Faculty of Engineering
Department of Environmental Engineering

Passive Wastewater Treatment System for Baker Lake, Nunavut

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Scope

The objective of the project was to design a passive wastewater treatment system for Baker Lake, Nunavut. The new wastewater treatment system is to manage wastewater from a projected population of 2966 in 2040.

Current System

- Lagoon and Tundra wetland system has been in operation for 30 years
- Cannot meet the predicted population growth or effluent quality regulations
- Current Flow Path:

Holding Cell → Lagoon Lake → Finger Lake → Airplane Lake → Baker Lake

Location

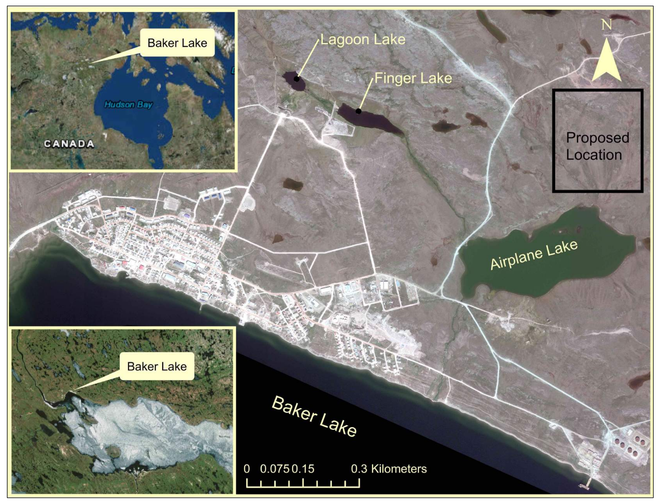
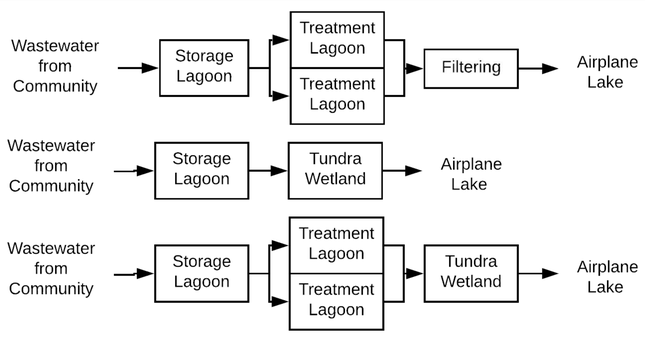


Figure 1: Baker Lake Proposed Site Location[1]

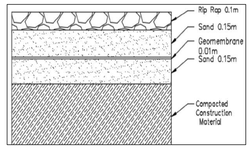
Climate[2]:

- Mean Winter temperature of -31°C and mean Summer temperature of 12°C
- Zone of continuous permafrost
- Average annual precipitation of 273 mm

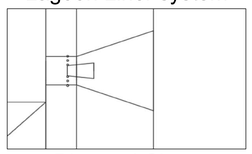
Design Alternatives



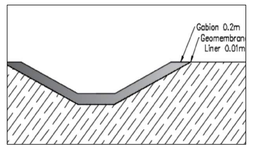
Detailed Design



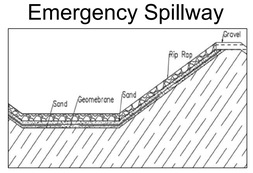
Lagoon Liner system



Disposal Chute



Emergency Spillway



Spillway Channel

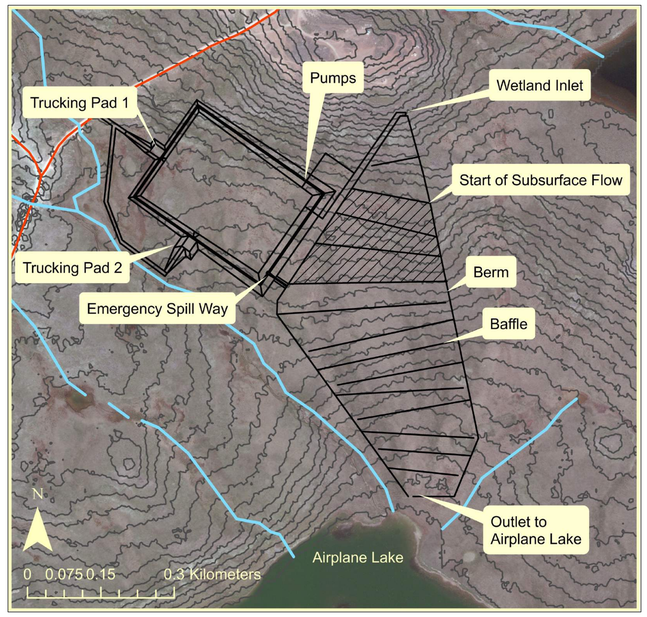
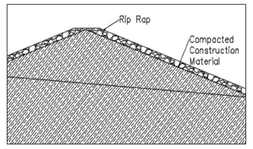
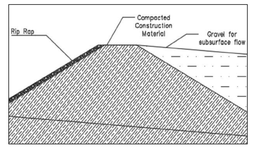


