					
Financing					
Tender					
Equipment Orders and Staging					
Construction					
In Service					

4.0 EVALUATION SUMMARY

Table 4.1 summarizes the evaluation discussion into quantitative and qualitive results for ranking. No weighting has been applied to the criteria. This could be factored in during future evaluation as combined with storage options.

Table 4.1 Evaluation Summary

Evaluation Criteria			Comparative Comment	
			Sylvia Grinnell River	**Unnamed Lake**
Technical	Capacity	Open-water	Yes; additional storage required	Yes; no additional storage required for year-round. Additional storage required for 3 – or 5-month resupply scenarios.
		Winter	No	Yes
	Supply	Required in 2050	Yes	Yes, if considering Apex River as supplemental. But to population of 17,000, annual recharge rate to be confirmed
		Required in 2026	Yes	Yes
		Addresses Climate Change Resilience	Yes	Yes
	Accessibility	New Roads Required	5,000 m	3,200 m
		Power & Pumping	Intake + Two Booster Power Requirement = 700 HP	Intake Only Power Requirement = -69.60 HP
		Pipeline Required	500 mm 6,500 m	200-400 mm, depending on resupply scenario 5,000 – 6,000m
	Implementation	Constructability	Generally the same constructability as UNL, however, there are more pumping stations required.	Generally the same constructability as SGR, however, less pumping infrastructure.
		O&M Complexity	Sylvia Grinnell will require more pumping stations and therefore, more maintenance	Less maintenance is required due to less pumping infrastructure. Reheat and recirculation required for year-round operations.
Economic	Costs	Capital	$32.5M (+$65M for options with additional storage requirements)	$13.5M - $15M (+$65M for options with additional storage requirements)
		Operational	Annual power cost = $1,100,000 - $1,500,000 Annual O&M = $300,000	Annual earnings (from power generation) = $148,000 Annual O&M Costs =
Environmental	Environmental / Socio-cultural	Biophysical Environment	Potential impacts to fish and fish habitat; summer only	Potential impacts to overwintering fish as approaching high withdrawal volumes
		Socio-cultural	Area of traditional and recreational land use; not supported by HTA	Limited recreational or traditional land use value; supported by HTA
		Regulatory Approvals	No special considerations; FAA will be required	No special considerations; FAA may be required

Evaluation Criteria			Comparative Comment	
			Sylvia Grinnell River	**Unnamed Lake**
		Land Use Planning	Watershed protection and site security needed	Watershed protection exists; site security needed
	Community Preference	Consultation Results	Not favoured (HTA consultation)	Preferred (HTA consultation

5.0 CONCLUSIONS & RECOMMENDATIONS

In accordance with the background data provided, Nunami Stantec has completed an evaluation of the SGR long-term supplementation of Lake Geraldine conceptual level report and the pre-conceptual level design from UNL. Within this document, we describe the information extracted from the background documents and determined that, according to projections:

3. SGR could be a sustainable supply for a population of 24,000, however, it would require an additional storage reservoir as it can only be used during open-water season.
4. UNL by itself could be a sustainable supply up to a population of 17,000 (with additional supply potential from Apex River). UNL does not require an additional reservoir as it, in itself, is a functioning reservoir.

The pumping scenario reviewed for SGR indicates that a three-month pumping regime would be used during open water. Because of the elevation increase from SGR to Lake Geraldine, this is paired with additional pumping requirements. The additional pumping requirements add cost and O&M requirements.

We consider that the optimal pumping scenario for UNL is to continuously resupply Lake Geraldine from UNL. That recommendation will require further analysis during detailed design to optimize pumping and other operational details. Required equipment and controls will also be determined later in design. UNL has minimal pumping requirements and could potentially generate power. While continuous pumping is optimal for the UNL system and would not require an additional reservoir ($65M), winter operations may present risk to the City. As such, it has been requested to move forward with three-month, summer operation of the UNL system and additional reservoir.

SGR optimal concept indicates that intake Site B with a pipeline route towards the airport runway then overland be selected. For UNL, at the pre-conceptual level, considering the minor differences in cost between Options 1 and 2, we suggest that both pipeline routing options remain considered for UNL until detailed topography is evaluated during design.

Following our analysis, we have created a list of information that would provide valuable information to confirm feasibility of UNL and move this project into further design stages.

- Construct a metering station comprising a weir and data logger in the downstream channel of UNL to measure outflow and compare the results with modeled outflow (Golder 2021) and the assumptions used in developing this pre-concept.
    - This is in addition to the existing transducer that is in UNL.
    - This data can be used to develop a relationship between flows recorded at UNL and those on the Apex River. This relationship could potentially be used to construct a synthetic dataset for UNL that extends back as far as records on the Apex River (1973).
- Assess the effect of drawdown on the abandonment of sub-basin to confirm total under ice water volumes used in this pre-concept.

- Re-assess the quality of bathymetric survey data to confirm stage-storage relationships that formed the basis of this assessments.
- Conduct a more detailed assessment of lake response to proposed withdrawals, particularly in drought years, including back-to-back occurrences, and under future climate scenarios.
- Ensure detailed topography is attained and used to optimize pipeline routes.
- Complete a drainage assessment of the area prior to road design.
- Consider the feasibility of complementary supplementation from the Apex River

Capital and operational cost of SGR, considering the requirement to construct an additional reservoir for storage, is much higher than UNL.

Community consultation will play a major role in selection of the source. We understand that UNL is currently the preferred option, however, this will be understood more at the subsequent project phases.

Understanding the available water and recharge rate of UNL is critical before selection of this as the long-term supplemental source and at least two years of data should be collected to confirm the hydrology of UNL and the effects on the downstream Apex River.

6.0 REFERENCES

DFO (Fisheries and Oceans Canada). 2013. Framework for Assessing the Ecological Flow Requirements to Support Fisheries in Canada. Canadian Science Advisory Secretariat Science Advisory Report 2013/017.

EXP. 2020. Iqaluit Water Storage Pre-Feasibility Study. Report to the City of Iqaluit dated October 16, 2020.

Golder Associates Ltd. 2021. Water Balance Assessment for Unnamed Lake. Report to the City of Iqaluit dated March 2021

Nunami Stantec Limited. 2018. Options Evaluation for Raw Water Supplementation from the Sylvia Grinnell River. Report to the City of Iqaluit, April 2018.

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Nunami Stantec Limited. 2019b. Lake Geraldine Reservoir Storage – Desktop Review and Assessment. Memorandum to the City of Iqaluit, January 2019.

