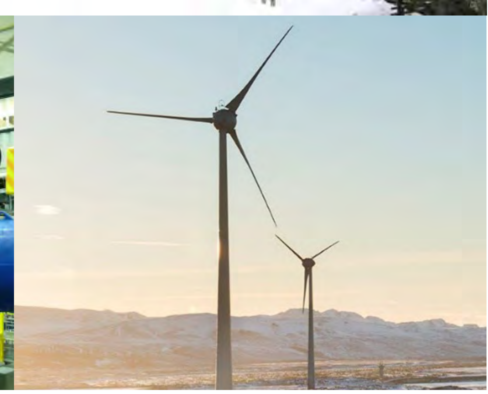
# Iqaluit Renewable Energy Project

Renewable Energy Supply Alternatives Report





CANADIAN PROJECTS LIMITED

January 4, 2024
ISSUED FOR USE
Revision 0

# Iqaluit Renewable Energy Project

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# ACKNOWLEDGEMENT

Canadian Projects Limited acknowledges the original contributions by Cory Williams, P.Eng., Chief Engineer in providing the strategic planning and insight to the undertaking of this study.

# EXECUTIVE SUMMARY

In December 2021, Nunavut Nukkiksautiit Corporation (NNC), in partnership with Growler Energy and with support by Canadian Projects Limited, secured funding to advance the development of a renewable energy supply for Iqaluit, Nunavut, and the neighboring region (the "Project").

The City of Iqaluit has a peak load demand of about 10 MW and average annual electrical energy requirements of about 60,000 MWh, requiring some 15,000,000 litres of fuel per year. NNC is a subsidiary of Qikiqtaaluk Corporation of the Qikiqtaaluk Innuit Association, focused on integrating renewable energy solutions across the Qikiqtani Region of Nunavut.

The utility, Qulliq Energy Corporation, has expended considerable efforts over the past two decades exploring the feasibility of constructing hydroelectric and wind power in the area. NNC is conducting its own due diligence and independent assessment that largely relies on the previous work. However, previous assessments may have considered Inuit Owned Lands as a constraint whereas this should not be the case. This assessment explores the most attractive renewable energy development options that the natural resources of the area have to offer, regardless of land ownership boundaries, to the beneficial use of its people.

The Project assessment objectives are:

- Assess the technical and economic feasibility of renewable energy supply alternatives available to the City of Iqaluit and surrounding area, including conventional hydroelectric power, wind power and hybrid systems. For some alternatives where energy storage is required, pumped storage hydroelectric power is also to be considered.
- Assist the Project partners in the selection of one renewable energy alternative that will be advanced to the preliminary engineering stage.

The engineering assessment presented focuses primarily on technical and economic considerations, however other important criteria such as environmental, social, and traditional knowledge are inputs that are also considered in the Project's decision-making selection process.

The overarching consideration for this assessment is that the selected renewable energy Project ultimately benefits the residents of the City of Iqaluit from economic, technical, environmental, and land-use perspectives. All parts of this assessment are based on these criteria and are explicitly captured in the alternatives screening matrix presented in this report. Further, these criteria align well with the objectives of an Independent Power Producer (IPP) in maximizing the economic benefit from a Project development that is positive for all stakeholders.

This assessment considers two load cases to provide an assessment of alternatives which could support the current electricity load requirements of the City of Iqaluit, as well as a future demand case and possible expansion of load for conversion of thermal load from oil to electric and an industrial off-taker. While the true demand for the community over the next 50+ years is difficult to predict, these load scenarios are intended to cover the high and low bounds of community load. As such, the ability to scale generation capacity to potential increases in the load over time is seen as favourable in the alternatives assessment. Note, the costs associated with converting the thermal energy infrastructure from fuel-based to electric is not included within this assessment.

**Iqaluit Load Characterization Summary**

| Load | Max Power (MW) | Average Power (MW) | Min Power (MW) | Energy (GWh/yr) | Percent |
|---|---|---|---|---|---|
| Electrical | 10 | 8 | 6 | 65 | 25% |
| Thermal | 42 | 16 | 2 | 140 | 60% |
| Industrial | 6 | 4 | 0 | 30 | 15% |
| **Coincident Demand** | **58** | **28** | **8** | **235** | **100%** |

For each assessed alternative it is assumed that an IPP is compensated only for the energy sold and not on a capacity basis. It is also assumed that the Levelized Cost of Energy (LCOE) governs the generation supply type, and existing or new diesel generators are not operating when demand is met by the lower-cost renewable energy supply.

Renewable energy technologies included in this assessment are hydroelectric power, wind power, and pumped storage hydroelectric (PSH). In total there are 15 alternatives sites that were identified within 150 km of the City of Iqaluit: 8 hydroelectric power sites, 5 wind power sites and 2 PSH sites. These alternatives were of suitable size to fulfil the load requirements, either by themselves or in combination with other sites. The key characteristics for the top three prospect alternatives, including their Combinative Distance-Based Assessment (CODAS) score, are:

**Top Three Project Alternatives – Key Characteristics**

| | | McKeand South Hydro | Niaqunguk Wind | Jaynes Inlet Hydro & Wind |
|---|---|---|---|---|
| **Rank** | | **1** | **2** | **3** |
| CODAS Ranking Score | 100% - 0% | 100% | 74% | 70% |
| Electric Load | | | | |
| Capacity | MW | 10 | 10 | 15 |
| Renewable Supply | % | 100% | 53% | 100% |
| Renewable LCOE | $/MWh | $335 | $250 | $389 |
| Aggregate LCOE | $/MWh | $338 | $571 | $462 |
| Capital Cost | $ Millions | $200 | $60 | $210 |
| Electric, Thermal, & Industrial Load | | | | |
| Capacity | MW | 30 | 30 | 45 |
| Renewable Supply | % | 79% | 45% | 73% |
| Renewable LCOE | $/MWh | $163 | $170 | $226 |
| Aggregate LCOE | $/MWh | $378 | $607 | $462 |
| Capital Cost | $ Millions | $270 | $130 | $310 |
| Environment / Socio-Economic | | | | |
| Scalability | Max Score 1-5 | 3 | 5 | 2 |
| Biophysical Environment | Min Score 1-5 | 5 | 2 | 4 |
| Resource Use | Min Score 1-5 | 2 | 2 | 2 |

The McKeand South hydroelectric project is markedly the best project of the top three prospect alternatives, as determined by the assessment process. It offers the lowest LCOE and can address the electrical demands initially and be expanded to include the thermal and industrial opportunity as they arise. Some overbuild is prudent to enable quick uptake growth as the incremental investment may be nominal for certain capacities, but this will need further study in the next phase of development.

The two next top prospect alternatives are commendable and can be held as backup should issues arise on the top prospect alternative as it progresses through approvals and design.

The current electricity supply price for diesel energy supply has an LCOE of $837/MWh. The corresponding McKeand South hydroelectric LCOE price is $338/MWh, some 60% lower in cost.

Based on the overall energy scenario for electricity, thermal and industrial loads the current diesel and heating oil LCOE was determined to be $869/MWh. The corresponding McKeand South hydroelectric LCOE is $378/MWh, which constitutes a cost reduction of 56%.

Therefore, there is substantial incentive to pursuing replacement of the current diesel energy supply with a renewable energy solution on this basis alone, plus there are environmental, climate, employment, and other benefits to be garnered. Based on this assessment, the McKeand South hydroelectric project is the best alternative.

The actual LCOE and project costs may differ; this economic analysis was done for comparative purposes only using a similar costing structure, whereas actual costs and pricing needs to consider actual conditions that may vary from the costing and economic assumptions made herein. The relative comparative results are valid but the absolute energy prices may vary.

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# 1 INTRODUCTION

## 1.1 Background

In December 2021, Nunavut Nukkiksautiit Corporation (NNC), in partnership with Growler Energy (Growler), with support from Canadian Projects Limited (CPL), secured funding to advance the development of a renewable energy supply for the City of Iqaluit, Nunavut, and the neighboring region (the "Project"). The City of Iqaluit has a peak load demand of about 10 MW and average annual electrical energy requirements of about 60,000 MWh, requiring some 15,000,000 litres of fuel per year. NNC is a subsidiary of Qikiqtaaluk Corporation of the Qikiqtani Innuit Association (QIA), focused on integrating renewable energy solutions across the Qikiqtani Region of Nunavut.

Development of the Project follows the Phase-Gate decision process, as defined by NNC. The process includes five phases and four decision gates. It is designed to reflect the realities of projects that will start construction following project sanction. The phases of the projects are managed by multi-functional teams, while the decision gates are structured decision points at the end of each phase. The process is shown in Figure 1.

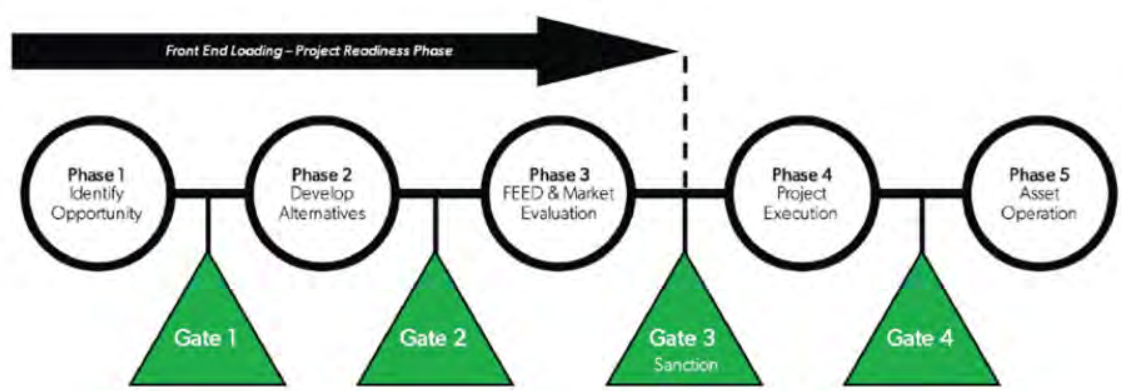


**Figure 1. Project Phase Gate Development Process**

The gates are described as:

1. **Gate 1 –** Acceptance of Opportunity Review and Approval to Explore Alternatives.
2. **Gate 2 –** Approval of Preferred Alternative and Start Front-End Engineering & Design.
3. **Gate 3 –** Project Sanction.
4. **Gate 4 –** Approval of Transition to Operations & Commence 1$^{st}$ Power Generation.

The scope of this report is within Phase 2, Develop Alternatives.

The utility, Qulliq Energy Corporation (QEC), has expended considerable efforts over the past two decades exploring the feasibility of constructing hydroelectric and wind power developments in the area. This work is embodied in the numerous studies provided to CPL as listed in Section 1.4. CPL understands NNC's need to conduct its own due diligence and independent assessment which largely relies on the previous work. CPL also understands that previous assessments may have considered Inuit Owned Lands as a constraint whereas this should not be the case. In this assessment, CPL explores the most attractive renewable energy development options that the natural resources of the area have to offer for the beneficial use of its people, regardless of land ownership boundaries.

SEM Ltd. (SEM) provided environmental consulting services in support of this assessment while QIA and Firelight Group (Firelight) led the community-based research effort. Reference has been made to the work completed by these consultants throughout this report. Further, both consultants have provided their own reports to the development group.

## 1.2 Objectives

The Project objectives are:

- Assess the technical and economic feasibility of renewable energy alternatives available to the City of Iqaluit and surrounding area, including conventional hydroelectric power, wind power and hybrid systems. Where energy storage is required, pumped storage hydroelectric (PSH) is also to be considered.
- Assist the Project partners in the selection of one renewable energy alternative that will be advanced to the preliminary engineering stage. While the engineering assessment presented in this report focuses primarily on technical and economic considerations, other important criteria, such as environmental, social, and traditional knowledge influence the Project's decision-making process.

## 1.3 Scope

The Project scope includes:

- Identification and summarization of the key Project criteria and constraints.
- Review of previous work completed by others.
- Collection and review of pertinent resource, constraint, and energy demand data.
- Development of a list of prospect alternative Projects for assessment.
- Visit prospect alternative Project sites to collect data.
- Development of inputs for a power and energy model analysis, including hydrologic, wind, fuel usage and cost data.
- Completion of power and energy modelling of the prospect alternatives.
- Completion of desktop geotechnical assessments of each prospect alternative.
- Completion of an economic analysis of each prospect alternative.
- Support the Project partners in assessment of electrical requirements, environmental implications and provide regulatory and stakeholder support.
- Assessment of Project alternatives using a comprehensive risk-based decision matrix.
- Development of a preliminary Project schedule.
- Preparation of a report complete with drawings and maps.

## 1.4 Previous Studies

The previous studies considered in this assessment include:

- Iqaluit Hydro-Electric Generation Sites: Identification of Ranking, Knight Piesold Ltd., (VA 103-137/1-1 Rev 0), Jan 17, 2006.
- Iqaluit Hydro-Electric Generation Sites: Phase II Pre-Feasibility Report, Knight Piesold Ltd., (VA 103-137/1-2), October 2, 2006.
- Manitoba Hydro International, Feasibility Study – Hydroelectric Generation and Transmission for Iqaluit – Supplementary report on Site Selection, June 2008 (for Qulliq Energy Corp).
- Iqaluit Hydro-Electric Generating Sites: Qikiqgijaarvik Hydrological Analysis, Knight Piesold Ltd., (VA 103-137/02-1), September 19, 2008.
- Iqaluit Hydro-Electric Generating Sites: Kangalait Hydrological Analysis, Knight Piesold Ltd., (VA 103-137/02-2), September 19, 2008.
- Iqaluit Hydro-Electric Generating Sites: Akulikutaaq Hydrological Analysis, Knight Piesold Ltd., (VA 103-137/02-3), September 19, 2008.
- Iqaluit Hydro-Electric Generating Sites: Tungatalik Hydrological Analysis, Knight Piesold Ltd., (VA 103-137/02-4), September 19, 2008.
- Qulliq Energy Corp – Fisheries Assessments for Five Potential Hydroelectric Generating Sites on Southern Baffin Island, North/South Consultants Inc., March 2007.
- Qulliq Energy Corporation – Iqaluit Hydroelectric Project: 2007 Environmental Baseline Studies Summary of the Environmental Baseline Report, Knight Piesold Ltd., (NB103-00137/2-2), April 2008.
- Qulliq Energy Corp – Iqaluit Hydroelectric project – Jaynes Inlet: Final Environmental Baseline Studies Summary Report, Knight Piesold Ltd., (NB103 00137/4-4), August 6, 2009.
- Qulliq Energy Corp – Aquatic Environment Investigations at Jaynes Inlet, Southern Baffin Island, North/South Consultants Inc., June 2009.
- Qulliq Energy Corp – Bird and Terrestrial Mammal Surveys – QEC Iqaluit Hydro Project – Final Baseline Studies Report, LGL Ltd.
- Qulliq Energy Corp – Caribou Habitat Sustainability & Related Inuit Qaujimajatuqangit for the Proposed Hydroelectric Generating Site in the Jaynes Inlet Watershed on Southern Baffin Island, NordEco, June 2009.
- Qulliq Energy Corp – Iqaluit Hydroelectric Project – Jaynes Inlet: Ecological Land Classification – 2009 Final Report, Knight Piesold Ltd., (NB 103-00137/4-2), Mar. 2009.
- Enokseot Holdings Ltd. – Socio-Economic Impact Assessment – Iqaluit Hydro Electric Development Project, Enokseot Holdings Ltd., Jan 2008.
- Iqaluit Hydro Project – Climate change Impacts Assessment Report, G.A. McBean Consulting & Nunavut Research Institute, U of Manitoba, and U of W.Ont., March 2009.
- Jaynes Inlet HEP – Environmental Baseline Study, RSW Inc., Jan 2010.