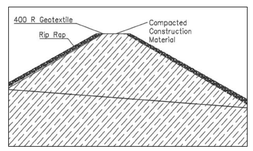
Figure 2: Baker Lake Proposed Design



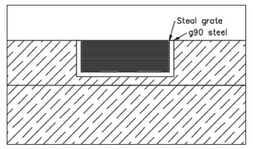
Outside Berm



Subsurface Flow Berm



Baffle



Subsurface Flow Weir

The wastewater will be trucked to the site and deposited into the storage lagoon via a chute. The lagoon will store the wastewater, and primary treatment will occur. During the treatment period of June to August the wastewater will be discharged into the wetland via pumps for secondary treatment. The treated effluent will be discharged into Airplane Lake.

Lagoon Specifications

Sizing:
- Footprint of 8.6 ha
- Volume of 154 187 m^3 with a depth of 2 m to 4 m

Berm:
- 3H:1V slope lined with rip rap to prevent erosion
- 3m top width to allow access

Truck and Haul:
- Two perpendicular discharge areas
- Wastewater deposited into chute
- Access road at a slope of 8 %

Liner:
- Axter Coletanche ES2 bituminous geomembrane
- Anchored in place at the top of the berm
- 0.15m of sand above and below to prevent damage

Emergency Spillway:
- Notch 4 m wide and 0.5 m deep at the top of berm
- Lined with 0.2 m thick gabion and geomembrane
- Routing channel to wetland

Outflow System Specification:
- Two Godwin CD100M pumps
- Pipes will be floated to prevent uptake of sludge
- Operating for 7 hours at a total rate of 250 m^3/day during treatment period

Wetland Specifications

Sizing:
- Footprint of 15.75 ha
- Hydraulic retention time of 27 days

Baffles:
- Height of 0.5 m
- 2H:1V slope lined with rip rap to prevent erosion
- Geotextile on every third baffle to promote treatment

Weir:
- 0.7 m x 2 m steel weir
- Carbon steel grate to ensure rockfill stability

Berm:
- Height of 1 m
- 3H:1V slope lined with rip rap to prevent erosion

Sub Surface Flow:
- 4.3 ha gravel section to promote subsurface flow and the reduction of *E. coli* and phosphorus

Risk Management

- Bollards installed at truck discharge stations to prevent trucks from entering the lagoon
- Fencing installed along the perimeter of lagoon
- Signage installed along perimeter of lagoon and wetland
- Regular inspection and sampling program

Design Process

Current System → Design Alternatives → Analyses → Detailed Design → Risk Analysis

Completed Analyses

Lagoon:
- Trucking pad turning radius
- Slope stability
- Sizing: Sewage generation and sludge accumulation
- Discharge pumping analysis

Wetland:
- Sizing: Hydraulic retention time
- Tank in series model
- Flow optimization
- Peak flow analysis
- Watershed delineation

Treatment Performance

Effluent quality meets stipulated treatment requirements:
- <25 mg/L of CBOD
- <25 mg/L of TSS [3]
- <0.3 mg/L of unionized ammonia
- <200 CFU/100 mL of *E. coli* [3]
- <1.0 mg /L of Phosphorus [3]

Subsurface flow sections and semi-permeable baffles were incorporated into the wetland design to ensure the *E. coli* and phosphorus concentrations met the treatment requirements.

Recommendations

- Topographic and hydrologic survey to better understand hydrologic and geological conditions of the site
- Detailed modeling of lagoon treatment based on field assessment of treatment performance at the current system
- Modeling of low flow conditions and flow routing in the wetland
- Modeling of *E. coli* and phosphorus reduction from addition of subsurface flow and semi-permeable baffles

Acknowledgements

We would like to thank Dr. Rob Jamieson, Jenny Hayward, Lindsay Johnston and Jennifer Strang for their assistance throughout this project

References

[1] Source: Esri, DigitalGlobe, GeoEye, Eathstar Geographics, CNES/Airbus DS, USGS,IGN and the GIS User Community
[2] Government of Canada (2018). Canadian climate normal 1981-2010 station data. Climate normal and averages. Past weather and climate, weather, climate and hazard. Environment and natural resources.
[3] Canadian Council of Ministers of the Environment. (2009). Canada-wide Strategy for the Management of Municipal Wastewater Effluent. Whitehorse, Canada.