Tetra Tech Canada Inc. Iqaluit DFO Bathymetric Lake Surveys. Memorandum to the City of Iqaluit, July 2019.

WSP. 2021. Unnamed Lake Fish and Fish Habitat Assessment Technical Report. Report to the City of Iqaluit, February 2021.

APPENDIX A
UNNAMED LAKE PRE-CONCEPT MEMORANDUM

NUNAMI
STANTEC LIMITED

Memo

To:	Amy Elgersma, CAO City of Iqaluit	From:	Erica Bonhomme Nunami Stantec Ltd.
File:	144903162	Date:	October 4, 2021

Reference: Unnamed Lake Pre-concept Memorandum

1 INTRODUCTION

The purpose of this memo is to describe and develop the Unnamed Lake (UNL) pumping and conveyance option to be used as a basis for the comparative evaluation between Sylvia Grinnell River (SGR) and UNL as supplementary sources of potable water for the City of Iqaluit.

On June 18, 2021, as the first step of the evaluation, Nunami Stantec Ltd (Nunami Stantec) submitted a draft evaluation criteria and summary of gaps analysis. Upon completion of this review, we identified that additional definition of the UNL option would be required to proceed with an overall evaluation of the two sources. As such, the City of Iqaluit (City) and Colliers Project Leaders (Colliers) decided to include a pre-concept study of the UNL option to address the identified information gaps.

This memo assumes that UNL provides the necessary amount of supplementation capacity for long-term requirements of the City (Golder 2021) and provides some validation to this assumption through the selection of the design basis for the withdrawal infrastructure and its operational regime. This work then provides a pre-concept design for an intake at UNL and two options for pipeline routing and conveyance from source to storage. The memo contains level-appropriate discussion on intake and discharge locations, conveyance direction and distance, infrastructure requirements (road, power, pipeline, pumping stations), operability and constraints, and an estimate of probable cost to construct and operate the system.

2 BACKGROUND DOCUMENT REVIEW

As discussed in the Iqaluit Water Storage Pre-Feasibility Study (EXP, 2020), using the high growth rate for population projections, the City of Iqaluit is expected to have a population of 24,000 people by 2050. Based on a raw water consumption rate to be 400 Lpcd, future demands are estimated to be 9,600 m^3/d. This is important data when considering the concept of UNL as a potential future water source. Based on this projected daily demand, the pre-concept described herein considers an annual raw water demand requirement of 3,500,000 m^3 by 2050.

Lake Geraldine currently has a capacity of 1,680,500 m^3 (4,600 m^3/d), of which 1,100,000 m^3 is accessible during winter months due to ice formation and only when the reservoir is full prior to freeze up. The calculations for winter months, considered conservatively to be from October to May, do not consider any inflows from precipitation or runoff (Nunami Stantec, 2019). Between October and May, or 8 months (242 days), the predicted 2050 demand equates to a required raw water demand of 2,323,200 m^3 during this period. This means that Lake Geraldine will have a shortfall of about 1,223,200 m^3 by 2050 (or population of 24,000) during winter months. Considering the projected annual demand, the required amount of water from UNL to supplement future needs of Iqaluit would be about 1,820,000 m^3, or 4,990 m^3/d (915 USGPM).

2.1 UNNAMED LAKE SUPPLY CAPACITY

A water balance assessment of Unnamed Lake was prepared in March 2021 (Golder, 2021). That study assumed a system that tops up lake Geraldine over a four-week period prior to freeze-up and found that "under current climate conditions, the Unnamed Lake supplementation has the potential to be a feasible additional water supply for the City of Iqaluit."

According to Golder (2021), the average annual outflows from UNL are estimated to be 1,591,928 m^3 (4,361 m^3/d) and the average annual outflows from Lake Geraldine are estimated to be 829,754 m^3 (2,273 m^3/d). For the purposes of this pre-concept we assumed that all of the outflow from UNL as estimated by Golder (2021) is available for use. While this amount would not reflect the available volumes on an annual basis, it is an approximation of potentially available water once other lake variables are accounted for (for example, lake evaporation). Nunami Stantec acknowledges that additional work is required to provide additional confidence to the hydrology of Unnamed Lake, however, the volumes presented in Golder (2021) will be used throughout this report as the amount of available water for use, annually, from UNL and Lake Geraldine.

To summarize, the following will be used as sustainable amounts that can be withdrawn from both UNL and Lake Geraldine.

- Annual regeneration from UNL: 1,591,928 m^3 (4,361 m^3/d)
- Annual regeneration from Lake Geraldine: 829,754 m^3 (2,273 m^3/d)

The UNL water balance study (Golder 2021) assumed that UNL's outlet channel invert elevation is at 202.1 m. Stage-storage curves for each of UNL's three sub-basins were provided in that study and suggest that there is a total volume of 5,534,000 m^3 in UNL during open water, and at the point where no outflow occurs from the lake (e.g at freeze-up or at 'full supply level'). Golder assumed that ice thicknesses on UNL ranges between 1.3 m and 1.8 m under current climate. For the purposes of this pre-concept, Nunami Stantec conservatively used an ice thickness of 1.8 m and this translates to an under-ice elevation of 200.3 m. Referring to the stage-storage curves provided in Golder 2021, and summing them to capture total volume, but omitting abandonment of sub-basins from the drawdown, results in a total minimum under ice volume of 4,252,000 m^3 in the Unnamed Lake. This is nearly four times the volume of water available in winter than can be stored in Lake Geraldine.

2.2 FUTURE POPULATION OF IQALUIT & WATER DEMAND PROJECTION

As discussed in the Iqaluit Water Storage Pre-Feasibility Study (EXP, 2020), using the high growth rate for population projections, the City of Iqaluit is expected to have a population of 24,000 by year 2050.

Table 2-1 indicates future needs based on population projections and average annual outflows of UNL and Lake Geraldine. Average annual outflows, as discussed in the water balance report by (Golder, 2021), are described in Section 2.1.

Reference: **Unnamed Lake Pre-concept Memorandum**

Table 2-1 Population Projection and Future Water Demands

YEAR	POPULATION HIGH GROWTH (3.38%)	DAILY DEMAND (M^3/D) (POPULATION X 400 LPCD)	UNL SUPPLEMENTATION REQUIREMENT (M^3/D)
2020	8,839	3,536	1,263
2025	10,440	4,176	1,903
2035	14,566	5,826	3,553
2040	17,204	6,882	4,609* Deficiency = 248
2045	20,321	8,128	5,855* Deficiency = 1,491
2050	24,002	9,600	7,327* Deficiency = 2,966

With this in mind, we see that based on the current information and assumptions, UNL is suitable as a stand-alone supplementation source to a population of 17,000, or about 2040 under the high growth rate scenario used by EXP (2020).