- Iqaluit Hydro Project – Updated Cost Estimates and Financial Analysis, Knight Piesold Ltd., (VA103-137/6-A.01), February 11, 2011.
- Iqaluit Hydro Project – Financial Analysis for the Iqaluit Hydroelectric Projects, Knight Piesold Ltd., (VA103-137/6-A.00), February 11, 2011.
- Iqaluit Hydroelectric Project Workshop PPT (2021-10-28_QIA Hydro Workshop.pdf), Pricewaterhouse Coopers (PwC), June 2021.
- Qulliq Energy Corp – Iqaluit Hydro-electric Generation Sites – Run-of-River Project Analysis, Knight Piesold Ltd. (Ref. no. VA103-137/1-A.01), January 22, 2007.
- Qulliq Energy Corp – Iqaluit Hydro-electric Generation Sites – Cost Estimate and Financial Details – Phase II Pre-Feasibility Study, Knight Piesold Ltd., (Ref. no. VA103-137/1-A.01), October 4, 2006.
- Qulliq Energy Corp – Iqaluit Combined Wind and Hydroelectric Energy Study, Knight Piesold Ltd., (Ref. no. VA103-137/1-A.01), October 6, 2006.
- Qulliq Energy Corp – Iqaluit Hydroelectric Project Proposal, Knight Piesold Ltd., February 12, 2013.
- Qulliq Energy Corp – Alternative Energy Report, December 2020.


# 2 PROJECT FRAMING

The overriding consideration for this assessment is that the selected renewable energy Project ultimately benefits the residents of the City of Iqaluit from economic, technical, environmental, and land-use perspectives. All parts of this assessment are based on these criteria and are explicitly captured in the alternatives screening matrix presented later in this report. Further, these criteria align well with the objectives of an Independent Power Producer (IPP) in maximizing the economic benefit from a Project development that is positive for all stakeholders.

## 2.1 Load Scenarios

The load scenarios considered in this assessment include:

1. The base load scenario is the current community electrical load. This case assumes that load growth continues at the current rate.

2. The second load case is intended to capture the total potential electric load for the community. This load case includes the current electrical load, the current thermal load (converted to electricity) and a hypothetical load by an industrial off-taker.

While the true demand for the community over the next 50+ years is impossible to predict, these load scenarios are intended to cover the high and low bounds of community load. The ability to scale generation capacity to potential increases in the load over time is seen as favourable in the alternatives assessment.

For each assessed opportunity, it is assumed that an IPP is compensated only for the energy sold and not on a capacity basis. It is also assumed that the Levelized Cost of Energy (LCOE) governs the generation supply type and existing or new diesel generators are not operating when demand is met by a lower cost energy supply.

## 2.2 Technologies

Renewable energy technologies included in this assessment are hydroelectric power, wind power and pumped storage hydroelectric (PSH) described in detail below. Solar and small modular nuclear reactors are also described; however, the assessment of these technologies is not included in the scope of this study.

### 2.2.1 Hydroelectric Power

Energy is generated by harnessing the elevation difference from upstream to downstream (head) and the flow of water. The more head and flow, the more energy available. The head is developed by the natural drop along a river, a dam, or a combination of the two. The water pressure and flow through a turbine turns an electric generator that produces electricity. Figure 2 shows the cross section of a typical hydroelectric power station.

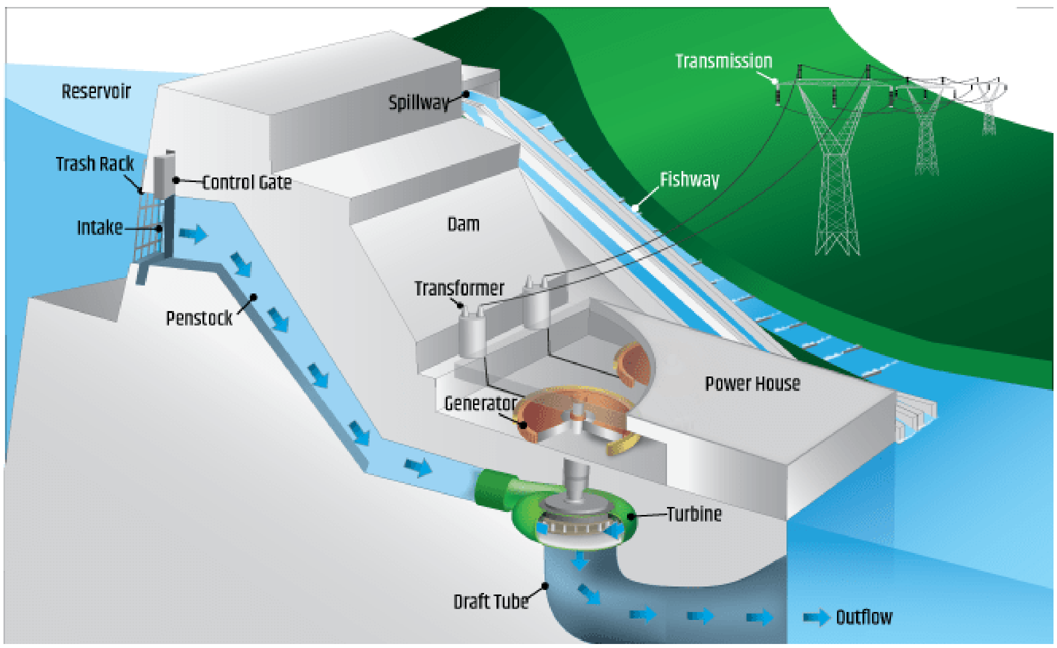


**Figure 2. Hydroelectric Power Technology**

Hydroelectric power can be operated as a run-of-river system or include storage reservoir. In a run-of-river type operation there is no change in river flows downstream of the power plant and the power generation is dependent on the flow of the river. In northern regions the natural river flow is not well matched to community power demand. That is, there is less water than needed in the winter and more water than needed in the summer.

With a storage reservoir operation, a lake or reservoir is formed by a dam and is used to store excess water in the summer and release it in the winter to better meet the power demand. The reservoir acts as a large battery. The total amount of water passing through the system remains the same each year, but the timing of the outflow is modified to be less in the summer and more in the winter. The Figure 3 and Figure 4 show the flow and power demand throughout the year for each scenario.

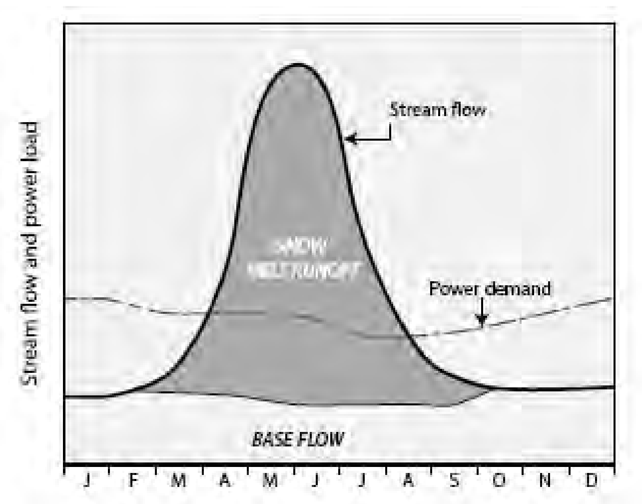


Figure 3. Run-of-River Flow

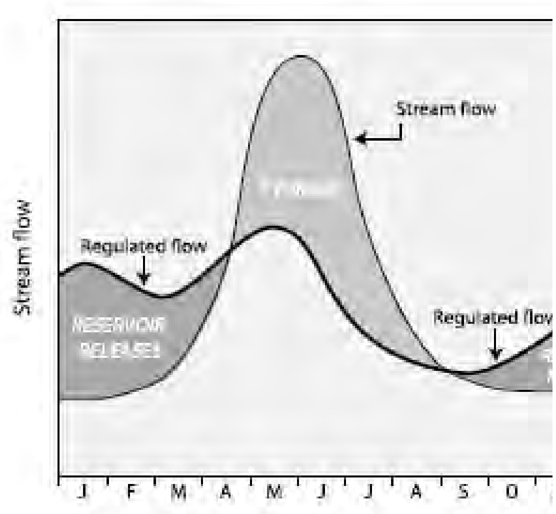


Figure 4. Storage Reservoir Flow

The key feature of hydroelectric power is that the power is proportional to the elevation difference and flow rate of the system. Hydroelectric power is considered a firm supply of energy.

### 2.2.2 Wind Power

Energy is generated by wind turning the propeller-like blades (rotor), which spins a generator and creates electricity. A turbine control system moves the nacelle so that the turbine is always pointed directly into the wind and controls the blade pitch to create efficient energy conversion operation. Figure 5 provides a simplified view of the electrical generation and delivery process.

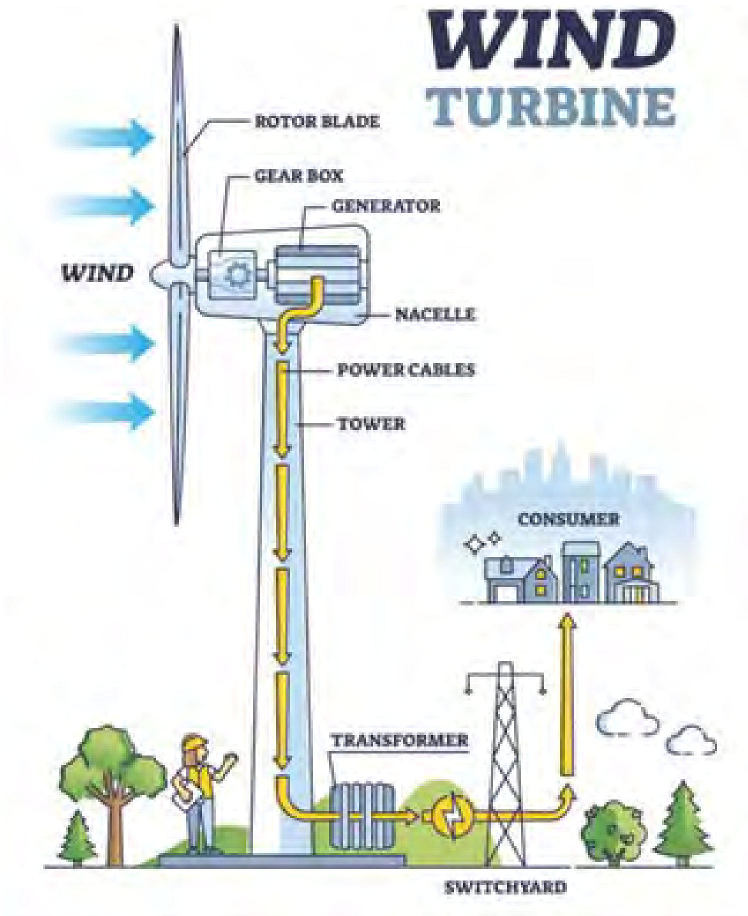


**Figure 5. Wind Turbine Generator**

Key aspects include:

- Factors that affect generation including tower height, rotor size, wind speed, direction and air density.
- Gusty wind and wind that changes direction frequently is more difficult to harness and produces less energy.
- Power is proportional to the wind speed cubed.
- Wind patterns are a result of air temperature differences in the atmosphere, irregularities of the ground surface and the rotation of the earth. Wind speed and generation varies daily (day vs night) with weather systems and seasonally (winter vs summer).
- Wind is not considered a firm supplier of energy due to its intermittency.
- Can be paired with energy storage systems, such as batteries or PSH, to store excess energy for use when wind speeds are not enough to meet the power demand.

### 2.2.3 Pumped Storage Hydroelectric (PSH)

Energy is generated by harnessing the elevation difference between an upper reservoir and lower reservoir. PSH is the same as conventional hydroelectric power except that a special turbine-generator is used that can also operate as a pump-motor to pump water back up to the upper reservoir for storage. This is often used to augment an intermittent energy source such as wind power, effectively acting as a battery to store excess energy and then dispatch this energy when the wind is not blowing. Figure 6 shows an example of a PSH system.

PSH operates in two cycles: a discharge cycle and a recharge cycle which depend on the demand and supply of energy.

<u>Discharge Cycle:</u> When the demand is higher than the available wind generation, water is permitted to flow from the upper reservoir to the lower reservoir passing through a hydroelectric turbine which rotates a generator and produces electricity.

<u>Recharge Cycle:</u> When the available wind generation is more than the demand, and the pumped storage system is not fully recharged, the excess energy is used to pump water from the lower reservoir to the upper reservoir.

**Figure 6. Pumped Storage Reservoir**

PSH can be an open or closed loop system. In an open loop system, water is allowed to flow in and out of the system, maintaining natural stream or river flow. In a closed-loop system, there is no net loss of water between the two reservoirs, it is simply a transfer of water up and down from one reservoir to another.

The energy storage capacity is a function of the elevation difference and water volume. PSH is the lowest cost energy storage system currently available for large energy storage requirements.

#### 2.2.4 Solar Power

A photovoltaic (PV) system converts sunlight into electricity. Solar panels comprised of photovoltaic cells capture photons from sunlight, exciting electrons and generating a flow of electricity. An inverter then converts this Direct Current (DC) into usable Alternating Current (AC) electricity.

The PV potential is primarily a function of its latitude and weather patterns. As illustrated in Figure 7Figure 7, regions at northern latitudes experience very short days in winter and very long days in summer. The region being assessed in this study is above 60°N, meaning daylight hours are limited to 6 hours or less for most of December and January.

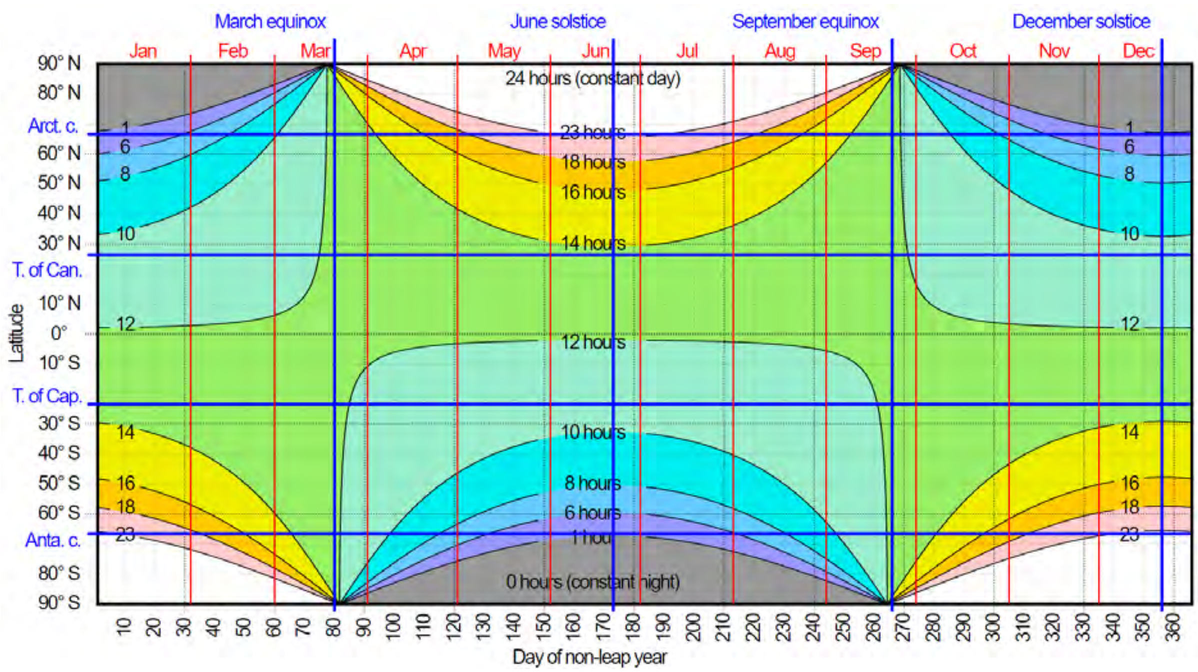


**Figure 7: Daylight Hours by Latitude**

Key aspects include:

- Solar energy production peaks during the summer when the days are longer and the angle of the sun is higher, whereas energy production during the winter is substantially lower because of the short days and reduced solar irradiance from low angle of the sun.
- For northern regions in Canada, average monthly PV potential in the winter is only 20% to 40% of the potential in the spring/summer months. This creates a mismatch in energy production timing and energy demand, which is considerably higher during the winter months.

Due to the seasonal limitations of available resource in the Iqaluit region, solar power was not considered for further assessment.

### 2.2.5 Small Modular Nuclear Reactors (SMR)

Small Modular Nuclear Reactors (SMR) are compact, modular nuclear power systems. They use nuclear fission to generate heat, which then produces steam to drive turbines and generate electricity.

Key aspects include:

- Modularity: SMRs are compact and modular, allowing for easier manufacturing, transport, and installation.