Some inaccuracies in the assumptions should be noted here. We see that the average consumption estimated here for 2020 is about 3,536 m^3/d. Based on the Iqaluit Systems Flows, the current average daily consumption is about 2,850 m3/d (July 2021). Based on the current population information, the high population growth rate may overestimate population growth. Nunami Stantec recommends the City and City planning department reconsider lower growth rate scenarios as part of the long-term water supply feasibility analysis so as to not discount viable sources into 2050. For the purposes of this assignment, we will consider the values presented in Table 2-1 and count UNL as a viable source to a population of 17,000 people, as opposed to projected demand to 2050.

3 RESUPPLY SCENARIOS AND DESIGN PUMPING REGIME

The mandate of this pre-concept design was to utilize information gathered from the UNL water balance (Golder, 2021). That study also determined that under a high consumption scenario of 115,000 m^3/month (or 3,780 m^3/d), the average pumping rates required from Unnamed Lake in the simulations were between 36 L/s and

540 L/s in the years simulated. Golder recommended a design pumping rate of 50% greater than 584 l/s for a system that tops up Lake Geraldine prior to winter. This flow rate was the maximum instantaneous required pumping rate observed in the results of their simulation and with the factor of safety equates to a design pumping rate of 867 l/s.

While this allows for recharge of Lake Geraldine prior to winter months, it does not address the winter month deficiency at Lake Geraldine resulting from increased future demands and inaccessible frozen water, as described by EXP (2020). The available capacity of water in Lake Geraldine in winter is 1,100,000 m^3 resulting in a deficit of 1,223,200 m^3. Either a winter recharge or the construction of additional reservoir capacity would therefore be required as demands grow in the future.

The high consumption rate of 115,000 m^3/month is defined as the entire demand for the City of Iqaluit, as opposed to an available amount from UNL. The high consumption rate does provide an increase from the City's current demand; however, it does not account for the predicted future growth to 2050 (population of 24,000), which has been estimated to be as large as 9,600 m^3/d (EXP, 2020). A system of such capacity as that recommended by Golder (2021) is possible, but the system will likely not be able to meet demand projections made by EXP (2020) demand for 2050 during the winter totals 2,323,200 m^3. These projections are what served as the basis of design for other options being evaluated alongside this pre-concept for UNL. Should those projections be realized by the time a population of 17,000 is observed, then the winter demand may exceed the 1,100,000 m^3 of water available under the ice in Lake Geraldine and would require additional pumping in mid-winter from UNL to replenish the supply. A more flexible system would be one that is designed to be able to draw from UNL continuously throughout the winter to top up Lake Geraldine. Continuous operation of a raw water pipeline will provide a more desirable operation of the system, preserving the available water in Lake Geraldine throughout the winter months, regardless of the water demand, without requiring the construction of additional winter storage capacity or reservoir.

Nunami Stantec is of the opinion that a continuous re-supply is a more suitable candidate for the long-term solution than an intermittent recharge program. By providing a continuous, lower rate flow of water, pumping requirements are much more reasonable as compared to intermittent pumping. As is used by the current utilidor system, maintaining flow within a pipe prevents freeze up. Understanding the Lake Geraldine storage capacity and future winter recharge requirements, continuous resupply will provide the necessary resiliency for operation and capacity as populations and demand grows. The reported outflows from the Lake Geraldine and UNL indicate that UNL can be used to supplement demands in Lake Geraldine until the population reaches 17,000.

If UNL is used as a supplement to meet the projected demand to 17,000 people, the system would need to provide 4,361 m^3/d (0.05 m^3/s, or 50 lps). UNL's total under ice volume of 4,252,000 m^3 (described in Section 2.1) exceeds this winter demand suggesting there is sufficient supply. Comparing this to the lake's total annual outflow of 1,591,928 m^3 suggests that there is potentially sufficient volume of throughflow in UNL to replenish its lake levels each year from such a drawdown. This still indicates that minimal pumping requirements are necessary to complete the action. This will be the daily flowrate throughout the year.

To summarize the operating scenario for this pre-concept memo:

- A pumping rate of 0.05 m^3/s (50 l/s) will be used
- UNL will be drawn down over the winter below 202.1 m elevation, sufficient to allow the full recovery of spring freshet with minimal or no overflow and discharge from UNL in the spring

4 INTAKE AT THE UNNAMED LAKE

The intake at Unnamed Lake would be comprised of a pumphouse on the west shore and a raw water line extending out into the lake and running along the lake bed to the withdrawal location. At the withdrawal location, the pipe would be screened with an orb type screen(s) with the pipe and screen affixed to an anchor block or pile footing to keep it in place and above the lake bed. The screening must be sized in accordance with Fisheries and Oceans Canada's (DFO) code of practice for end of pipe fish screening. eDNA samples taken from the lake (WSP 2021) identified the presence of arctic char, but no other fish, though Ninespine stickleback have potential to be present. Arctic char and Ninespine stickleback both have a subcarangiform mode of swimming and under the code of practice a withdrawal rate of 50 l/s would require a screen area of 0.51 m^2 to prevent entrainment and impingement. This screen area can be accommodated with a single drum type orb screen with openings no larger than 2.54 mm, in accordance with the code. The screens would also be fitted with an air scour that is operated by an airline running in parallel with the raw water line and connected to a compressor at the pumphouse. The air scour can be run continuously in winter to mitigate frazil or in bursts to control biofouling.

The withdrawal should occur in an area of the lake that is deep enough to accommodate the screens without risk of entrainment of lake sediment from being too close to the bottom; or damage from ice, or the entrainment of frazil from being too near the surface. The screens contemplated in this pre-concept and should be placed no less than 2 m from the lake bed. The screens should have at least a minimum of 2 m of water above them to accommodate ice thickness however Stantec recommends a minimum of 4 m for this pre-concept. Totaling these assumed values suggests the intake should be in a minimum of 8 m of water. Bathymetry of the lake bottom (Tetratech, 2019) suggests the maximum depth in Unnamed Lake is 22 m and there are a considerable number of areas in unnamed lake where this depth is exceeded. Based on desktop review of the bathymetry Stantec recommends that the intake withdraw from the deeper portions of the lake around 7072500N 527400E z19. The pumphouse would be located on shore near this location. This assumption served the basis for pipeline and access road routing for the pre-concept.

5 PIPELINE ROUTING OPTIONS

UNL is located approximately 3.5 km northeast of Lake Geraldine. It is located approximately 200 m asl, with Lake Geraldine located at about 95 m asl, with topography generally sloping down. The Apex River runs between these lakes, creating a topographic valley. In our limited analysis of routing options, we've taken a general approach to routing, which would require optimization with detailed topography prior to detailed design. In this approach, we've identified two routes from UNL to Lake Geraldine, one running from the intake location along the northwest side of UNL to directly into Lake Geraldine and a second running from the intake location along the western side of UNL directly to Lake Geraldine. To compensate for future route optimization, we will be adding 30% to the length of each of these pipelines in the costing analysis.

The assumed discharge locations are to locations within Lake Geraldine that are accessible by the Water Treatment Plant (WTP intake), as estimated from bathymetric data. This can be further confirmed during detailed design.

5.1 PRE-CONCEPT PIPELINE ROUTING, OPTION 1

Option 1 for pipeline routing consists of a pipeline running from the intake location (central UNL) past the northwest side of UNL directly to Lake Geraldine at a location accessible by the current WTP intake. This discharge location would feed Lake Geraldine directly without requiring any modifications to the current WTP intake structure. Following this path, the pipeline would generally flow down from 202 m asl at UNL to about 95 m asl at Lake Geraldine.

This route is shown in Figure 2-1.

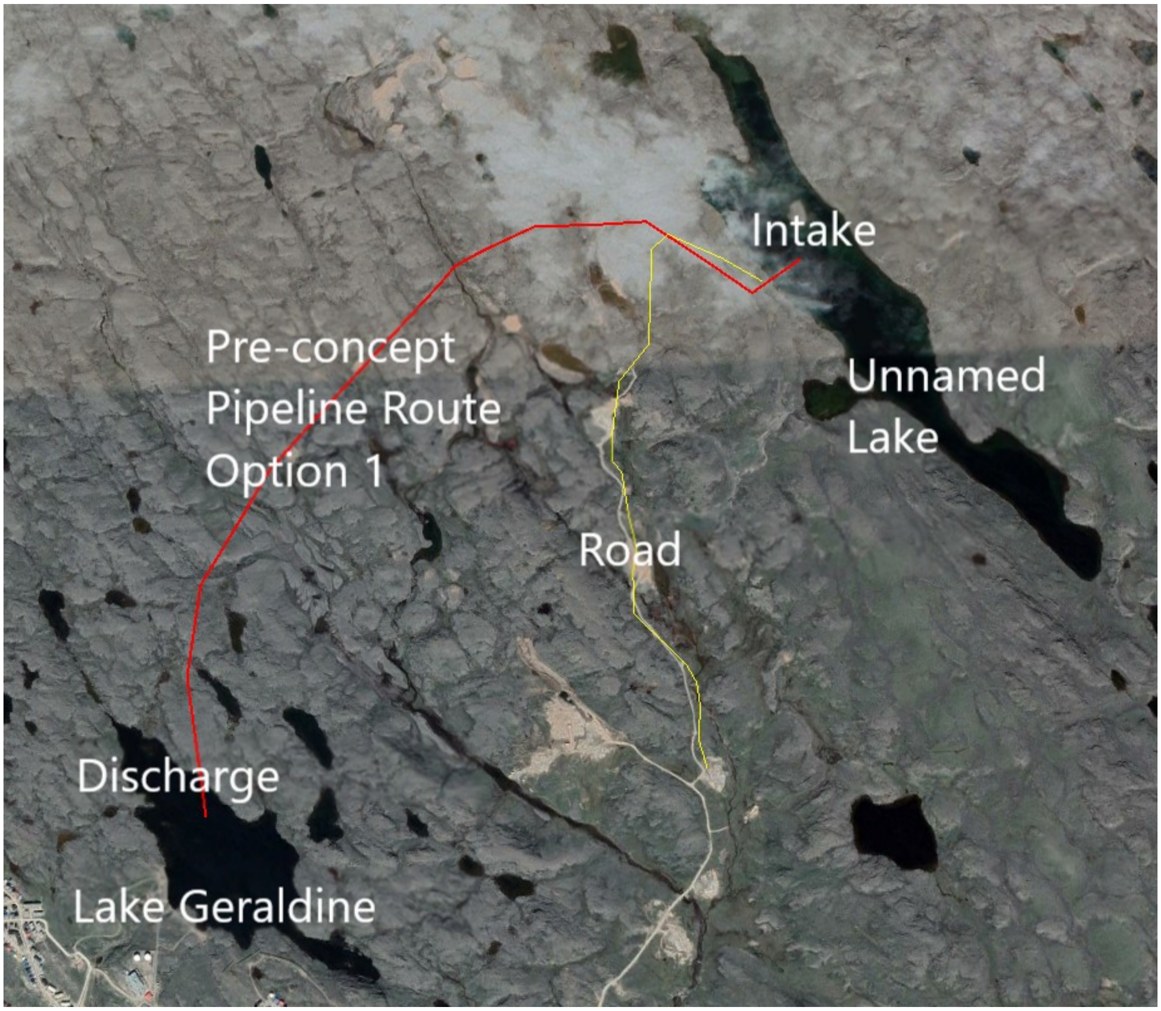

Figure 2-1 Pre-concept Pipeline Route Option 1

5.2 PRE-CONCEPT PIPELINE ROUTING, OPTION 2

Option 2 for pipeline routing consists of a pipeline running from the intake in the central region of UNL past the western side of UNL to eastern side of Lake Geraldine. This discharge location would feed Lake Geraldine directly at a location that remains accessible by the current WTP intake as based upon bathymetric data. Following this path, the pipeline would generally flow down from 202 m asl at UNL to about 95 m asl at Lake

Geraldine. This route was selected as it generally aligns with the current pipeline route from the Apex Supplemental Pumping infrastructure.

This route is shown in Figure 2-2.