- Enhanced Safety: SMRs incorporate passive safety features and advanced designs, minimizing potential risks and reducing the need for active human intervention during emergencies.

- Versatile Deployment: SMRs can power remote areas, support industrial processes, and provide grid stability, offering flexible energy solutions for various applications.

SMRs are considered a long-term energy solution for Nunavut (QEC, Alternate Energy Report, 2020). Deployment of SMR technology is currently unable to meet the targeted implementation timeline for this Project and was therefore not considered for further assessment.

## 2.3 Sites

CPL's site investigation explored the most attractive renewable energy development alternatives that the natural resources of the area have to offer to the beneficial use of its people, regardless of land ownership boundaries.

In the previous work for identifying hydroelectric sites in the Iqaluit region, several sites were identified and characterized. As part of this study, CPL completed an independent assessment of these known sites, as well as a thorough regional survey and assessment for other potential renewable energy sites via desktop review. Several new Project alternatives, and several alternate configurations for previously identified sites, were developed and are included in this study.

An outer bound of 200 kms from the City of Iqaluit was used as a benchmark for investigation of alternatives. Beyond this range, developments are unlikely to be economically viable due to the high costs of long-distance electrical energy transmission.

## 2.4 Site Conditions

### 2.4.1 Terrain

The Government of Canada High Resolution Digital Elevation Model (HRDEM) derived from airborne LiDAR and satellite data was used to characterize the terrain for this assessment. This data has sufficient accuracy and precision for the purpose of this phase of the work.

### 2.4.2 Hydrology

There are many freshwater lakes and rivers located around Frobisher Bay, several of which are suitable locations for hydroelectric power facilities. All waterbodies in the area are seasonally covered by ice, and rivers flow without ice cover from about mid-May to December. Hydrographs are generally characterized by a significant peak during June and July, which coincides with the spring freshet. Flows steadily decrease from early summer until rivers become ice covered in December where the rivers lowest flow occurs until mid-May.

The Water Survey of Canada (WSC) has established hydrometric stations at several potential hydroelectric power sites. Extensive hydrological analysis, previously carried out by Knight Piesold (KP), culminated in the development of synthetic flow series for these station locations. However, KP based its work on data records of only one year in length. The WSC has since collected data at these same locations over a period of 5-7 years which improves the quality and confidence of the river flow data set. Building on the work completed by KP, CPL developed long-term synthetic flow series to use as input for the assessment power and energy modeling.

Although additional more recent flow records have become available, the WSC data records for the hydroelectric power site alternatives are still limited. For example, at the time of writing the available flow record for Armshow South (WSC Station 10UH005) spanned 2007-2014 for an inclusive total of 8 years of record. In contrast, records for the Sylvia Grinnell station (10UH001) spanned 1971-2018 and included 42 years of records (records for 2000-2005 not available). The Sylvia Grinnell records were used as the basis for the long-term synthetic flow data for each Project alternative.

In summary, data from WSC's Sylvia Grinnell station (10UH001 – Sylvia Grinnell near Iqaluit) were matched against available, site specific WSC flow data. The matched flow relationships were analysed using linear regression and statistical analysis software. Sylvia Grinnell flow records were then scaled to each project site using the derived, site-specific regression equation to produce a synthetic long-term flow series. In each case, the derived regression equation was deemed a good predictor of flows for each site with $R^2$ values ranging from 0.98 to 0.99. Due to a lack of WSC flow records at the McKeand South site, the synthetic flow records from the McKeand North option were scaled to McKeand South based on the drainage area ratio of McKeand South to McKeand North.

The synthetic flow data for each site were used to facilitate comparisons across sites. Additional analyses and flow monitoring will be completed for the preferred alternative in subsequent phases of the Project.

### 2.4.3 Wind Resource

Eastern Nunavut possesses a substantial wind resource. Dominated by strong polar easterlies and influenced by topography, its coastal and elevated regions experience consistent and potent winds year-round. These consistent winds make it a promising area for harnessing wind energy, with the potential to support sustainable power generation.

Data from the Canadian Wind Atlas was used as inputs for the power and energy modeling. For context, average annual wind speeds of 6.5 m/s or greater at 80 m above ground are generally considered commercially viable for wind energy (Center for Sustainable Systems, University of Michigan, 2022).

### 2.4.4 Geology

The geology throughout the area was mapped at 1:5,000,000 by the Geological Survey of Canada and published in 1996. Limited in-depth research has been done in the area. Digital maps were obtained from the FTP Maps Canada website (NRCan Website). The files were downloaded as 2m polar-stereo geo-tiff files. The files were used to obtain topography, slope angles, slope directions, cross section profiles, and were used for large scale terrain assessment. See Appendix A for a detailed discussion of the site geology.

### 2.4.5 Oceanography

Except for the McKeand River site, the hydroelectric power alternatives included in this assessment are located on rivers that discharge to Frobisher Bay. The chemical and physical characteristics of these waters are influenced by freshwater rivers, as well as sea water from the

North Atlantic Ocean. Frobisher Bay is seasonally covered by ice which forms in early December and breaks up in mid-June. In addition to temperature changes, strong winds influence the forming and breakup of sea ice. The deepest parts of Frobisher Bay exceed 300 metres.

# 3 ENERGY DEMAND

## 3.1 Overview

Currently, the City of Iqaluit's electrical energy demand is met entirely by diesel generation, with six diesel generators in operation. These generators range in capacity from 2.0 to 5.0 MW, providing a total capacity of 22.6 MW. The installed firm capacity, which considers the possibility of the largest generator being out of service, is 17.6 MW.

In addition to electrical demand, thermal energy in the City of Iqaluit is supplied by oil heaters. The reliance on both diesel and oil heaters presents an opportunity to displace or offset both electrical and thermal energy supply with renewable sources. By transitioning to renewable sources, the City of Iqaluit will reduce its dependence on fossil fuels, improve energy security and mitigate the environmental impact of its energy consumption.

Potential also exists to supply energy to future industrial operations. Several of the alternatives under assessment are in proximity to proposed mining developments and may offer a green and more cost-effective power supply. The industrial off-taker demand was developed assuming mining operations during 8 months of the year with peak operations occurring between May and October. An average daily load during peak operations was assumed to be 6 MW with the daily load variation developed by CPL based on previous experience with the mining industry.

## 3.2 Diesel Electric Generation

Historical and forecasted diesel-fueled electrical generation and electrical demands was based on information as provided by QEC. Annual diesel generation data from 1995 to 2021 has been provided along with QEC's projected annual diesel generation from 2022 to 2030. Values are tabulated in Table 1 and displayed in Figure 8. Load projections from various other prior studies are shown in Figure 9.

In the 20 years from 1995 to 2015, the average annual growth rate in demand was 3.2%. Over the same period, the City of Iqaluit population grew at a rate of approximately 4.2% (Statistics Canada, 2023). However, from 2016 to 2022 the electrical demand grew by only 0.7% per year, on average. This may largely be due to a flattening of the population growth, with the total population decreasing between 2016 and 2021 from 7,740 to 7,429 (-4%). Overall, QEC predicts a 9% increase in annual electrical demand from 2020 to 2030.

**Table 1. Historical and Forecast Power and Energy Demand for Iqaluit (QEC)**

| Year Ending | Total Sales (kWh) | Total Losses (kWh) | Station Service (kWh) | Total Historical Demand (kWh)[1] | Forecasted Demand (kWh)[1] | Average Load (kW)[1] | Peak Load (kW)[1] |
|---|---|---|---|---|---|---|---|
| 1995 | 28,220,815 | 1,231,360 | 1,719,908 | 31,172,083 | | 3,558 | 5,725 |
| 1996 | 28,607,696 | 1,433,304 | 1,570,000 | 31,611,000 | | 3,609 | 5,800 |
| 1997 | 28,749,317 | 1,598,964 | 1,487,622 | 31,835,903 | | 3,634 | 5,725 |
| 1998 | 29,220,601 | 1,641,154 | 1,565,972 | 32,427,727 | | 3,702 | 5,750 |
| 1999 | 30,468,598 | 1,343,842 | 1,973,619 | 33,786,059 | | 3,857 | 6,050 |

| Year Ending | Total Sales (kWh) | Total Losses (kWh) | Station Service (kWh) | Total Historical Demand (kWh)[1] | Forecasted Demand (kWh)[1] | Average Load (kW)[1] | Peak Load (kW)[1] |
|---|---|---|---|---|---|---|---|
| 2000 | 32,873,218 | 2,823,118 | 2,600,691 | 38,297,027 | | 4,372 | 6,900 |
| 2001 | 36,648,814 | 1,935,835 | 2,280,205 | 40,864,854 | | 4,665 | 7,194 |
| 2002 | 39,107,191 | 2,365,771 | 1,959,718 | 43,432,680 | | 4,958 | 7,488 |
| 2003 | 40,676,193 | 2,353,679 | 2,286,808 | 45,316,680 | | 5,173 | 7,862 |
| 2004 | 42,494,407 | 1,643,808 | 2,519,855 | 46,658,070 | | 5,326 | 7,943 |
| 2005 | 44,422,805 | 723,579 | 2,407,296 | 47,553,680 | | 5,429 | 8,575 |
| 2006 | 44,586,726 | 1,511,685 | 2,754,559 | 48,852,970 | | 5,577 | 8,541 |
| 2007 | 47,295,165 | 446,444 | 2,804,521 | 50,546,130 | | 5,770 | 8,858 |
| 2008 | 45,884,110 | 3,955,122 | 2,421,018 | 52,260,250 | | 5,966 | 8,940 |
| 2009 | 47,845,953 | 2,952,325 | 2,460,412 | 53,258,690 | | 6,080 | 8,938 |
| 2010 | 50,987,616 | 1,253,828 | 2,399,056 | 54,640,500 | | 6,238 | 9,447 |
| 2011 | 52,824,403 | 318,659 | 2,200,868 | 55,343,930 | | 6,318 | 10,008 |
| 2012 | 53,923,036 | 1,911,463 | 1,889,481 | 57,723,980 | | 6,589 | 9,712 |
| 2013 | 52,624,023 | 1,067,047 | 3,197,576 | 56,888,646 | | 6,494 | 9,744 |
| 2014 | 52,998,549 | 2,228,668 | 2,034,985 | 57,262,202 | | 6,537 | 9,742 |
| 2015 | 53,740,920 | 1,863,158 | 2,202,436 | 57,806,514 | | 6,599 | 9,813 |
| 2016 | 54,951,207 | 2,001,196 | 2,187,665 | 59,140,068 | | 6,751 | 9,738 |
| 2017 | 55,492,441 | 1,906,138 | 2,247,297 | 59,645,876 | | 6,809 | 9,707 |
| 2018 | 54,839,419 | 1,734,452 | 2,241,783 | 58,815,654 | | 6,714 | 9,731 |
| 2019 | 54,391,066 | 2,880,023 | 2,070,913 | 59,342,002 | | 6,774 | 9,600 |
| 2020 | 56,031,481 | 958,676 | 2,040,629 | 59,030,786 | | 6,739 | 10,087 |
| 2021 | 54,355,844 | 2,968,869 | 1,906,301 | 59,231,014 | | 6,762 | 9,671 |
| 2022 | 56,471,005 | 2,339,712 | 1,779,221 | | 60,589,938 | 6,917 | 11,093 |
| 2023 | 55,995,749 | 2,407,580 | 2,083,361 | | 60,486,690 | 6,905 | 10,195 |
| 2024 | 56,481,189 | 2,526,123 | 2,064,239 | | 61,071,550 | 6,972 | 10,333 |
| 2025 | 57,295,871 | 2,712,642 | 2,044,376 | | 62,052,889 | 7,084 | 10,596 |
| 2026 | 57,575,188 | 2,661,315 | 2,026,781 | | 62,263,284 | 7,108 | 10,630 |
| 2027 | 58,112,183 | 2,588,557 | 2,047,213 | | 62,747,954 | 7,163 | 10,811 |
| 2028 | 58,666,767 | 2,649,775 | 2,110,420 | | 63,426,963 | 7,241 | 10,801 |
| 2029 | 59,132,519 | 2,696,484 | 2,112,596 | | 63,941,599 | 7,299 | 10,911 |
| 2030 | 59,661,923 | 2,731,074 | 2,121,715 | | 64,514,712 | 7,365 | 11,028 |

[1]Data Source. Load Forecast Model Master File for 2022-23 (QEC, 2022)

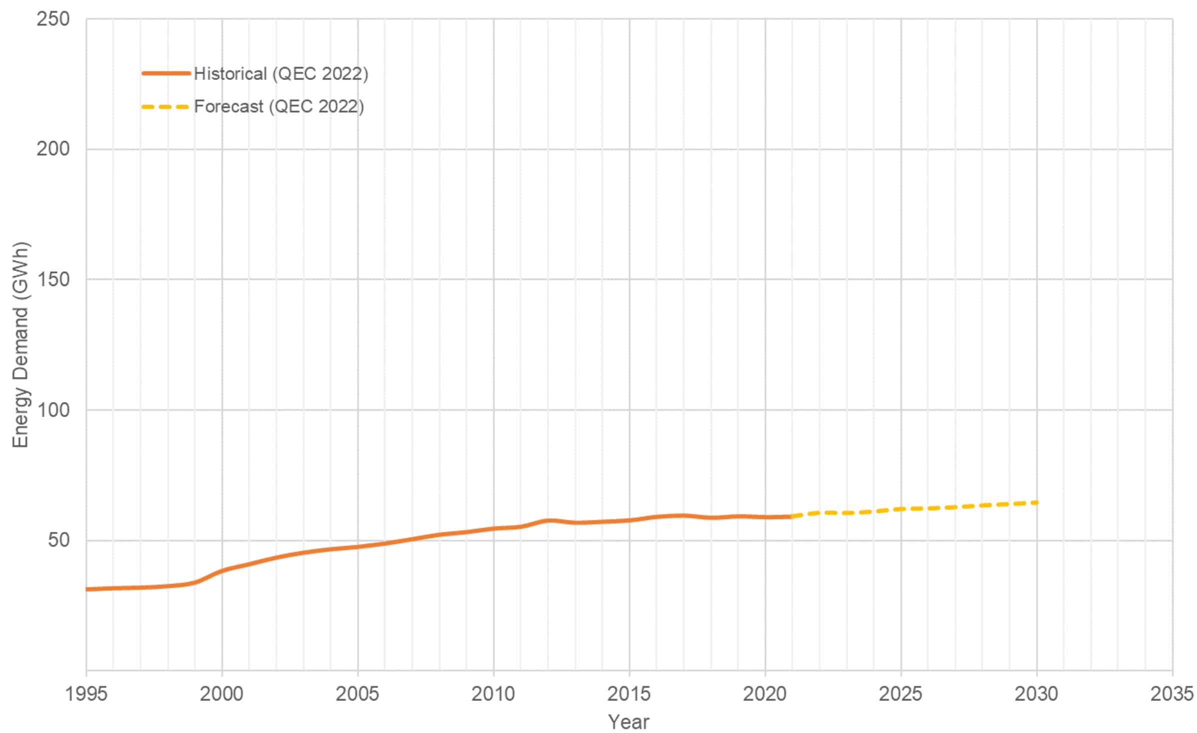


**Figure 8. Annual Energy Demand for Iqaluit (QEC)**

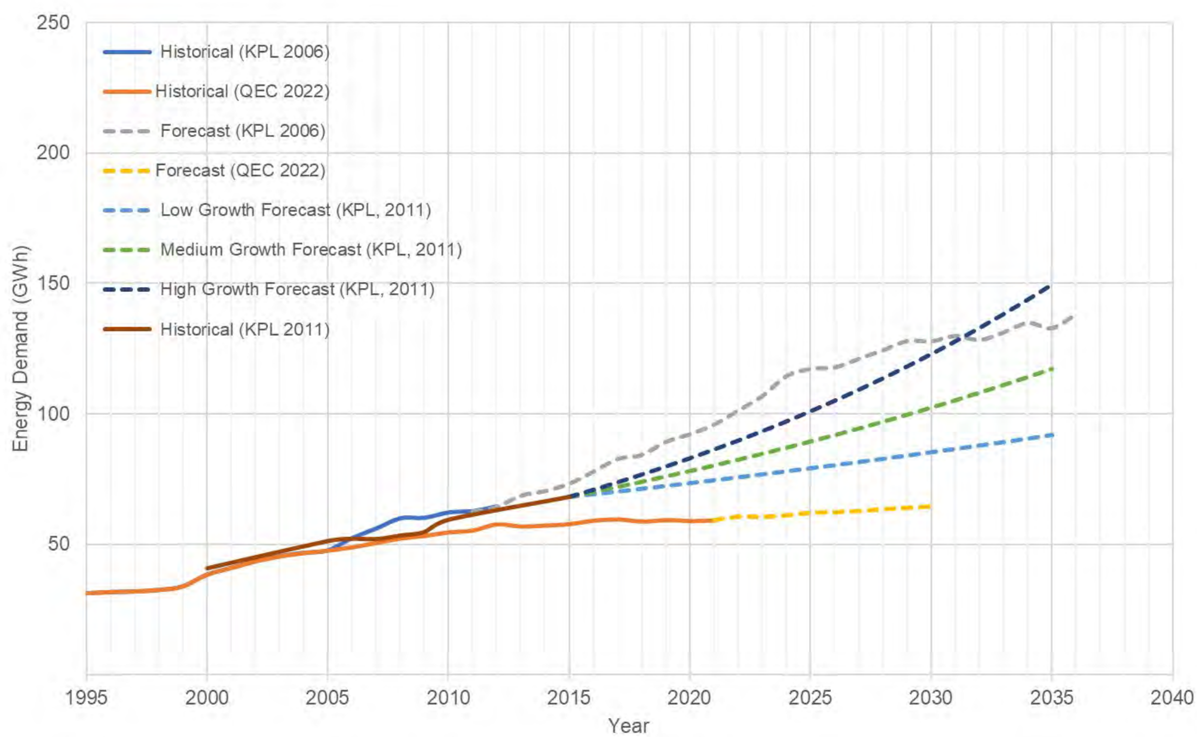


**Figure 9. Previous Studies Annual Energy Demands for Iqaluit**

## 3.3 Fossil Fuel Heating (Thermal)

The heating demand in the City of Iqaluit is significantly higher than the energy requirement for electricity, with household oil furnaces being the primary source of heating for most homes. Each home is equipped with an oil storage tank, and heating oil is delivered via truck several times a year. An above-ground pipeline connects the City's oil storage tanks to the port docks, which receive deliveries during the summer months. The Petroleum Products Division (PPD) of the Government of Nunavut is responsible for supplying heating fuel.