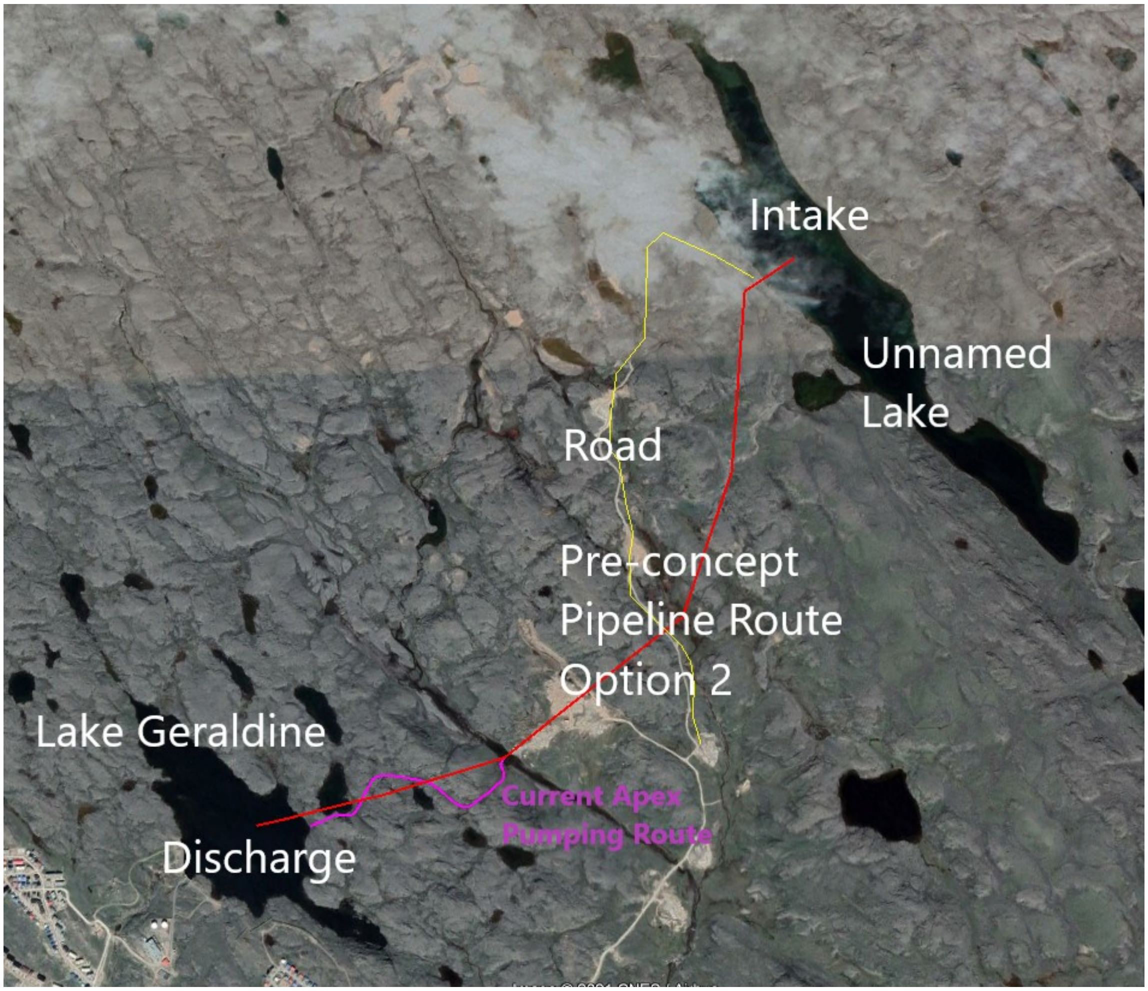

Figure 2-2 Pre-concept Pipeline Route Option 2

6 EVALUATION CRITERIA DISCUSSION

The criteria that will be used in the SGR and UNL evaluation will be described in the following sections.

6.1 ACCESSIBILITY

6.1.1 Roads

Though a temporary road was constructed for the 2019 Lake Geraldine Emergency Supplementation program, utilizing UNL as a permanent part of the Iqaluit potable water supply will require roads to be engineered, constructed, and maintained. Pumping stations at stages along the pipeline will not be required. As a result, a road or trail along the UNL pipelines will not be required for maintenance purposes.

For both routing Options 1 & 2, upgrading the existing road from Road to Nowhere (just past the Iqaluit Shooting Range) to the northwest side of UNL will be required. The general path of the existing temporary road will suffice for this analysis, with an additional path required to reach the central portion of UNL where we estimate will be the intake location. The road requirements are approximately 3,200 m in length. Further analysis and design will be required to understand optimal routes for grading and drainage, with respect to topography.

6.1.2 Pipeline

The pipeline for Option 1 has is shown as about 4,700 m and 4,050 m for Option 2. For each of these, as mentioned, we will be adding a 30% contingency onto the length as an optimal route will be selected at a concept level design with detailed topography analysis. As such, this pre-concept report will consider the pipeline length for Option 1 as 6,100 m and 5,300 m for Option 2.

With the continuous resupply scenario, we've selected a 300 mm insulated HDPE pipe. The pipe can be placed either directly on the ground surface or buried in a bermed area. Heat tracing, while may be included for recovery following emergency shut down periods, will not be required to function for normal operation under the continuous flow system. As mentioned, ideal routing will be selected using detailed topography during the subsequent design phases.

6.1.3 Pumping Stations and Power Requirements

The UNL plant will not require interim pumping stations to lift the water to Lake Geraldine as there is a net elevation loss along the route. The only pumping requirements of the UNL to Lake Geraldine system for the continuous resupply scenario will be to pump the water out of the reservoir. The elevation fall (static head) from UNL to Lake Geraldine is -107 m. We assume a flow rate of 50.47 lps (800 USGPM). The total dynamic head (TDH), which considers the frictional loss and static head, is -105.31 m. Converting this to pressure, the TDH is equal to -147.90 psi.

The hydraulic power required to convey this water is -68.93 HP. In theory, this system could generate about 44.80 HP of electrical, assuming 65% efficiency, and result in about $146,000 in annual power earnings with use of a micro hydro plant. Feasibility of the installation of a micro hydro plant will need to be evaluated further at concept level, however, it is mentioned here to illustrate the potential optimal pumping dynamics of the UNL to Lake Geraldine system.

6.1.4 Power

For the "continuous resupply" pre-conceptual resupply scenario, power requirements can be either fulfilled by use of a diesel generator or direct grid connection with power poles. Since the pumping requirements for this concept are minimal, a generator near the intake pump would likely be suitable.

As noted in the previous section the operation of the continuous flow pipeline could potentially produce more power than is need for pumping out of the lake. Thus power could only be required on startup, making a generator or batteries a viable option rather than grid power.

For the “bulk resupply” pre-conceptual resupply scenario, power requirements are much greater. A permanent grid power connection would be recommended, although a generator would also be possible.

6.2 IMPLEMENTATION

6.2.1 Constructability

By identification of major construction activities, constructability is considered at this project phase to being discussions on risk management for the project during subsequent design phases. While this section does not address every detail, it is expected to form the basis of risk and constructability through detailed design.

The road to UNL will require detailed topographic information to ensure adequate drainage is delineated to prevent washout. Also, the overall quantity and type of granular material should be specified to ensure stockpiles are ready at the time of construction. Given our current understanding of terrain conditions, substantial amounts of materials will be required. The temporary road built for the Lake Geraldine Resupply 2019 project, while in relatively good condition at this time, was not constructed using any detailed design for drainage or material quality and built mostly of locally sourced material. This road is not suitable for long-term use and maintenance; however, it has mapped out the general location of the pre-conceptual design requirements. It will also provide access during construction of the long-term road.

As mentioned, the pipeline routing will be confirmed with detailed topographic information during detailed design. The optimal route does not require a maintenance road; however, it will likely require a temporary construction path for installation. Once the route is selected, borrow sources for gravel can be considered. Construction of the long-term road is recommended before installation of the pipeline. Insulated HDPE pipe is readily available; however, it does have a longer lead time and must be ordered in advance of the construction season. This material should be ordered such that it arrives to Iqaluit on the first sealift of the season.

The intake at UNL will require access to the central part of the lake. The temporary road from 2019 does not run to this exact location so additional road construction will be required prior to installation of the intakes and supporting structures (i.e. generator room, site office).

Power requirements for operation can be in the form of a direct grid connection or from a diesel generator. The long-term road must be in place prior to installation of power poles, if this option is selected. Adequate distance from UNL (minimum 30 m) and secondary containment will be required for placement of any diesel fuel storage or the generator. If a generator and fuel storage is required, it is recommended to be ordered in advance of the first sea lift such that it arrives in Iqaluit in July.

UNL will require some security to ensure this remains a protected water supply. As access to the area increases, so does community interest. The temporary 2019 road has already brought interest to UNL and an increase in activities (i.e. camping and ATV use) has been observed. Signage and fencing will likely be required in various areas.

Supplementation from UNL will require approval and authorizations from the Nunavut Water Board, GN Department of Health and Fisheries and Oceans Canada. A screening by the Nunavut Impact Review Board will be required. To support applications for approval, the City will need to engage with Amaruq Hunters and

Trappers Association, Qikiqtani Inuit Association, and residents of Iqaluit. Additional studies that may be required include:

- Further validation of the water balance model,
- Water quality profile, and
- Archaeology of the road and pipeline route and species at risk.

A key aspect of the regulatory review process is expected to be the water balance.

The number of contractors expected to bid on this is limited, due to the remoteness of the site.

6.2.2 Operation & Maintenance Complexity

Operation and maintenance complexity is largely dependent on the selected resupply scenario. For Resupply Scenario 1, bulk period resupply periods, the line will be required to be drained after each use. If a generator is used to supply power, all fuel should be removed from site and the equipment during each shut down period. Roads must be maintained throughout the entire winter as demands increase as winter pumping will be required. Any planned shutdowns must be timed adequately to ensure pipes with water do not freeze. Resupply Scenario 2 will also require carefully timed shutdowns for maintenance and road maintenance. The site must be kept clear of snow as with any municipal building or infrastructure.

Automatic controls should be in place, including alarms, so City operations can be alerted of any problems resulting from low flow conditions. Thermal analysis will be included during the detailed design to determine alarm setpoints.

6.3 ESTIMATE OF PROBABLE COST

6.3.1 Capital Cost

Based on the identified site conditions, anticipated intake types, and pipeline options with associated infrastructure (i.e., access roads, power, pumping stations), Nunami Stantec has developed an (AACE No.18R-97) Class 5 estimate of probable infrastructure costs. This has been completed for both Sylvia Grinnell River and Unnamed Lake options. So as to make a comparison, the unit prices have been normalized to match the 2019 estimate from Sylvia Grinnell River concept report. Costs are summarized in Table 6-1.

Table 6-1 Estimate of Probable Cost Summary

COST ITEM	UNNAMED LAKE PRE-CONCEPT	
	Option 1	Option 2
GENERAL REQUIREMENTS (MOB/DEMOB, ECO PLAN AND ENV. MONITORING, UTILITIES COORDINATION)	$160,000	$160,000
SITE PREPARATION	$70,000	$70,000
INTAKE (INCLUDING PUMPHOUSE AND EQUIP.)	$1,582,000	$1,582,000
POWER SUPPLY, ROAD, AND PIPE	$6,695,000	$6,335,000
SUB-TOTAL (NO CONTINGENCY)	$8,507,000	$8,147,000
TOTAL CONSTRUCTION COSTS (INCL. 30% CONTINGENCY)	$11,059,100	$10,591,100

6.3.2 Power Cost

Table 6-2 Power Cost

ANNUAL POWER COST	UNNAMED LAKE PRE-CONCEPT
POWER REQUIREMENTS	Power required = -69.60 HP Generation potential = 45.24 HP Annual earnings = $148,000

7 CONCLUSIONS AND RECOMMENDATIONS

In accordance with the background data provided, Nunami Stantec has completed a pre-conceptual level design of long-term supplementation of Lake Geraldine from Unnamed Lake. Within this document, we describe the information extracted from the background documents and determined that, according to projections, UNL could be a sustainable supply up to a population of 17,000.

We believe that the optimal pumping scenario is to continuously resupply Lake Geraldine from UNL. That recommendation will require further analysis during detailed design to optimize pumping details. Required equipment and controls will also be determined later in design.

At the pre-conceptual level, considering the minor differences in cost between Options 1 and 2, we suggest that both pipeline routing options remain considered until detailed topography is considered.

Following our analysis, we have created a list of information that would provide valuable information to confirm feasibility and move this project into further design stages.

- Construct a metering station comprising a weir and data logger in the downstream channel of Unnamed Lake to measure outflow and compare the results with modeled outflow (Golder 2021) and the assumptions used in developing this pre-concept.
    - This is in addition to the existing transducer that is in Unnamed Lake.
    - This data can be used to develop a relationship between flows recorded at UNL and those on the Apex River. This relationship could potentially be used to construct a synthetic dataset for UNL that extends back as far as records on the Apex River (1973).
- Assess the effect of drawdown on the abandonment of sub-basin to confirm total under ice water volumes used in this pre-concept.
- Re-assess the quality of bathymetric survey data to confirm stage-storage relationships that formed the basis of this assessments.
- Conduct a more detailed assessment of lake response to proposed withdrawals, particularly in drought years, including back-to-back occurrences, and under future climate scenarios.
- Ensure detailed topography is attained and used to optimize pipeline routes.
- Complete a drainage assessment of the area prior to road design.