The PPD has provided a fuel sales data sheet which includes the amount of fuel sold per month for each type of fuel from April 2019 to March 2020. The data is provided monthly for most communities, however, data for the City of Iqaluit is limited. The City of Iqaluit data includes just one month of heating fuel sales with a value of over twice the annual consumption from 2015. This value was disregarded as it is significantly higher than what is considered realistic. Therefore, the energy model uses the monthly heating load distribution for the community of Kinngait, scaled to the estimated annual heating load for the City of Iqaluit. The estimated annual heating load for the City of Iqaluit was derived from the 2015 total heating fuel sales assuming the thermal load increase between 2015 and 2021 is proportional to the electrical load increase within the same period (2.5%).

In addition to oil heating, several City of Iqaluit buildings, including the hospital, courthouse, and recreation center, are heated via a district energy system that captures the waste heat from the diesel generators. This approach helps to offset the use of fossil fuels for heating, however there is a significant opportunity to transition to renewable sources of thermal energy to reduce the City's reliance on fossil fuels and improve energy efficiency.

In future scenarios, it should be noted that with increased energy availability and decreased power costs within a region, there is a significant increase in per capita electricity usage for purposes such as space heating (Feehan, 2018). Thus, the demand load estimates could double in the long-term and hence the required plant capacities, or the expandability potential needs to take this into account.

## 3.4 Other Energy Sources

There are no other known energy sources contributing at scale to the City of Iqaluit.

# 4 ELECTRICAL SYSTEMS AND INTERCONNECTION

## 4.1 Diesel Generation

Through correspondence with QEC, the existing diesel-fueled generation capacity for the City of Iqaluit was provided and is summarized below. It is understood that the generators are operated under an N+2 reliability configuration, with one generator operated in standby and one generator in maintenance at any given time. Information on the diesel generating units from QEC is shown in Table 2.

This information is used to help understand the electrical demand requirements, as well as the potential diesel fuel offsets for the renewable energy systems.

**Table 2. Iqaluit Existing Diesel Generating Capacity**

| Installed Units | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Unit** | **Brand** | **Model** | **kW Rating** | **Year Installed** | **Engine Hours** | **RPM** | **Engine Life** |
| G1 | Wartsila | 9R32 | 3000 | 1993 | 128,493 | 720 | 120000 |
| G2 | Wartsila | 12V32 | 4300 | 2000 | 153,212 | 720 | 120000 |
| G3 | Wartsila | 12V200 | 2000 | 1996 | 94,422 | 1200 | 100000 |
| G4 | Cat | D 3612 | 3300 | 1992 | 152,926 | 720 | 120000 |
| G7 | Wartsila | 12V32 | 5000 | 2013 | 41,373 | 720 | 120000 |
| G8 | Wartsila | 12V32 | 5000 | 2013 | 42,930 | 720 | 120000 |

Data Source. Load Forecast Model Master File for 2022-23 (QEC, 2022)

## 4.2 Integration Requirements

While the integration requirements of the utility are not defined, CPL has assumed and allowed for comprehensive upgrades to the existing electrical system for interconnection with a new renewable energy development.

A new protection and metering scheme will need to be implemented to the existing grid and generating station with the components depending on the development and integration strategy. If the Project concept operates with an independent substation, and interconnects into the distribution infrastructure, the protection scheme must consider the islanding conditions. Whereas this may not be required for an interconnection point at the existing QEC substation.

System controls will also be heavily dependent on the type of generation being brought online. Studies will be required during the detailed design phase to determine the requirements and particular elements.

QEC will continue to distribute the power to the community except for any large independent industrial load. To supply an industrial off-taker a separate substation with independent protection, metering and controls is required.

## 4.3 Power Quality

To achieve suitable power quality for the system, one or combination of these elements will be used: a load bank, filter bank, capacitor bank and/or Battery Energy Storage System (BESS). Each of these types of power quality compensation systems operate differently but may serve a similar purpose depending on the needs of the system. The hydroelectric and PSH alternatives will require less power quality control compared to wind-only options. Larger wind options may only require a filter bank, while smaller installments may require a BESS to limit the short-term fluctuations in available wind energy. The BESS capacity would be optimized to operate for power quality control rather than a proper energy storage or load balancing purpose.

Due to the nature of the generation types being evaluated, it is expected that all the concepts will provide improved power quality compared to the current diesel arrangement.

## 4.4 Transmission Systems

Transmission systems were assumed to be standard overhead lines with pile or rock anchor foundations. Preliminary routing for transmission considered the regional topography and water bodies but did not include an assessment for additional constraints. Installation of the lines was assumed to be conventional and accessed by vehicle (not by helicopter).

Subsea cable transmission was not included in the assessment of alternatives.

# 5 RENEWABLE ENERGY ALTERNATIVES

## 5.1 Project Identification

Phase 1 of the assessment included the identification of prospect alternatives for all potential renewable energy development options meeting the criteria. This involved an initial evaluation of the available energy potential and a characterization of the main site parameters for each alternative. A high-level screening was then completed to rule out alternatives which would face unsurmountable technical or environmental challenges. A desktop concept development was completed for the screened alternatives using the HRDEM terrain data including rough locations for access roads, transmission lines, barge landings, dams, penstocks and a powerhouse or substation. For selected alternatives, a site visit was conducted to further investigate, identify terrain hazards, and characterize the geotechnical conditions.

## 5.2 Site Visit

Site inspections of seven potential hydro sites were completed by Zach Vorvis, P.Eng., Anders Frappell, P.Eng. and Adam Leece, M.Sc., P.Eng. of CPL on September 7-9, 2022. The team was periodically accompanied by Heather Shilton of NNC and Keith Drover of Growler. The focus of the site inspections included:

- Development of an understanding of site-specific features that would either promote, permit, inhibit or prevent a renewable energy development from advancing at each of the defined locations.
- Assessment of surficial geologic conditions to document potential geologic hazards, preliminary information relating to foundation requirements, and gather information relating to requirements for future geotechnical investigations.
- Assessment of conditions to the developments and assess hazards or concerns relating to transmission line corridors connecting the developments to Iqaluit.

In addition to utilizing helicopter access at each location to conduct an aerial reconnaissance, a site walkthrough of the proposed dam sites, intake and spillway locations and powerhouse locations was completed. The generally high-level routing for proposed transmission corridors were flown over and viewed from the air. No prohibitive geological features were observed.

Photos at all locations were collected utilizing a variety of digital camera devices, including the Theodolite App on iPhone, Garmin Montana 680, and an DJI Mavic 2 Pro (unmanned aerial vehicle). All photos recorded the geographic and survey information within the photo metadata, including the position, altitude, bearing, elevation and horizontal angles.

## 5.3 Hydroelectric Power

### 5.3.1 Methodology

Concept design for hydroelectric power is an iterative procedure of locating the highest power location by way of the best head and flow combination. For reservoir development, terrain locations that provide maximum water storage with dam sites that are narrow and shallow are sought to minimize dam volume and extent. Proximity to bedrock borrow sources and overall solid foundation characteristics are then evaluated. Once the hydroelectric site power and reservoir size is determined, the concept layout and sizing can be completed including intake, penstock, and powerhouse infrastructure, along with access roads, transmission line routes and construction areas. With the concept completion, enough detail is determined to provide high-level power and energy assessment and costing to analyse the site economics, as well as the environmental and social aspects.

Details of the parameters used for the power and energy modeling, costing and economics are included in the power and energy modelling outputs included in Appendix B. Hydroelectric power is one of the most efficient forms of energy production with an overall efficiency in the 84% range. Power output can be quickly controlled to match demand changes making it ideal for sustainable community energy supply especially with a reservoir to adjust seasonal availability.

### 5.3.2 Previous Work

In 2005, QEC embarked on an exploration of the hydroelectric power potential surrounding the City of Iqaluit, initiating a collaboration with engineering firm, KP, to conduct an evaluation of potential sites. The first outcome was an engineering study titled Site Identification and Ranking, produced in January 2006. This assessment pinpointed 5 promising project sites out of a total of 14 across 13 rivers within a 100 km radius of the City of Iqaluit (Knight Piésold, 2006a). Among the notable locations were the Sylvia Grinnell River, the McKeand River system, various sites within Cantley Bay, as well as options southwest of the City of Iqaluit, like the Armshow River and Jaynes Inlet. The following month, a Phase II pre-feasibility study was finalized, incorporating further engineering and environmental evaluations of the selected 5 project sites (Knight Piésold, 2006b). Simultaneously, QEC engaged the WSC to set up hydrometric stations in the majority of identified river systems for precise streamflow data collection.

Spanning the period from 2006 to 2008, QEC dedicated significant effort to extensively assess the short-listed sites. Their endeavors encompassed preliminary environmental baseline analyses and consultations with the Inuit community to pinpoint crucial environmental factors influencing QEC's site selection strategy. This comprehensive approach extended to recognizing the potential presence of migrating anadromous arctic char, as well as intensive land use considerations. QEC also established a hydro committee comprising local stakeholders. QEC enlisted an owner's engineer, Manitoba Hydro International, to ensure the quality of the pre-feasibility study and offer insights into engineering and financial aspects. Concurrently, QEC pursued external funding sources to facilitate a feasibility study, the next pivotal phase in the project's evolution (Knight Piésold, Iqaluit Hydroelectric Project Proposal, 2013).

In early 2011, an updated pre-feasibility engineering and financial analyses was completed, bolstered by independent cost evaluations conducted by Peter Kiewit Infrastructure of Canada and ISTAK of Iceland (Knight Piésold, 2011).

## 5.4 Wind Power

The regions surrounding the City of Iqaluit are high in wind power potential with the most favourable wind regimes located on the high elevation plateaus. Combining wind with hydroelectric provides favourable Project economics where infrastructure can be shared, such as access road and transmission development.

### 5.4.1 Methodology

Wind sites were assessed for favourable topography, access, wind generation potential, proximity to the existing community infrastructure and proximity to future development concepts (i.e., Armshow hydroelectric site). The site selection is guided by Project economics, which incorporates the quality of the wind generation resource, as well as the new infrastructure requirements, such as length of road and transmission line and degree of difficulty for construction.

Inputs to the wind resource models are based on a combination of the Canadian Weather Energy and Engineering Datasets (CWEEDS) meteorological monitoring data collected at Environment and Climate Change Canada's Iqaluit Station 2005-2017, and the Environment and Climate Change Canada's Wind Atlas.

Several Wind Turbine Generator (WTG) models and their associated power curves were reviewed for applicability to the sites. Potential turbine sizes were assessed based on several factors, including the ability to provide an appropriate number of turbines for maintenance rotation, commercial availability, good balance between constructability (height, component size, and foundation requirements) and capacity, and to be large enough to garner a good cold climate functionality package. Based on this, a turbine capacity between 2 and 4 MW was deemed an appropriate commercial range.

An Enercon E70 power curve was used for the analysis but there are several other wind turbines that can be used as well. The E70 turbine is rated at 2.3 MW with a 71m rotor diameter and a 75m hub height. It is an IEC Class 1A turbine that is well suited to this wind regime and site conditions. The power curve is presented in Figure 10Figure 10.

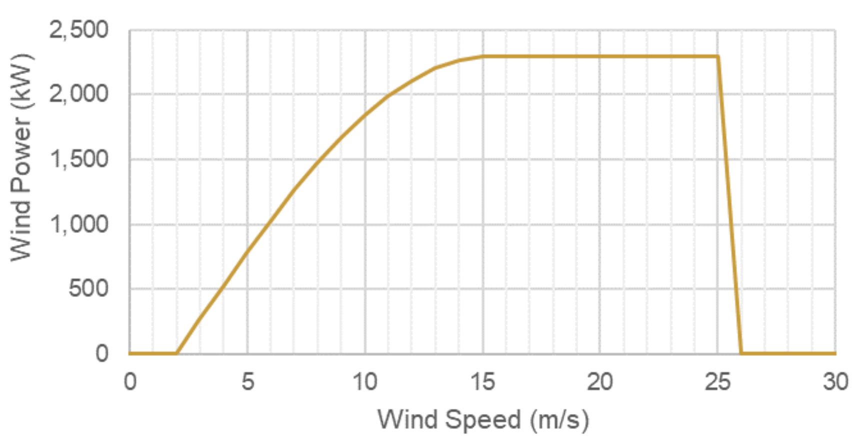


**Figure 10. E70 Turbine Power Curve**

### 5.4.2 Previous Work

Wind power in the City of Iqaluit has been investigated several times since 2006. KP was commissioned by QEC in 2006 to complete a preliminary review of the potential for wind development, including the combination of wind and hydroelectric (Knight Piesold Ltd., 2006). KP's report concluded that the development of a 10 MW wind and 5 MW hydroelectric scheme would result in estimated annual savings of just over $13 million in energy costs. Installation of a 10 MW wind facility would only generate an estimated annual savings of $4.5 million.

Tugliq Energy reviewed wind energy in the City of Iqaluit from 2017 to 2018. The group first assessed potential development sites around the City, visiting the two best options. With the support of Hatch, the group installed a MET mast at one of the locations in spring of 2017.

Later in the year, Tugliq was commissioned by QEC to complete a scoping study on the integration of wind into the existing diesel generation system in the City of Iqaluit (Tugliq Energy Co., 2017). The real data from the recently installed MET mast was not ready for use, therefore virtual MET data was used for the analysis. The study reviewed different WTG models and capacities to determine what was predicted to be the most cost effective and reliable. The proposed development included two (2) 2.35 MW Enercon E-103 WTGs for a total capacity of 4.7 MW at an estimated capacity factor of 27%. Capex and Opex estimates were included. The study concluded wind energy development is economically achievable with an estimated LCOE of $440/MWh. It was also estimated that the development could avoid the consumption of approximately 58 million liters of diesel over the 20-year life.

Hatch completed a wind resource assessment report one year after the MET mast was commissioned (Hatch, 2018). The assessment utilized the single year of data collected at the MET site along with a 10-year set of simulated data by Vortex to compare and create a long-term forecast. The analysis found that a 33% capacity factor would be achievable using two 98m HH WTGs, assuming 15.7% losses.