The content of this memo has been prepared and reviewed by professional engineers and geoscientists licensed to practice in Nunavut, including: Matthew Follet, P.Eng., Walter Orr, P.Eng., Matt Wood, P.Eng., and Dr. David Luzi, Ph.D.

Nunami Stantec Ltd.

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APPENDIX B

NIAQUNGUK (APEX) RIVER WATER WITHDRAWAL ANALYSIS MEMORANDUM

NUNAMI
STANTEC LIMITED

Memo

To:	Erica Bonhomme Yellowknife, NT	From:	Mike Soloducha, David Luzi Victoria, BC
Project/File:	144903162	Date:	May 29, 2022

Reference: Niaqunguk (Apex) River Water Withdrawal Analysis

Introduction

The City of Iqaluit (City) obtains and distributes potable water from Lake Geraldine, an engineered reservoir located north of the city. Due to prevalent supply shortages in the reservoir, the city applied for and received an amendment (Amendment #4) to its type A water license 3AM-IQA1626 to permit supplementation from the Niaqunguk (Apex) River on an annual basis if required.

As part of a study on long term water sourcing options, a review of water availability was completed for the Apex River based on available data from the Water Survey of Canada (WSC) station Apex River at Apex [10UH002]. This work updates earlier work presented by exp (2014) and Nunami (2017), expanding the period of analysis until 2021.

This technical memorandum summarizes the results of the review of water availability at the supplemental pumping location (SPL) located on the Apex River, approximately 1 kilometre upstream of the bridge on the Road to Nowhere, under several scenarios based on pumping capacity and observed streamflow. The SPL receives flows from the Apex River watershed upstream of the SPL, and excludes outflows from Unnamed Lake.

Methods

Long term flow data for Apex River was obtained from the WSC hydrometric station *Apex River at Apex* (Station ID 10UH002). There are 37 years of streamflow data available for this station for the period between 1973 and 2021 (data was not available in 1984 and 1996-2005). The station is only operational during the open water season, and the observed period of record (i.e. number of days with measurements) is not consistent between years and thus the results presented here may not be reflective of actual streamflow available. To convert the streamflow record of Apex River to the SPL, a scaling factor of 0.73 was applied to the mean daily discharge recorded at the Apex River station to account for differences in streamflow at the point of diversion (Apex River 1Km Above Bridge to Nowhere [WSC Station 10UH015]) and the monitored station location (10UH002 *Apex River at Apex*). The period of record at the Apex River 1km Above Bridge to Nowhere station has only been active since 2019 and streamflow has not been reliably produced by WSC for the station as of yet and the period of record is too short to use for planning purposes.

Volumetric outflow was computed for each year in which streamflow data was available to determine the maximum amount of water that would have been available for supplementation at the SPL. Note that this result differs from exp (2014) and Nunami (2017) which only looked at withdrawals from July to September of each year and for a location further downstream of our assessment point. Also note that the results are not intended to be used to forecast, as it is based on historical observations. This study considered all recorded daily streamflow over the period of record. Additionally, this analysis did not consider any restrictions related to minimum flow requirements for riverine ecosystems (DFO 2013).

Reference: Contract Change Order Request #3 (CCO-03) to SC00248 – Draft Evaluation Report Additions and Presentation to Engineering Committee – Rev3

In addition to assessing volumetric outflow, which considers availability of water under a variable, and unrestricted pumping scenario, three fixed rate pumping scenarios were evaluated for comparative purposes. The three pumping scenarios were 50 L/s, 100 L/s and 200 L/s. For each pumping rate, pumping was assumed to be operated at a fixed rate and therefore observed streamflow must be either equal to or greater than the specified pump rate for withdrawals to occur. For example, if the daily average streamflow was 150 L/s (0.15 m^3/s), 150 L/s would be available for pumping and withdrawal could occur with the 50 L/s and 100 L/s pump scenario but not for the 200 L/s scenario on that day. Under the unrestricted pumping scenario, 150 L/s would be available for withdrawal.

Results and Discussion

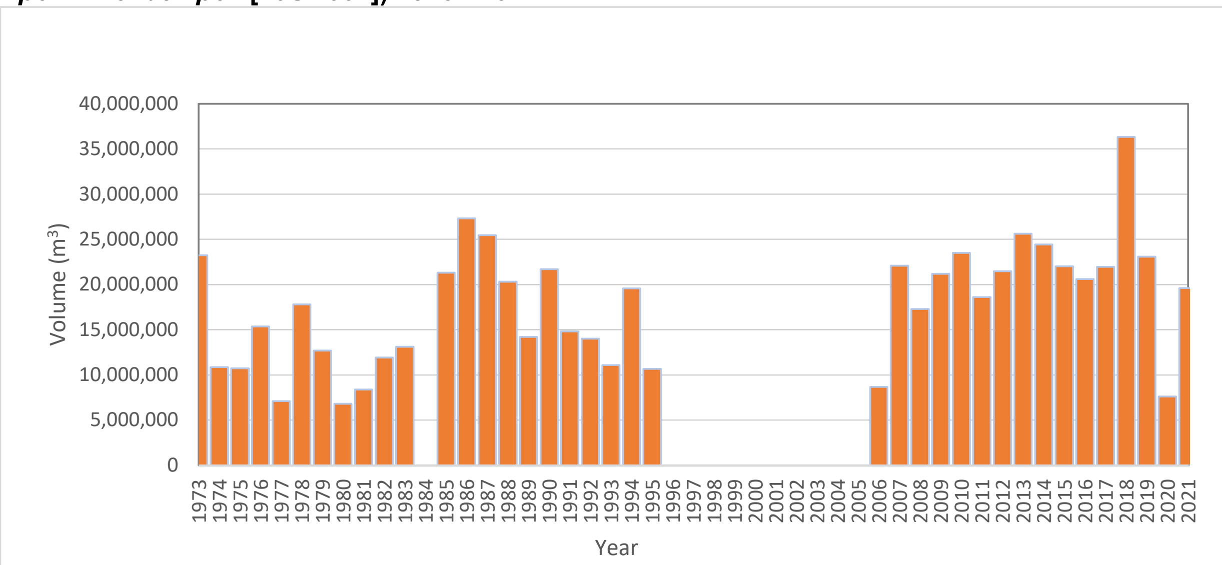
Water availability was assessed for the four scenarios outlined above, volumetric outflow (i.e. the unrestricted scenario), 50 L/s, 100 L/s and 200 L/s. Summary results for pumping volumes using each scenario are included in Table A.1 and Figure A.1.

Table A.1 Summary of Water Availability at the Supplemental Pumping Location (scaled based on *Apex River at Apex* [10UH002]) 1973 - 2021

Statistics	Period of Record (days)	Annual Volumetric Outflow (m^3) – Unrestricted Scenario	Pumping Scenario-50 L/s (m^3)	Pumping Scenario-100 L/s (m^3)	Pumping Scenario-200 L/s (m^3)
Average	141	17,697,765	543,183	1,054,989	2,005,389
Minimum	64	6,800,371	276,480	552,960	1,088,640
Maximum	225	36,333,915	747,360	1,451,520	2,782,080

.

Figure A.1 Annual Volumetric Outflow (m^3) Supplemental Pumping Location (scaled based on *Apex River at Apex* [10UH002]) 1973 - 2021



Reference: Contract Change Order Request #3 (CCO-03) to SC00248 – Draft Evaluation Report Additions and Presentation to Engineering Committee – Rev3

The average annual volume available (volumetric outflow) from the Apex River at the SPL, if there are no ecological flow requirements, is over 17.5 million m^3, 2018 the volume exceeded 36 million m^3, in 1978 the annual volume was only 6.8 million m^3. The low volume year in 1978 was likely due to streamflow observations starting after freshet, so only a partial hydrograph was available for that year. The three fixed pump rate scenarios result in substantially lower volumes of water withdrawn. On average the 200 L/s pump rate results in 2,005,389 m^3, which is greater than the other two pump rates, both minimum and maximum flows are greater in the 200 L/s scenario.

Table A.2 presents the annual summary of available volumes at the SPL for the period of record.

Table A.2 Annual Water Availability at the Supplemental Pumping Location (scaled based on *Apex River at Apex* [10UH002]) 1973 - 2021

Year	Period of Record (days)	Annual Volumetric Outflow (m^3) – Unrestricted Scenario	Pumping Scenario-50 L/s (m^3)	Pumping Scenario-100 L/s (m^3)	Pumping Scenario-200 L/s (m^3)
1973	122	23,232,442	527,040	1,054,080	2,073,600
1974	105	10,862,035	453,600	907,200	1,814,400
1975	105	10,732,262	453,600	907,200	1,814,400
1976	107	15,367,536	462,240	924,480	1,848,960
1977	92	7,101,130	397,440	794,880	1,589,760
1978	64	17,796,326	276,480	552,960	1,105,920
1979	92	12,697,430	397,440	794,880	1,589,760
1980	99	6,800,371	427,680	855,360	1,710,720
1981	87	8,385,379	375,840	751,680	1,503,360
1982	153	11,927,434	509,760	984,960	1,866,240
1983	116	13,124,765	488,160	881,280	1,088,640
1984					
1985	156	21,321,274	630,720	1,209,600	2,332,800
1986	136	27,338,170	540,000	1,054,080	2,056,320
1987	121	25,446,442	518,400	1,036,800	2,056,320
1988	158	20,297,261	630,720	1,209,600	2,280,960
1989	146	14,198,890	479,520	924,480	1,762,560
1990	145	21,694,522	583,200	1,114,560	2,108,160
1991	161	14,800,493	604,800	1,157,760	2,211,840
1992	145	14,026,522	548,640	1,036,800	1,952,640
1993	131	11,096,179	522,720	1,010,880	1,935,360
1994	190	19,563,552	699,840	1,365,120	2,592,000
1995	124	10,650,269	522,720	1,019,520	1,952,640
1996 to 2005					
2006	75	8,676,720	302,400	587,520	1,140,480
2007	184	22,075,114	561,600	1,054,080	1,987,200
2008	174	17,281,210	630,720	1,226,880	2,384,640
2009	160	21,196,166	557,280	1,071,360	2,039,040
2010	217	23,512,118	747,360	1,451,520	2,782,080
2011	144	18,603,475	578,880	1,114,560	2,211,840
2012	160	21,469,882	673,920	1,304,640	2,522,880
2013	159	25,611,984	648,000	1,261,440	2,436,480
2014	181	24,443,942	721,440	1,365,120	2,505,600
2015	151	22,013,285	609,120	1,157,760	2,177,280

Reference: **Contract Change Order Request #3 (CCO-03) to SC00248 – Draft Evaluation Report Additions and Presentation to Engineering Committee – Rev3**

2016	214	20,598,811	617,760	1,192,320	2,246,400
2017	225	21,941,225	678,240	1,278,720	2,401,920
2018	143	36,333,915	617,760	1,200,960	2,332,800
2019	170	23,077,115	730,080	1,451,520	2,401,920
2020	146	7,606,676	475,200	941,760	1,624,320
2021	102	19,612,755	440,640	881,280	1,762,560
AVG	141	17,697,765	543,183	1,054,989	2,005,389
MIN	64	6,800,371	276,480	552,960	1,088,640
MAX	225	36,333,915	747,360	1,451,520	2,782,080

Limitations

The analysis presented above did not account for the potential effects of climate change on the volume available from the Apex River and thus this should not be considered as a predictive tool. Additionally, no consideration, beyond the selected pumping rates, was given to any engineering limitations with regards to the engineering design or operations of the pumping program. Lastly, the requirements related to regulatory approvals was not considered.

Closing

The analysis conducted here illustrates that under a scenario of no environmental flow requirements, the Apex River would on average be able to provide over 17.5 million m^3 of water a year as based on the historical record. Over the period of record annual volumes ranged between 6.8 million m^3 and 36.3 million m^3, this would potentially be available for an unrestricted withdrawal scenario Three additional withdrawal scenarios were examined at fixed pumping rates of 50 L/s. 100 L/s and 200 L/s. Of the three fixed rate pumping scenarios assessed the 200 L/s rate resulted in the largest volumes.

Nunami recommends that additional work be undertaken to determine an optimal pump rate that incorporates future peak water demand, historic streamflow record, pump size and pipeline diameter in determining the pump configuration scenario to support long term supplementation. This additional work could also incorporate a consideration of ecological flow requirements, that may not meet the DFO (2013) guidance, but could still maintain ecosystem needs.

Regards,

Nunami Stantec Limited

[Original signed by]

on behalf of
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