## 5.5 Pumped Storage Hydroelectric (PSH)

PSH provides the lowest cost energy storage for large energy supply requirements. Sites are similar to those used for conventional hydroelectric, with the exception that a top and bottom reservoir in proximity are necessary. Some conventional hydroelectric sites may also be potential PSH sites to be developed later when the need arises. 20 MW of capacity or more is needed for this form of energy storage to be practical. PSH is very efficient with an overall cycle efficiency in the 72% range.

### 5.5.1 Methodology

The approach for PSH concept design is similar to conventional hydroelectric with the added challenge of requiring both an upper and lower reservoir. For the broader City of Iqaluit area, with its several lakes and rivers, there are a few locations where the right site characteristics exist. These sites are then filtered out based on size, initial site conditions assessment and proximity to the City of Iqaluit.

## 5.6 Identified Sites

Table 3, Table 4 and Table 5 list the sites that were identified by the preliminary site screening process:

**Table 3. Hydroelectric Sites**

| Hydroelectric Sites | Type | Pumped Storage Compatible? | Capacity Range (MW) | Max Gross Head (m) | Max. Dam Height (m) | Penstock Length (m) | Catchment Area (km$^2$) | Transmission Distance (km) | Pros | Cons |
|---|---|---|---|---|---|---|---|---|---|---|
| McKeand River North Hydro | Conventional Hydro | No | 10 - 50 | 140 | 140 | 500 | 7500 | 140 | Scalable, Large capacity. | Large dam, Distance to Iqaluit. |
| McKeand River South Hydro | Conventional Hydro | Yes | 10 - 30 | 90 | 25 | 3400 | 3800 | 60 | Scalable, PSH option. | Distance to Iqaluit. |
| Jaynes Inlet Hydro | Conventional Hydro | Yes | 10 | 437 | 5 | 5500 | 203 | 100 | PSH option, Available head, Dam size. | Distance to Iqaluit, Penstock length. |
| Armshow South Hydro | Conventional Hydro | No | 5 - 10 | 245 | 20 | 7300 | 280 | 45 | Available head. | Penstock length. |
| Armshow River Hydro | Conventional Hydro | No | 10 - 15 | 120 | 60 | 3900 | 0 | 50 | | |
| Cantley Bay Hydro | Conventional Hydro | No | 10 - 20 | 225 | 80 | 7800 | 1800 | 55 | | |
| Sylvia Grinnell Bend Hydro | Conventional Hydro | No | 10 - 30 | 67 | 70 | 1800 | 2500 | 30 | | |
| Sylvia Grinnell Jag Hydro | Conventional Hydro | No | 10 - 40 | 126 | 104 | 1300 | 3100 | 15 | | |

**Table 4. PSH Sites**

| PSH Sites | Type | Capacity Range | Max Gross Head (m) | Max Upper Reservoir Vol. (m3) | Max. Lower Reservoir Vol. (m3) | Penstock/Tunnel Length (m) | Transmission Distance (km) | Pros | Cons |
|---|---|---|---|---|---|---|---|---|---|
| Kynersley Iqalliarvik PSH | Closed-Loop | 20 - 60 | 230 | 76.8 (x$10^6$) | 76.3 (x$10^6$) | 2300 | 20 | Close to Iqaluit. | |
| Jaynes Inlet PSH | Open-Loop | 10-30 | 437 | 44.0 (x$10^6$) | 6.0 (x$10^6$) | 5500 | 100 | ROR option, Available head, Dam size. | Distance to Iqaluit, Penstock length. |

**Table 5. Wind Sites**

| Wind Sites | Mean Wind Speed (m/s) | Mean Wind Energy (W/m$^2$) | Ground Elevation (m) | Access Road Length (km) | Tie-In Point New or Existing | Proximity to Tie-in (km) | Transmission Distance to Iqaluit (km) | Pros | Cons |
|---|---|---|---|---|---|---|---|---|---|
| Niaqunguk Wind | 6.68 | 375 | 325 | 10 | Iqaluit Grid | 7 | 7 | Close to Iqaluit. | View & Noise Abatement. |
| Qasitujuak Lake Wind | 7.76 | 445 | 500 | 35 | Sylvia Grinnel Hydro | 2 | 15 | Ties to Hydro. | |
| Kynersley Lake Wind | 6.97 | 413 | 420 | 30 | KI PSH | 1 | 20 | Close to Iqaluit, Adjacent PSH. | |
| Armshow Lake Wind | 8.6 | 706 | 475 | 25 | Armshow Hydro | 1 | 50 | Ties to Hydro. | Distance to Iqaluit. |
| Jaynes Inlet Wind | 8.42 | 536 | 750 | 20 | Jaynes Hydro | 5 | 100 | Ties to Hydro. | Distance to Iqaluit. |

*Mean Wind Speed and Mean Wind Energy are taken at 50m above ground.

# 6 ENERGY AND ECONOMIC MODELLING

## 6.1 Power and Energy

The power and energy analyses were completed by developing a custom time-series based power and energy model to model the ability for the alternatives to meet the design energy load profile and consequently optimize project sizing. The model uses multi-year data and integrates the generation types with concept-specific and technology-specific constraints.

The concepts are optimized using the model to achieve the lowest aggregate LCOE and sensitivity analysis can be done on key variables of the economics, such as the cost of diesel, carbon tax and others.

### 6.1.1 Model Approach

The basic islanded grid power system as modelled within this study is depicted in Figure 11. The elements associated with the renewable energy system include the wind and hydroelectrical generation, supplemented with a PSH system, a step-up transformer, overhead transmission line, a step-down transformer, existing diesel generation and a BESS, all which tie into the existing electrical distribution system within the City of Iqaluit.

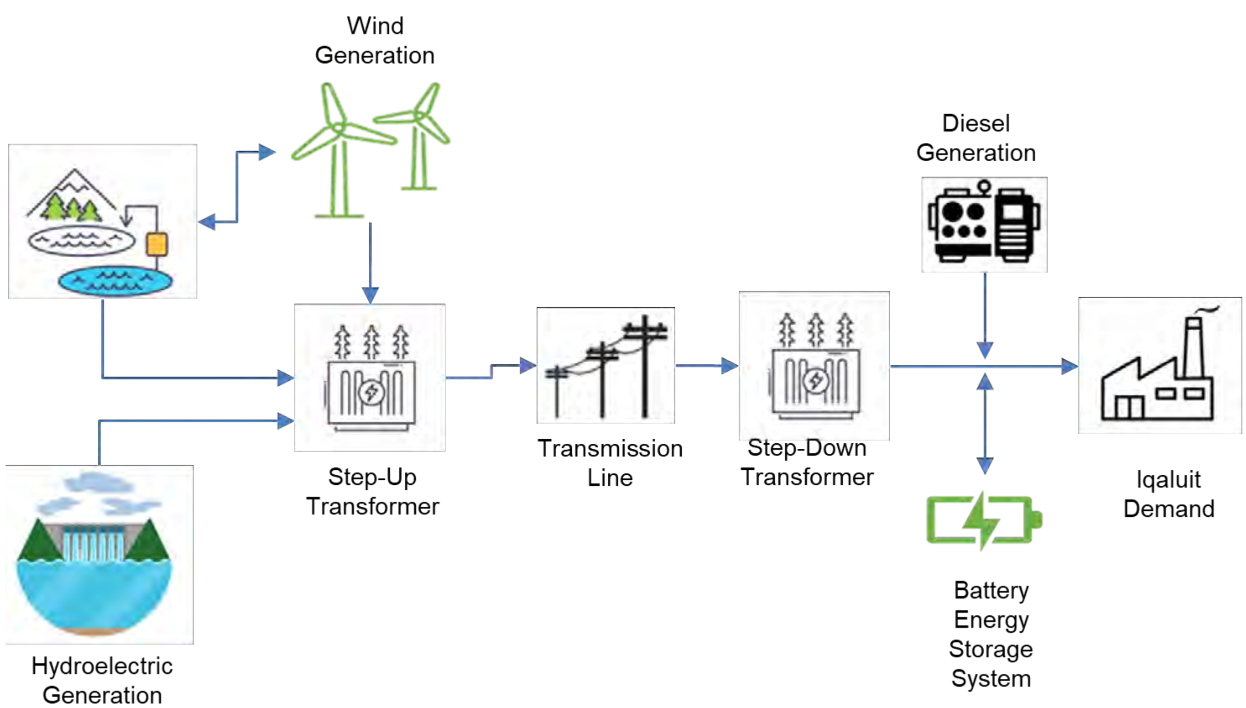


**Figure 11. Basic Islanded Grid Power System Model**

Within the power and energy model, all surplus power generated beyond the hourly demand and storage deficit was assigned to a theoretical load bank. The surplus power is limited by gross curtailing wind generation through a combination of unit and array shutdowns and load control functionality, or a combination of the two depending on the generating technology.

It is expected that a BESS will be the primary source of load balancing and power quality control and will be of sufficient size to preclude the need for an actual load bank.

### 6.1.2 Load Characterization and Scenarios

The electrical load used in the model was developed using data provided by QEC as the basis. Synthetic data was created where QEC data was unavailable. Annual electrical energy demand data for the City of Iqaluit provided by QEC is shown in Table 1 and includes the historical demands on a yearly basis. Load growth was estimated to be approximately 10% over 10 years. To generate an annual load profile and typical daily load profile, a second data set with nine months worth of 10-second generation data was used. Gaps in the data were generated synthetically.

Historical and forecasted thermal heating demands were based on information as provided by QEC. The thermal demands were characterized by 2020 heating oil consumption data.

Industrial demand was generated theoretically based on CPL's experience and consultation with the Project stakeholders.

Table 6 and Figure 12 provide the general load characteristics for each load portion.

**Table 6. Load Characterization Summary**

| Load | Max Power (MW) | Average Power (MW) | Min Power (MW) | Energy (GWh/yr) | Percent |
|---|---|---|---|---|---|
| Electrical | 10 | 8 | 6 | 65 | 25% |
| Thermal | 42 | 16 | 2 | 140 | 60% |
| Industrial | 6 | 4 | 0 | 30 | 15% |
| **Coincident Demand** | **58** | **28** | **8** | **235** | **100%** |

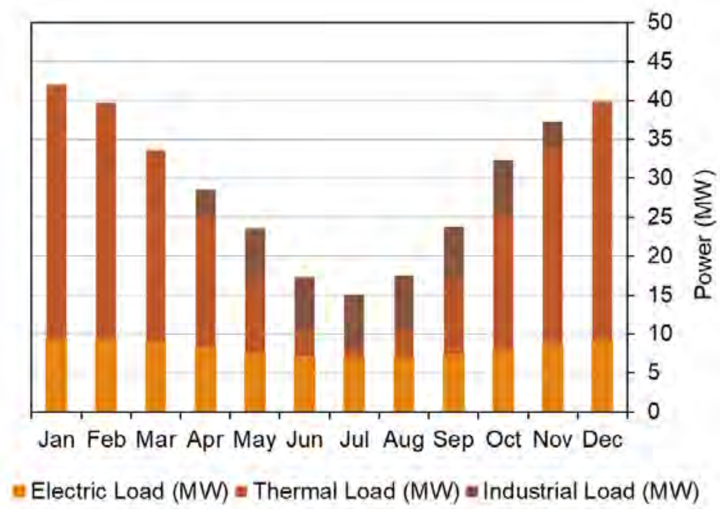


**Figure 12. Annual Load Profile**

### 6.1.3 Diesel Generation

Diesel generation is modelled as a load following generator, filling in the gaps of renewable generation when load is high and/or renewable supply is low. The diesel dispatch philosophy follows the logic in Table 7.

**Table 7. Diesel Dispatch**

| Unit | G1 | G2 | G3 | G4 | G7 | G8 | Units Operating | Maximum Load |
|---|---|---|---|---|---|---|---|---|
| Capacity | 3.00 | 4.30 | 2.00 | 3.30 | 5.00 | 5.00 | | |
| Dispatch Table | | | | | | | | |
| 1 | | | 1 | | | | 1 | 2.00 |
| 2 | 1 | | | | | | 1 | 3.00 |
| 3 | 1 | | 1 | | | | 2 | 5.00 |
| 4 | 1 | 1 | | | | | 2 | 7.30 |
| 5 | 1 | 1 | 1 | | | | 3 | 9.30 |
| 6 | 1 | 1 | 1 | 1 | | | 4 | 12.60 |
| 7 | 1 | 1 | 1 | 1 | 1 | | 5 | 17.60 |
| 8 | 1 | 1 | 1 | 1 | 1 | 1 | 6 | 22.60 |

A base load diesel generation can be set in the model where at least one generator is always operating at a minimum of 35% its capacity.

Diesel generation capacity is expected to remain in place and be able to service the full electrical load in a cold stand-by capacity.

### 6.1.4 Renewable Power and Energy

Available renewable energy is calculated on an hourly basis across the multi-year time series. Gross available power is derived from the resource data for the specific site (wind, flow, reservoir volume, etc.). For simplification of the model, a net efficiency value is applied on each generation type for all power generated. This is the net efficiency and represents the power available at the load.

Priority is given to the form of energy with the lowest LCOE. For the prospect alternatives under evaluation, wind is consistently the lowest followed by hydroelectric and PSH, and then diesel.

**Hydroelectric and PSH**

Flow data is used for the hydroelectric and PSH model calculations. While the WSC has installed gauging stations at several rivers included in this assessment, the records are relatively short in duration (typically less than eight years). A review of the available local data sets revealed that a gauging station located on the Sylvia Grinnell River (10UH001) is most representative of the conditions of the rivers included in this assessment. Daily synthetic inflows were developed using a regression analysis approach. These synthetic flows compared favorably with the available measured flows.

Available reservoir volume was determined using the HRDEM of the site. Concept-specific maximum and minimum reservoir levels were determined by the conceptual design of dams, channels, and spillways with consideration for environmental constraints on water level fluctuations.

The gross available power is calculated using the hourly flow, calculated head loss, efficiency, and real-time available head found by the modeled reservoir heights. An Instream Flow Release (IFR) was assumed for all sites at 10% of the monthly mean flow.

For PSH, the available power for delivery or storage is governed by the reservoir volumes and the pump-turbine capacity. The system provides load balancing by charging during times of excess renewable generation and discharging at times of low renewable generation. An efficiency is applied to the recharge and discharge operation of the system.

The hydroelectric efficiency, which is calculated for both recharge and discharge, is intended to capture the net efficiency of the plant including transmission losses. The breakdown of hydroelectric efficiency is shown in Table 8.

**Table 8. Net Hydroelectric/PSH Plant Efficiency**

| Parameter | Efficiency |
|---|---|
| Turbine | 90.0% |
| Generator | 97.5% |
| Transformer | 99.0% |
| Station Service Power Consumption | 99.0% |
| Line Losses | 97.0% |
| **Net Efficiency** | **83.4%** |

**Wind**

Data for wind speed, temperature, pressure and wind direction are used to determine the gross available wind power. The turbine power curve and net efficiencies are applied to calculate the energy that is available at the load.

Measured wind data from the Iqaluit airport weather station was used to form the wind energy model by scaling the wind data to each of the development location. Hourly data was used from 2007 to 2012. Scaling of the data was done using the average seasonal wind speeds for each of the alternative locations which were sourced from the Canada Wind Atlas. This scaling includes a vertical correction from the 10m anemometer height at the weather station to a height of 50m at the development location. Further scaling was then done to reach the desired turbine hub height.

The gross power available for each model hour was calculated using the power curve adjusted for air density, which was calculated from the air temperature and barometric pressure from the scaled MET data. Where available wind power exceeds the load and the available storage capacity, power is curtailed by directing power to a theoretical load bank.

A net wind power balance of plant efficiency of 85.4% net of transmission line losses was applied to the air density compensated power curve based on the component work up. The breakdown is shown in Table 9.

**Table 9. Net Wind Plant Efficiency**

| Parameter | Efficiency |
|---|---|
| Power Curve Turbulence Variation | 100.0% |
| Topographic Efficiency | 100.0% |
| Wake Effects | 98.0% |
| Collector Losses | 97.0% |
| Station Service Consumption | 99.5% |
| Transmission Losses | 98.0% |
| Icing and Blade Degradation | 95.0% |
| Substation Maintenance | 100.0% |
| Effective Turbine Availability | 98.0% |
| Hysteresis | 99.5% |
| **Net Efficiency** | **85.4%** |

## 6.2 Costs

The capital and operating cost estimates are intended for relative comparison of power and energy system options and should not necessarily be considered to provide an absolute representation of costs. The capital and operating cost estimates presented herein are not detailed estimates and should not be used for investment decision-making.

### 6.2.1 Fossil Fuel Energy

Diesel generating costs were requested from QEC at the start of the Project. At the time of writing, reliable cost data has not been provided. Therefore, the diesel generation cost estimates are based on a combination of current market information, published papers and CPL's experience. Costs are adjusted for 2023 inflation. Table 10 and Figure 13 summarize the breakdown of diesel costs for the first year of energy production in a diesel-only scenario. The fixed Capex and Opex will be dramatically less in a scenario where the electrical demand is entirely or almost entirely met by renewables.

**Table 10. Diesel Fuel Costs for Year 1**

| | Basis at Year 1 | Escalation | Basis |
|---|---|---|---|
| Rack Fuel Cost | $1.75 /L | 4.0% | Existing/Forecasted Market Pricing |
| Fuel Subsidy | -$0.50 /L | -2.0% | Assumed |
| Generator Efficiency | 3.75 kWh/L (35%) | N/A | Typical |
| Base Carbon Tax | $50 /tonne | 2.5% | Set to achieve $100/tonne in 2050 |
| Fixed Capex & Opex | $325,000 /MW | 2.0% | Published Study[1] |
| Variable Capex & Opex | $40 /MWh | 2.0% | Published Study |

[1] Annualized Capex and Opex informed by "Diverging from Diesel", Gwich'in Council International, Intergroup Consultants, and Lumos Clean Energy (undated) and "Why is it so difficult to replace diesel in Nunavut, Canada?", Journal of Renewable and Sustainable Energy Reviews, Pinto and Gates, 2021. Capacity versus energy-based splits are assumed.

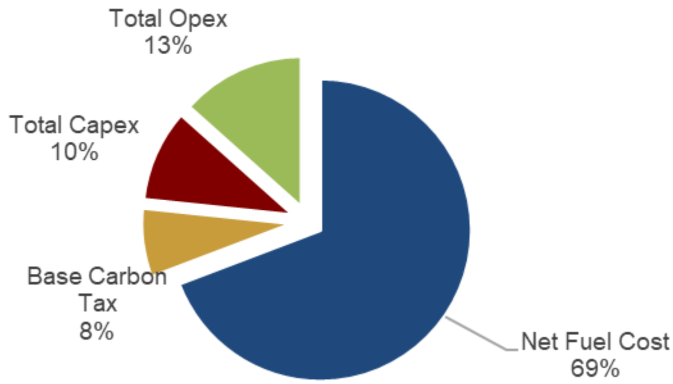


**Figure 13. Current Diesel Cost Breakdown**

### 6.2.2 Renewable Energy Costs

Cost estimates utilized to develop the renewable economic metrics are parametric-based derived from CPL's industry experience, as well as other readily available information applied to the northern and remote location of the prospect alternatives. All dollar figures quoted within this study are in Canadian (CDN) funds.

To estimate the wide variety of concepts and capacities, unit cost rates were customized to the development scenario. Where wind and hydroelectric or wind and PSH were combined, efficiencies for shared infrastructure, such as transmission line, access, substation, etc. were captured. The parameters are based on readily accessible data and/or experience on similar projects in generally accessible locations with a premium applied to site work for the remote location.

An example of the cost estimate breakdown for a "typical" hydroelectric site are shown in Table 11 and Table 12. The typical site assumes a 10 MW hydroelectric plant approximately 60 km from the City of Iqaluit.

Further detail for specific concepts is included in the power and energy (PE) results attached as Appendix B.

**Table 11. Typical Hydroelectric Capital Cost Estimate Breakdown**

| Component | Cost |
|---|---|
| Mobilization & Site Services | $7,050,000 |
| Access Roads / Bridges / Barge Landing | $24,750,000 |
| Laydown and Staging Areas | $300,000 |
| Reservoir Dam / Spillway / Intake Works | $31,00,000 |
| Tunnel / Shaft Works | $11,000,000 |
| Penstock Supply and Install Works | $38,000,000 |
| Turbine-Generator Package Supply | $6,00,000 |
| Turbine-Generator Install | $500,000 |
| Powerhouse | $1,650,000 |
| Substation and BOP Electrical | $1,500,000 |

| Component | Cost |
|---|---|
| Transmission Line | $22,000,000 |
| Iqaluit Electrical System Upgrades | $500,000 |
| Remote Labour Premium | 3.0% |
| Engineering, PM, & CM | 4.0% |
| Environmental & Permitting | 2.5% |
| Owner's Cost | 7.0% |
| Interest During Construction (IDC) | 5.0% |
| Debt Service Reserve | 5.0% |
| Bonding and Insurance | 2.0% |
| Contingency | 10.0% |

**Table 12. Typical Hydroelectric Capex and Opex**

| Component | Cost |
|---|---|
| **CAPEX** | |
| Civil | $100,000 |
| Electrical | $125,000 |
| Mechanical | $60,000 |
| Contingency | 20% |
| **OPEX** | |
| Management / Operators / Service | $500,000 |
| Environmental & Regulatory | $25,000 |
| Stakeholder Benefit Agreements | $0 |
| Landowner Payments | $0 |
| Crown Land Lease Payments | $20,000 |
| Insurance, Taxes, Utilities | $1,600,000 |
| Contingency | 10% |

The cost breakdown for a typical wind site is shown in Table 13 and Table 14. The values presented are not associated with a particular site but are shown to provide a typical breakdown. The values below assume a 10 MW wind development less than 10 kms from Iqaluit.

**Table 13. Typical Wind Capital Cost Estimate Breakdown**

| Component | Cost |
|---|---|
| Mobilization & Site Services | $3,330,000 |
| Access Roads | $4,800,000 |
| Civil / Siteworks / Foundations | $2,060,000 |
| Turbine Supply | $21,050,000 |
| Turbine Transport, Installation | $1,200,000 |
| Mobile Crane Purchase | $3,000,000 |
| Substation & Elec BOP | $1,500,000 |
| Transmission Line 69 kV DB | $4,250,000 |
| Iqaluit Electrical System Upgrades | $750,000 |
| Operations Building | $300,000 |
| Remote Labour Premium | 2.0% |
| Engineering, PM, & CM | 4.0% |
| Environmental & Permitting | 2.5% |
| Owner's Cost | 10% |

| Component | Cost |
|---|---|
| Interest During Construction (IDC) | 5.0% |
| Debt Service Reserve | 5.0% |
| Contingency | 10.0% |

**Table 14. Typical Wind Capex and Opex**

| Component | Cost |
|---|---|
| **CAPEX** | |
| Civil | $10,000 |
| Electrical | $20,000 |
| Mechanical / Turbine | $150,000 |
| Contingency | 15% |
| **OPEX** | |
| Management / Operators / Service | $950,000 |
| Environmental & Regulatory | $10,000 |
| Stakeholder Benefit Agreements | $0 |
| Land Lease Payments | $20,000 |
| Insurance, Taxes, Utilities | $550,000 |
| Contingency | 10% |

For the thermal energy scenario, the cost to convert existing heating oil systems to electric heaters has not been included.

## 6.3 Economics

The Project lifetime of wind developments was assumed to be 20 years. The WTG life span is governed by eventual fatigue from cyclical loading of the main elements and therefore must be replaced in its entirety. Re-powering of wind was considered 70% of the initial capital since roads, transmission lines and substation infrastructures have a longer service life.

Hydroelectric and PSH developments are expected to operate through the entirety of the 50-year economic planning period. The economics were evaluated with no residual value, however hydroelectric has an effective life of over 100 years with periodic upgrades.

In assessing the relative attractiveness of each renewable energy system design, levelized cost of energy (LCOE) was used. LCOE is the Net Present Value (NPV) of escalated cash flow exclusive of financing arrangements and income tax considerations divided by the NPV of average annual energy, all at the specified discount rate over the economic planning period. Initial capital costs are considered to be fully expended at the beginning of the first operating year.

It is important to note that as renewable penetration increases, cost of diesel may increase because of fixed capacity costs and lower volume discounts. Therefore, the alternative that results in the lowest cost of renewables may not be the same as the alternative resulting in the lowest overall cost of energy. Figure 14 is an example of changing LCOE at increased wind capacity using Jaynes Inlet 10MW hydroelectric supplemented with wind considering electrical, industrial, and thermal load.

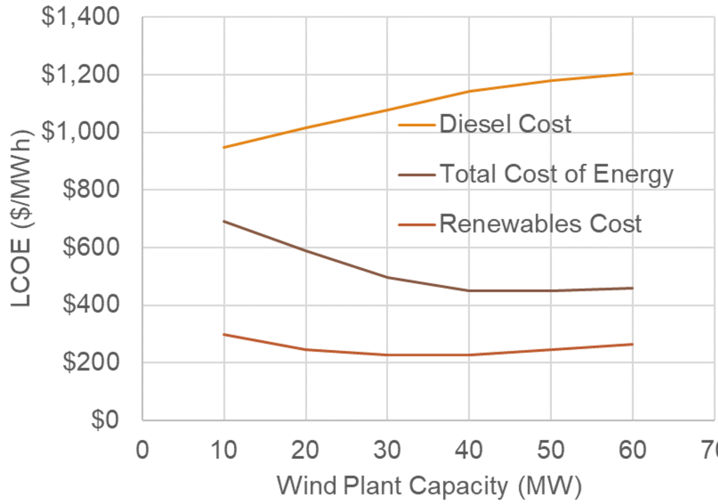


**Figure 14. LCOE vs. Hydroelectric and Wind Plant Capacity**

# 7 SCHEDULE

The Project schedule will ultimately be dictated by the prospect alternative selected. At this stage, preliminary schedules by calendar year with associated activities have been developed for review and are presented in Table 15 and Table 16. It is expected that SEM will provide more details around the environmental permitting process which can be incorporated into later versions of the schedule.

**Table 15. Preliminary Hydro Schedule**

| Year | Activities |
|---|---|
| 2024 | Environmental permitting, archeological surveys, conceptual engineering design. |
| 2025 | Environmental permitting, preliminary engineering design, geotechnical investigation. |
| 2026 | Environmental permitting, geotechnical investigation, detailed engineering design. |
| 2027 | Phase 1 construction, including civil works such as access road, dam, intake structure, penstock, powerhouse. |
| 2028 | Phase 2 construction, including mechanical and electrical items such as substation, transmission line and powerhouse completion. Commissioning would take place at the end of 2028. |

**Table 16. Preliminary Wind Schedule**

| Year | Activities |
|---|---|
| 2024 | Environmental permitting, preliminary engineering design, geotechnical investigation. |
| 2025 | Environmental permitting, major equipment procurement, detailed engineering design. |
| 2026 | Phase 1 construction, including access road, site preparation, foundations. |
| 2027 | Phase 2 construction, including WTG delivery, WTG install, Collector, Substation, Transmission line. Commissioning would take place in fall 2027. |

This schedule is 1 to 2 years longer than other regions in Canada. Consideration is made to account for the absence of an established regulatory or environmental process for renewable energy development projects and associated learning activities. Certain steps may be able to be taken to reduce this timeline, depending on government/community will and resources.

# 8 COMPARISON OF ALTERNATIVES

The prospect alternatives were assessed and compared using a comprehensive risk-based decision matrix. Criteria for the matrix were developed in collaboration with the Project stakeholders and other contributors. The matrix was structured to capture all key development considerations for the alternatives including technical, constructability, schedule, environmental constraints/challenges, stakeholder issues/constraints, community impact and other risks or opportunities, as well as the power and energy characteristics and economics.

## 8.1 System Analysis

Each prospect alternative was run for both load scenarios and an optimization exercise was done to achieve the minimum aggregate LCOE for various capacities or combination of capacities. Where two or more options gave a LCOE within negligible difference, the option with a smaller capital cost was taken as the optimum to reduce project risk.

A “business as usual” case was also run as a comparison assuming continued fossil fuel supply for all energy demand. In this case, the LCOE for electric load only over the 50-year evaluation period was found to be $837/MWh. For the all-load scenario, the LCOE was $869/MWh.

### 8.1.1 Technical and Design Considerations

There are several unique aspects to development in the Iqaluit region. In the development of the prospect alternatives, the following technical and design considerations were given high importance. The aspects discussed here are not necessarily captured/factored in the economic evaluation and should be given further attention in the next phase of development.

1. Access and Constructability

    a. All sites require road or barge and road access which will need to be built for construction and operation of the facility:

        i. Barge access sites will be limited greatly by the sea ice in Frobisher Bay.

        ii. Road access sites will have greater flexibility for time of year, although large stretches of access road will require significant maintenance during construction and operation due to the harsh weather and snowpack.

    b. All sites will have a new transmission line built from the site to the existing Iqaluit substation. Routing will generally follow the path of least distance and best terrain and will follow the road infrastructure, where practical.

    c. Construction camps are expected to be required at the majority of sites during construction seasons.

d. Material supply, such as aggregate, rock fill, and concrete, will likely be required to be produced at site. For the prospect alternative assessment, it was assumed suitable materials are available within proximity to the site.

2. Cold Climate Effects and Climate Change

   a. Reservoir icing will inevitably create challenges for hydroelectric and PSH operations in the Iqaluit region and should be investigated further in Phase 3.

   b. Climate change brings uncertainty to the future availability of renewable energy resources with potential for longer dry periods and more frequent extreme weather events.

3. Scalability

   a. The thermal energy transition away from fossil fuels is expected over the next 10-20 years and will not develop in the near-term. Therefore, a phased development of renewable energy generation capacity will be required to avoid a large initial “overbuild”.

4. Energy Demand Uncertainty

   a. Utility forecasting is historically a simple projection based on trending demand per user and population. Forecasting in 2010 overestimated demand for 2020.

   b. Applying a nominal compounded percentage growth or contraction model results in significantly different future load profiles

   c. Is the population or per capita energy use currently constrained by infrastructure, energy availability and/or water availability issues?

### 8.1.2 Sensitivity Analysis

In Phase 1 and 2 of the Project, a high-level sensitivity analysis was completed across all alternatives for their relative sensitivity to key variables. A more detailed sensitivity analysis can be performed following the selection of alternatives to pursue in Phase 3.

## 8.2 Screening Matrix

A comprehensive decision matrix was developed to screen the alternatives systematically with respect to the priorities of the Project developers and stakeholders. Workshops were held throughout the study period to engage Project stakeholders and collaborators for input on the matrix criteria and scoring methods. The full screening matrix with values for each of the alternatives is included in Appendix C.

### 8.2.1 Criteria

The screening criteria and descriptions are listed below.

| | |
|---|---|
| Capacity | Total installed capacity. |
| Average Energy | Average annual energy from the project, which is consumed by load, excludes surplus energy. |
| Renewable Supply | Percentage of total energy demand met by renewables. |
| Capital Cost | Capital cost as a separate criterion from LCOE is intended to capture ability to finance / cost of capital. Projects may be too large to secure financing. |
| LCOE Aggregate | Levelized cost of energy in 2023 dollars, 50-year economic life, 10% discount rate, no residual value, 2% inflation on operating and sustaining capex (hydro generator replacement, turbine overhauls, wind project repowering) and project energy pricing, effective 2.3% inflation on total cost of fossil fuel energy inclusive of fuel price projections and future carbon taxation, net of subsidies and capital cost offsets. Evaluated on total scenario load with no value for surplus renewable generation. |
| LCOE Renewable | Same as above excluding diesel generation costs. |
| Emissions Reduction | Carbon emission in tons of $CO_2$ per year assuming heating fuel conversion to electric. Intended to capture significance beyond real cost accounted for in LCOE, which includes an estimate of escalation for carbon tax and fuel base pricing. Canada's target of net-zero emissions by 2050 or public / stakeholder perception of the same. |
| Cold Climate Risks | Technical risks focusing on cold weather nature of Projects. Ice management, cold weather adaptations. |
| Geotechnical | Technical risks related to geotechnical conditions. Rock quality for tunnelling, availability of material for dam construction. |
| Resource Availability | Technical risks associated with wind and water with respect to uncertainty and climate change. |
| Reliability | Technology associated risks with respect to outages, spare parts, maintenance, MTBF, repair time. |
| System Integration | Difficulty of system integration and control issues. |
| Access | Potential access issues risk. |
| Transmission Length | Longer transmission line increases risk of outages. |

| | |
|---|---|
| Schedule | Approximate development years to operation considering scope of the Project, equipment supply, regulatory approvals, contractor availability. |
| Constructability | Complexity, availability of specialized equipment, reliance on weather windows, level of interfacing required, experience. |
| Scalability | Ability to accommodate scaled deployment. |
| Health and Safety | Perceived or actual risk to Project personnel and the public during construction and operations. Electrical safety, reservoir fluctuations during ice covered period, wind turbine noise, visual health impacts. |
| Biophysical Environment | Interactions including vegetation/habitat as well as aquatic, terrestrial, and avian species. Include potential adverse effects on Species at Risk, contaminant uptake (ecological risk), population dynamics and habitat disturbance / disruption / destruction. Consider the potential for residual adverse effects to be significant. Exclude consideration of induced effects (harvesting, resource use, economy, tourism). |
| Local Infrastructure | Degree to which new local infrastructure is required to support the development including electrical system upgrades, substations, roads, fabrication facilities. |
| Economic Benefits | Direct and indirect contributions to the local economy during construction and throughout the project lifecycle including employment, service industry benefits, growth potential associated with any inherent surplus sustainable energy supply. |
| Stakeholder Support | Perceived or actual support (or opposition) from the public, utility, government, and regulators. Consider "social license" and how many intervenors are likely. |
| Rightsholder Support | Perceived or actual support (or opposition) from the land rights holders. |
| Size Perception | Perceived negative view associated with a large footprint / large appearance viewed from Iqaluit and commonly travelled routes. |
| Resource Use | Impacts to terrestrial, aquatic, or marine resource use. Impacts to fishing and harvesting patterns, hunting, foraging, use for recreation and tourism. |
| Protected Areas | Parks or wildlife, ecological, conservation reserves potentially affected by the Project. |

| | |
|---|---|
| Permits and Approvals | Perceived or actual level of effort, risks, issues with lack of framework or possible changes, number of required permits and approvals. Impact to land use planning process. |
| NIRB | Project is the same scope as current NIRB file 13UN006 either in part or completely. |
| Inuit Owned Lands | Percentage of the Project footprint on Inuit Owned Lands, including transmission line. |

### 8.2.2 Weighting

Weightings for the criteria were assigned by Growler and NNC, with several weighting scenarios considered to evaluate the selection sensitivity to key criteria. The six weighting scenarios (A through F) are shown in Table 17. The prospect alternatives were ranked based on the average of its relative scores across the six weighting scenarios.

**Table 17. Weighting Scenarios**

| Weighting Scenarios | | | | | | |
|---|---|---|---|---|---|---|
| | A | B | C | D | E | F |
| Balance of Criteria | 70% | 0% | 0% | 0% | 0% | 100% |
| **Electric Load Only** | | | | | | |
| LCOE Renewables | 0% | 100% | 0% | 0% | 0% | 0% |
| LCOE Aggregate | 15% | 0% | 100% | 0% | 0% | 0% |
| **Electric, Thermal, Industrial Loads** | | | | | | |
| LCOE Renewables | 0% | 0% | 0% | 100% | 0% | 0% |
| LCOE Aggregate | 15% | 0% | 0% | 0% | 100% | 0% |

The weighting scenario tables with the criteria, evaluation type, relative weighting and the score awarded to each alterative are included in Appendix C. Technical and economic criteria were evaluated and assigned a score by CPL. The environmental and stakeholder scores were determined with input from Growler, NNC, LVP, SEM and Firelight.

## 8.3 Results

To assess the alternatives against one another, relative scores were developed using the Combinative Distance-Based Assessment (CODAS) method. This produces a normalized score of 1.0 (100%) for the highest-ranking alternative and a score of 0.0 for the lowest. Table 18 and Table 19 contain the average relative score of each prospect alternative across the six weighting scenarios and their respective ranking.

**Table 18. Alternatives Screening Results (Sorted by ID)**

| Alternative | Project | Rank | Relative Score |
|---|---|---|---|
| 1 | Armshow River | 14 | 9% |
| 2 | Armshow South | 11 | 45% |
| 3 | Jaynes Inlet | 7 | 51% |

| Alternative | Project | Rank | Relative Score |
|---|---|---|---|
| 4 | Cantley Bay | 12 | 40% |
| 5 | McKeand North | 13 | 22% |
| 6 | McKeand South | 1 | 100% |
| 7 | Sylvia Grinnell Bend | 15 | 0% |
| 8 | Sylvia Grinnell Jag | 16 | 0% |
| 9 | Niaqunguk Wind | 2 | 74% |
| 10 | Qasitujuak Wind | 9 | 48% |
| 11 | Kynersley Wind | 10 | 47% |
| 12 | Armshow Wind | 6 | 51% |
| 13 | Jaynes Inlet Wind | 4 | 66% |
| 14 | Jaynes + Wind | 3 | 70% |
| 15 | Jaynes PSH + Wind | 5 | 62% |
| 16 | KI PSH + Wind | 8 | 50% |

**Table 19. Alternatives Screening Results (Sorted by Rank)**

| Alternative | Project | Rank | Relative Score |
|---|---|---|---|
| 6 | McKeand South | 1 | 100% |
| 9 | Niaqunguk Wind | 2 | 74% |
| 14 | Jaynes + Wind | 3 | 70% |
| 13 | Jaynes Inlet Wind | 4 | 66% |
| 15 | Jaynes PSH + Wind | 5 | 62% |
| 12 | Armshow Wind | 6 | 51% |
| 3 | Jaynes Inlet | 7 | 51% |
| 16 | KI PSH + Wind | 8 | 50% |
| 10 | Qasitujuak Wind | 9 | 48% |
| 11 | Kynersley Wind | 10 | 47% |
| 2 | Armshow South | 11 | 45% |
| 4 | Cantley Bay | 12 | 40% |
| 5 | McKeand North | 13 | 22% |
| 1 | Armshow River | 14 | 9% |
| 7 | Sylvia Grinnell Bend | 15 | 0% |
| 8 | Sylvia Grinnell Jag | 16 | 0% |

The top three prospect alternatives include hydroelectric (McKeand South), wind (Niaqunguk), and hydroelectric and wind combined (Jaynes Inlet Hydro & Wind). The top prospect alternatives vary in the advantages and range in capacity from 10 to 45 MW, depending on the development scenario. Under both development scenarios the top three prospect alternatives provide an LCOE that is substantially less than the current cost of diesel energy for the City of Iqaluit, with a cost reduction per MW between 20% to 60% depending on supply scenario and load profile.

Key technical characteristics for the top three prospect alternatives are summarized in Table 20.

**Table 20. Characteristics of Top Three Project Alternatives**

| | | McKeand South Hydro | Niaqunguk Wind | Jaynes Inlet Hydro & Wind |
|---|---|---|---|---|
| **Rank** | | **1** | **2** | **3** |
| CODAS Ranking Score | 100% - 0% | 100% | 74% | 70% |
| Electric Load | | | | |
| Capacity | MW | 10 | 10 | 15 |
| Renewable Supply | % | 100% | 53% | 100% |
| Renewable LCOE | $/MWh | $335 | $250 | $389 |
| Aggregate LCOE | $/MWh | $338 | $571 | $462 |
| Capital Cost | $ Millions | $200 | $60 | $210 |
| Electric, Thermal, & Industrial Load | | | | |
| Capacity | MW | 30 | 30 | 45 |
| Renewable Supply | % | 79% | 45% | 73% |
| Renewable LCOE | $/MWh | $163 | $170 | $226 |
| Aggregate LCOE | $/MWh | $378 | $607 | $462 |
| Capital Cost | $ Millions | $270 | $130 | $310 |
| Environment / Socio-Economic | | | | |
| Scalability | Max Score 1-5 | 3 | 5 | 2 |
| Biophysical Environment | Min Score 1-5 | 5 | 2 | 4 |
| Resource Use | Min Score 1-5 | 2 | 2 | 2 |

### 8.3.1 Industrial Off-taker Considerations

Following the ranking of prospect alternatives, the top three were evaluated for an additional load case - Supply of Iqaluit electrical demand and the theoretical industrial load. While this case is highly variable depending on the industrial operation characteristics, each of the top three prospect alternatives can be built to allow for expansion and sufficient capacity to supply the predicted loads.

The top prospect alternatives may be developed with provisions in the design and construction to adjust for the unknown industrial off-taker requirements and timing. It is expected that the industrial site will require a separate tie in and have a microgrid with diesel backup generation. Provisions, such as overbuilding the hydroelectric powerhouse for an additional turbine-generator, leaving space in the substation yard for an additional feeder and transmission line tie-in, and others will allow for this expansion.

To complete the detailed modelling, preliminary design, and cost estimating, key characteristics of the industrial off-taker needs to be defined. At the most basic level, the key characteristics include, location, access, load projections and fluctuations, and the expected operational lifetime. The approach for cost sharing of infrastructure can also be considered in the economics for the project. Due to these uncertainties, representation of the system costs and LCOE for this load case are not presented within this report.

# 9 CONCLUSIONS

Of the top three prospect alternatives, the McKeand South hydroelectric project is markedly the best as determined by the assessment process. It offers the lowest LCOE and can address the electrical demands initially and be expanded to include the thermal and industrial opportunity as they arise. Some overbuild will be prudent to enable quick uptake growth as the incremental investment may be nominal for certain capacities, but this will need further study in the next phase of development.

The next two top prospect alternatives are commendable in their own right and can be held as backup should issues arise with the top alternative as it progresses through approvals and design.

With the business-as-usual electricity supply price for diesel energy supply at an LCOE of $837/MWh, the McKeand South hydroelectric LCOE price $338/MWh is some 60% lower in cost.

Based on the overall energy scenario for electricity thermal and industrial loads, the business-as-usual LCOE was determined to be $869/MWh and the corresponding McKeand South hydroelectric LCOE is $378/MWh which constitutes a cost reduction of 56%.

Therefore, there is substantial incentive to pursue the replacement of the current diesel supply with a renewable energy solution on this basis alone. Additional benefits to be garnered include environmental, climate, employment, and other benefits. Based on this assessment, the McKeand South hydroelectric project is the best prospect alternative to pursue.

It should be noted that the actual LCOE and project cost may differ as this economic analysis was done for comparative purposes only, using a similar costing structure, whereas actual costs and hence pricing needs to consider actual conditions that may vary from the costing and economic assumptions made herein. Hence, the relative comparative results are valid but the absolute energy prices may vary.

# 10 NEXT STEPS

The next steps have been broken into three groups, namely: Planning and Engineering, Environmental and Regulatory and Development Activities with details as follows.

## 10.1 Planning and Engineering

1. Selection of the preferred alternative(s) to carry into Phase 3 of the work for further technical feasibility, preliminary engineering, environmental scoping and regulatory review.

2. Develop a project schedule with details of the Phase 3 activities.

3. Undertake project feasibility analysis and optimization with options. Identify any major unknowns, opportunities or challenges that need resolution, consideration or mitigation strategies, such as winter reservoir operations, seasonal constraints, or reservoir expansion etc.

4. Develop the required site investigation programs including:

   a. Install metrological and/or hydrometric metering stations at the selected site(s) for a minimum 2-year data collection and analysis program, ideally done at the start.

   b. Undertake or acquire a LiDAR Survey of the Project site(s) including reservoirs, borrow areas, access routes and transmission corridor. Ideally done mid-summer to fall without snow cover (may need to be done immediately to not wait a year).

   c. Undertake a more detailed geotechnical investigation of areas at proposed Project infrastructure locations and options such as: access road and transmission corridors, dams, foundations, buildings, and material supply locations.

5. Undertake detailed electricity load studies to determine the initial plant capacity and future growth timing including:

   a. Further define the immediate "offset-able load" including more detailed daily/hourly energy demand profile information from the Iqaluit Utility.

   b. Complete an investigation into potential PPAs with potential industrial off-takers with an estimated load profile and schedule.

   c. Investigate potential for thermal energy demand transitioning to electricity demand in concert with building energy efficiency programs to better estimate future electricity load growth magnitude and timing.

6. Complete the preliminary engineering design based on the site investigations, selected capacity, and optimization options. Provide an in-depth Project description report with drawings suitable for environmental and regulatory submittals.

## 10.2 Environmental and Regulatory

1. Provide input to the alternative(s) selection process.

2. Undertake the preliminary environmental and regulatory screening scope based on the selected alternative feasibility layouts and options to identify potential major issues that may affect the design or approvals. Environmental survey including archeological surveys prioritized to identify potential showstoppers or major issues upfront. Acquire the field study and site investigation permits. Typically, the field study effort includes: 1st year of broader field study followed by drafting of the Environmental Assessment, then a 2nd year of focused field study for EA verification, as required.

3. Complete the Environmental Assessment (EA) and regulatory documentation and submit for review and approvals using the preliminary design documentation.

4. Liaison with the regulatory and permitting agencies to garner the necessary permits and approvals for the Project for compliance with environmental, social and technical standards.

### 10.3 Development Activities

1. Scope the Phase 3 work including selection of the alternative(s) to advance with input on the engineering and environmental aspects.
2. Collaboration and Stakeholder Engagement: Establish a robust communication channel with local communities, government agencies and other stakeholders to address their concerns, gather insights, and align the Project goals with regional regulations and priorities.
3. Regulatory and Permitting Agency Engagement: Discuss the necessary permits and approvals that will be required to attain compliance with environmental, social and technical standards. May require providing assistance to the agencies for missing or inadequate approvals processes as part of a capacity building effort.
4. Financing and Funding Opportunities: Investigate specific financing and funding options, including federal and provincial grants, incentive, tax credits. Develop a comprehensive financial strategy for the Project(s).
5. Risk Assessment and Mitigation Plan: including a thorough risk assessment covering technical, financial, environmental, and social aspects to address potential Project challenges.
6. Operation, Maintenance and Monitoring Plan: Develop an overall on-going, operation and maintenance and monitoring plan for the plant including regular performance assessment, maintenance activities, and potential upgrades to ensure optimal long-term operation and efficiency.

## 11 REFERENCES

Center for Sustainable Systems, University of Michigan (2022).

G.A McBean Consulting & Nunavut Research Institude. (2009). *Iqaluit Hydro Project - Climate Change Impacts Assessment Report.* U of Manitoba, and U of W.Ont.

Hatch. (2018). *Iqaluit Wind Project - Wind Resource Assessment Report.*

Knight Pieseold Ltd. (2006). *Iqaluit Hydro-Electric Generation Sites: Identification of Ranking.*

Knight Piesold Ltd. (2006). *Iqaluit Hydro-Electric Generation Sites: Phase 2 Pre-Feasibility Report.*

Knight Piesold Ltd. (2006). *Quilliq Energy Corp - Iqaluit Combined Wind and Hydroelectric Energy Study.*

Knight Piesold Ltd. (2006). *Qulliq Energy Corp - Iqaluit Hydro-electric Generation Sites - Costs Estimate and Finacial Details - Phase 2 Pre-Feasibility Study.*

Knight Piesold Ltd. (2007). *Quilliq Energy Corp - Iqaluit Hydroelectric Generation Sites - Run-of-River Project Analysis.*

Knight Piesold Ltd. (2008). *Qulliq Energy Corporation - Iqaluit Hydroelectric Project: 2007 Environmental Baseline Studies Summary of the Envionmental Baseline Report.*

Knight Piesold Ltd. (2011). *Iqaluit Hydo Project - Updated Cost Estimates and Fincial Analysis.*

Knight Piesold Ltd. (2011). *Iqaluit Hydro Project - Financial Analysis for the Iqaluit Hydroelectric Projects.*

Knight Piesold Ltd. (2013). *Qulliq Energy Corp - Iqaluit Hydroelectric Project Proposal.*

North/South Consultants Inc. (2007). *Qulliq Energy Corp - Fisheries Assessments for Five Potential Hydroelectric Generating Sites on Southern Baffin Island.*

Statistics Canada. (2023, February 3). *Census Profile. 2021 Census of Population. Statistics Canada Catalogue no. 98-316-X2021001.* Retrieved from StatCan: https://www12.statcan.gc.ca/census-recensement/2021/dp-pd/prof/index.cfm?Lang=E

Tugliq Energy Co. (2017). *Scoping Study - Wind Energy - Iqaluit, Nunavut.*

# Appendix A
# Geotechnical Site Assessment

## General

Digital maps were obtained from the FTP Maps Canada website (NRCan Website). The files were downloaded as 2m polar-stereo geo-tiff files. The files were used to obtain topography, slope angles, slope directions, cross section profiles, and were used for large scale terrain assessment.

## McKeand River North

### 1. Arctic DEM Observations

The proposed location is shown over the DEM in Figure A1. The dip direction is shown by colour in Figure A2 for any angle greater than 10° to highlight the lineations. It is noted that the slopes on both sides of the river are bedrock controlled with limited vegetation. Slight L1 lineations were observed off site approximately 1.5 km from the east side of McKeand River, although there is a possibility of the lineation affecting the site, further investigation is considered low priority. The McKeand River may be following a L1 lineation. A potential L2 lineation may cause the McKeand River divergence and veer southwest approximately 500 m south of the proposed location.

A closeup of the proposed location with dam and flow direction is shown in Figure A3. The cross-section profile of the proposed dam location is shown in Figure A4. The maximum dam height was estimated at 82 m (El. 374 m) with a corresponding crest length of about 1,010 m. The abutment slope was measured to be approximately 16° slope on the right abutment, and an 11° slope on the left abutment. The river flow was from southeast to northwest.

### 2. Site Observations

The proposed dam site appears to have a relatively thin layer of frost shattered rock covering bedrock. Local excavation of shattered bedrock / angular colluvium / alluvium may produce material to form a portion of the dam shell with the spillway excavation producing more of the larger rock fill.

Upstream borrow sites may be used to create a neutral cut-fill balance. The right bank of the tributary appears to contain a large volume of alluvial sands and gravels.

The angles of the abutments (effective angle less than 16°) suggest it will be unlikely to have an abutment stability issue. However, localized instabilities may require localized treatment in the form of rock bolts or other treatment.

The riverbed appears to be bedrock controlled but this needs verification.

### 3. Site Interpretation

Although some potential L2 lineations were observed in DEM, the lack of their persistence throughout the area suggests the features may be related to natural topography. One or more appear to fall within the footprint of the proposed dam. A site exploration program to determine nature of the lineations and potential impact to proposed structure will be required.

## Sylvia Grinnell Jag

### 1. Arctic DEM Observations

The proposed location is shown over the DEM in Figure A5. The dip direction is shown by colour in Figure A6 for slopes with angles steeper than 10° to highlight surface lineations. One L1 larger lineation was observed approximately 1 km west of the proposed Sylvia Grinnell Dam site, although there is a possibility of the lineation affecting the site, further investigation of this feature is considered low priority. The McKeand River may be exploiting another L1 lineation.

A closeup of the proposed location with dam and flow direction is shown in Figure A7. The cross-section profile at the proposed dam location is shown in Figure A8. The dam height is about 50 m (150 m elevation) above current grade wait a crest length of approximately 790 m. The slopes on both abutment sides of the river are bedrock controlled with limited vegetation. The distance across the base of the channel at the proposed location is about 590 m. The effective abutment slope angles on either side of the river are about 8° suggesting low risk of abutment instabilities.

### 2. Site Observations

The site is relatively flat and most of the site is alluvial sands in the form of extensive sand bars. Sand is considered to be in plentiful supply as at least two river terrace deposits were observed. The depth of the alluvium is not known. The deposition of the sand is by fluvial processes so the water table should be considered close to the surface.

### 3. Site Interpretation

The topography around Sylvia Grinnell is quite gentle with no observed large-scale challenges. Potential alluvial bank instability was observed in the DEM so field reconnaissance is needed but this issue should be relatively low effort to manage proactively. A site investigation to determine nature of the instabilities and potential impact to proposed structure is required.

## Kynersley Iqalliarvik Pumped Storage Hydroelectric (PSH)

### 1. Arctic DEM Observations

The proposed location is shown over the DEM in Figure A9. The dip direction by colour is shown in Figure A10 for angles above 10° to highlight surface lineations. The topography is mostly bedrock at, or very near surface with limited vegetation. The proposed PSH tunnel is approximately 4.4 km long, trending from west-southwest to east-northeast. The tunnel is likely to intersect a pronounced L1 lineation at the east-northeast extent. A closeup of the proposed dam location with tunnel location and flow direction is presented in Figure A11.

The cross-section profile along the proposed tunnel alignment is shown in Figure A12. The tunnel is estimated to slope about 3° over about 3.7 km. A lineation likely to be intersected at around 2 km to 2.25 km from the upper lake was observed dipping at an angle of 26° towards 173°. Depending on the optimal tunnel alignment the apparent dip of this lineation may be different.

A cross-section profile along an alternate proposed tunnel alignment to avoid surface lineations is shown in Figures A12 and A13. This alternate tunnel was measured to slope about 4° over 2.7 km, with a downstream portal daylighting onto a potential alluvial fan.

### 2. Site Interpretation

The upper reservoir is adjacent to a lineation, which could potentially be an area of fractured bedrock. A site investigation to determine nature of the lineations and potential impact to proposed structure is recommended. An alternative tunnel alignment was proposed to the southwest that may be more favourable for the tunnel. However, the site for the powerhouse / pumpstation may be on alluvial material of unknown depth at the downstream portal. One alternative option would be to cross the lineation at an angle closer to normal to reduce the potential exposure of fractured rock (if present).

## Armshow River

The proposed dam site is located at a section of the river valley that is narrower than the immediate upstream and downstream segments. Downstream of the dam site are sections of rapids where the elevation drop is more significant than at the dam site itself.

At the proposed dam location, there is exposed rock at both the left and right abutments. There are notable lateral (potential) shear zones within with the right abutment. The right abutment is substantially steeper, while the left abutment material tends to have a more gradual slope. The right abutment has a rock face with some potentially unstable larger features (large boulder sized rocks) that need to be addressed at the start of construction. There may need to be some remedial work required if boreholes are needed close to the toe of this slope.

On the valley floor the surface materials include occasional shallow soils, underlain by rounded cobbles and large boulders forming alluvial sediments. There are notable terraces of fluvial gravel and sand deposits on either side of the river. The Armshow River itself is well contained at the location of the proposed dam but the depth of the alluvial sediments is not known.

### 1. Arctic DEM Observations

The proposed location is shown over the DEM in Figure A14. The dip direction by colour is shown in Figure A15 for slopes with angles greater than 10° to highlight the lineations. The slopes on both sides of the river are bedrock controlled with limited vegetation. The Headworks for Armshow River are to the west of the Powerhouse location, potentially along an L2 lineation. The proposed dam is approximately 5 km long. A closeup of the proposed dam location is shown in Figure A16 with flow direction.

L1 lineations were observed on both the north and south side of the river, with some observed outcropping at the river. A pronounced lineation that can be followed at least 10 km north outcrops on the north side of the river approximately 2.5 km from the proposed dam site. The Powerhouse is located just west of a pronounced lineation which appears to correlate to a mapped fault.

The dip and dip direction were obtained by looking at lineations with a slope angle over 30° and taking an average dip and dip direction. The lineations on the north slope of the proposed dam had a mean dip angle of 38° and dip direction of 194°. The lineations on the south slope of the proposed dam had a mean dip angle of 38° and dip direction of 44°.

The cross-section profile at the proposed dam location is shown in Figure A17. The maximum dam height is about 57.5 m (El. 166 m) with a crest length of about 620 m. The right abutment slope has an angle of about 15° and left abutment slope was measured at about 18°.

### 2. Site Interpretation

Some lineations were observed on both sides of the river alignment almost parallel to the proposed dam alignment, which could indicate potential fractured bedrock beneath the river. A site investigation to determine the nature of the lineations and potential impact to the structure foundation is required.

## Armshow Lake

### 1. Arctic DEM Observations

The proposed location is shown over the DEM in Figure A18. The dip direction by colour is shown in Figure A19 for angles above 10° to highlight the lineations. The slopes on both sides of the river are bedrock controlled with limited vegetation. The Headworks for Armshow River are to the west of the Powerhouse, potentially along an L2 lineation. The distance from the proposed Headworks to the proposed Powerhouse is approximately 5 km. A large-scale view of the proposed dam location with flow direction is shown in Figure A20, as well an alternate tunnel route is indicated.

A small waterfall was observed to the north of the proposed intake and was constantly flowing during the visit. The helicopter landing site was on an alluvial fan. This lake could be explored further to see if a surface channel can be excavated to divert more water into Armshow South Lake.

L1 lineations were observed through the bedrock surrounding the lake, with a pronounced lineation on the south extent of the lake. L2 lineations were observed to the west-southwest with the northernmost lineation intersecting the lake from the west.

The cross-section profile at the proposed dam location is shown in Figure A21. The maximum dam height is about 25 m (El. 250 m). The dam length is approximately 470 m. The abutment slope on the south-west side was about 10° and on the north-east side was measured at 13°.

It appears the remains of a morainal deposit was washed away which suggests that this lake was naturally dammed at least once since the glacial retreat.

### 2. Site Interpretation

The river downstream of Armshow Lake may potentially follow a lineation which indicates that potential fractured bedrock may exist beneath the river. A site investigation to determine the nature of the lineations and possible impact to the proposed structure foundation is required.

## Jaynes Inlet

### 1. Arctic DEM Observations

The proposed location is shown over the DEM in Figure A22. The dip direction by colour is shown in Figure A23 for slopes with angles above 10° to highlight the lineations. The slopes on either side of the inlet are bedrock controlled with limited vegetation. The length of the proposed inlet is about 5.8 km long and the alternate tunnel route is about 2.5 km long. L1 lineations were observed crossing the proposed inlet across the entire alignment.

Jaynes Inlet runs between two mapped faults. A thrust fault was mapped about 6 km to the west from the Inlet and a normal fault about 4.5 km to the east of the Powerhouse. A closeup of the proposed dam location with flow direction is shown in Figure A24 shows, as well as the alternate tunnel route.

The cross-section profile along the proposed tunnel alignment is shown in Figure A25. The tunnel slope is about 7° over the ~2.5 km length.

The cross-section profile along the alternate proposed tunnel alignment is shown is Figures A26. This alignment was selected to avoid surface lineations. The alternate tunnel slope is also about 7° over an estimate length of 2.0 km. The tunnel outlet portal is in potential alluvium at the downstream end.

### 2. Site Interpretation

The river downstream of Armshow Lake may potentially follow a lineation, which could indicate potential fractured bedrock beneath the river. A site investigation to determine the nature of the lineations and potential impact to the structure foundation is required.

## Cantley Bay

### 1. Arctic DEM Observations

The proposed location is shown over the DEM in Figure A27. The dip direction by colour is shown in Figure A28 for slopes with angles above 10° to highlight the lineations. The slopes on both sides of the river are bedrock controlled with limited vegetation. The crest length of the proposed dam is approximately 2 km. A potential pronounced L1a lineation was observed approximately 250 m upstream of the proposed location. Less pronounced lineations were observed on either side of the pronounced lineation. Cantley Bay dam site may be aligned across a L2 lineation. Less pronounced L2 lineations that were observed on the DEM are approximately 5 km away with likely no further investigation needed for those remote lineations. A large-scale view of the proposed dam location with flow direction is shown in Figure A29.

The cross-section profile at the proposed dam location is shown in Figure A30. The maximum dam height is about 54 m (El. 210 m) with a crest length of about 1.38 km. The abutment slope on the west side was measured at about 16° and on the northeast side was measured at about 19°.

There appears to be about 3 km of lateral offset between the north side of the river and the south side. This is inferred from a north-south marker band as shown in Figures A31 and A32. As the elevation difference along the lineation descends from about El. 350 m to sea level (El. 0 m) the lineation appears to be vertical. If this lineation is vertical, then the fractured rock / fault gouge may be extensive, thus grouting requirements for the foundation may be fairly deep.

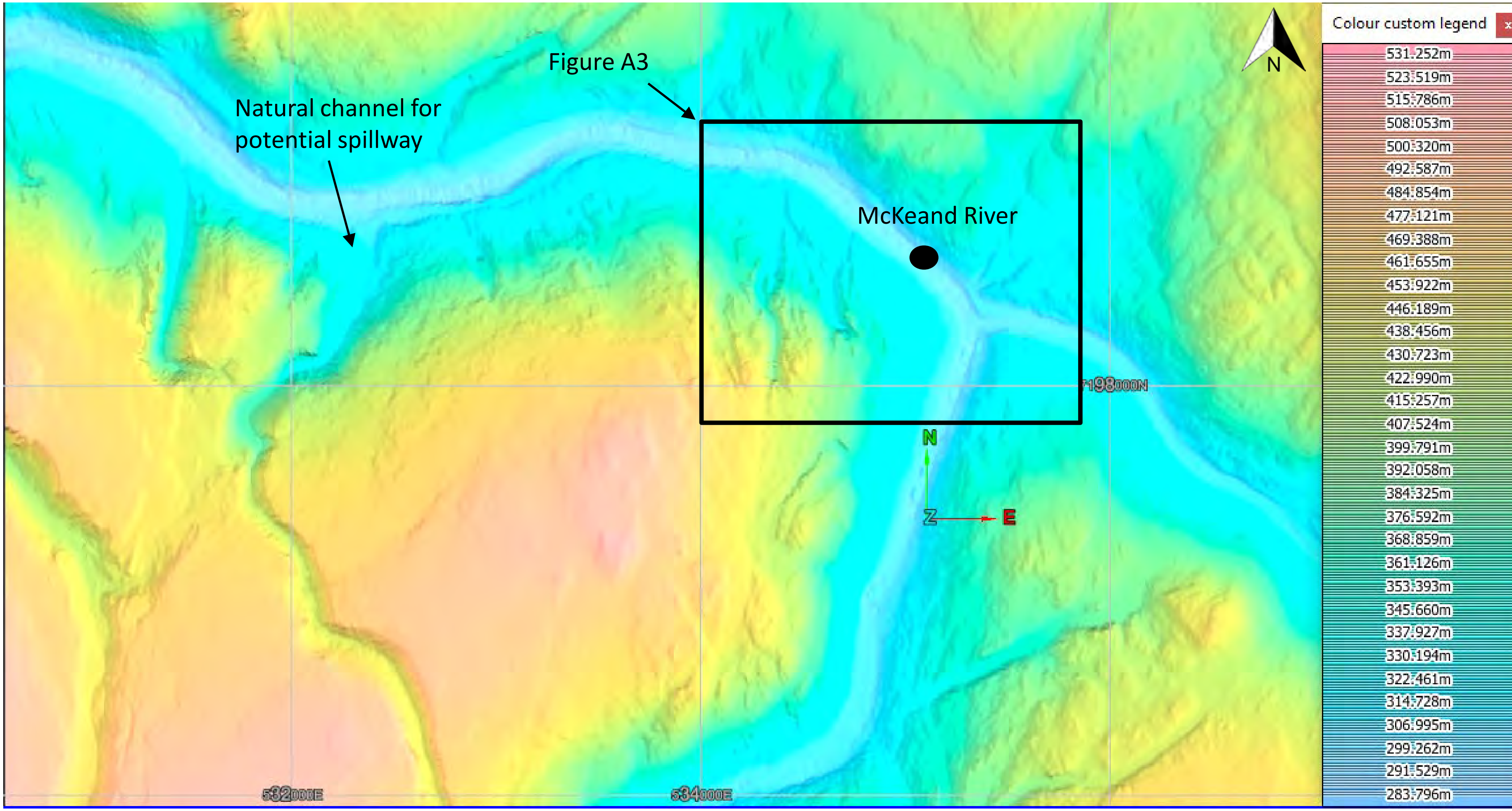
Figure A3
Natural channel for potential spillway
McKeand River
N
N
Z
E
7198000N
532000E
534000E
Colour custom legend
531.252m
523.519m
515.786m
508.053m
500.320m
492.587m
484.854m
477.121m
469.388m
461.655m
453.922m
446.189m
438.456m
430.723m
422.990m
415.257m
407.524m
399.791m
392.058m
384.325m
376.592m
368.859m
361.126m
353.393m
345.660m
337.927m
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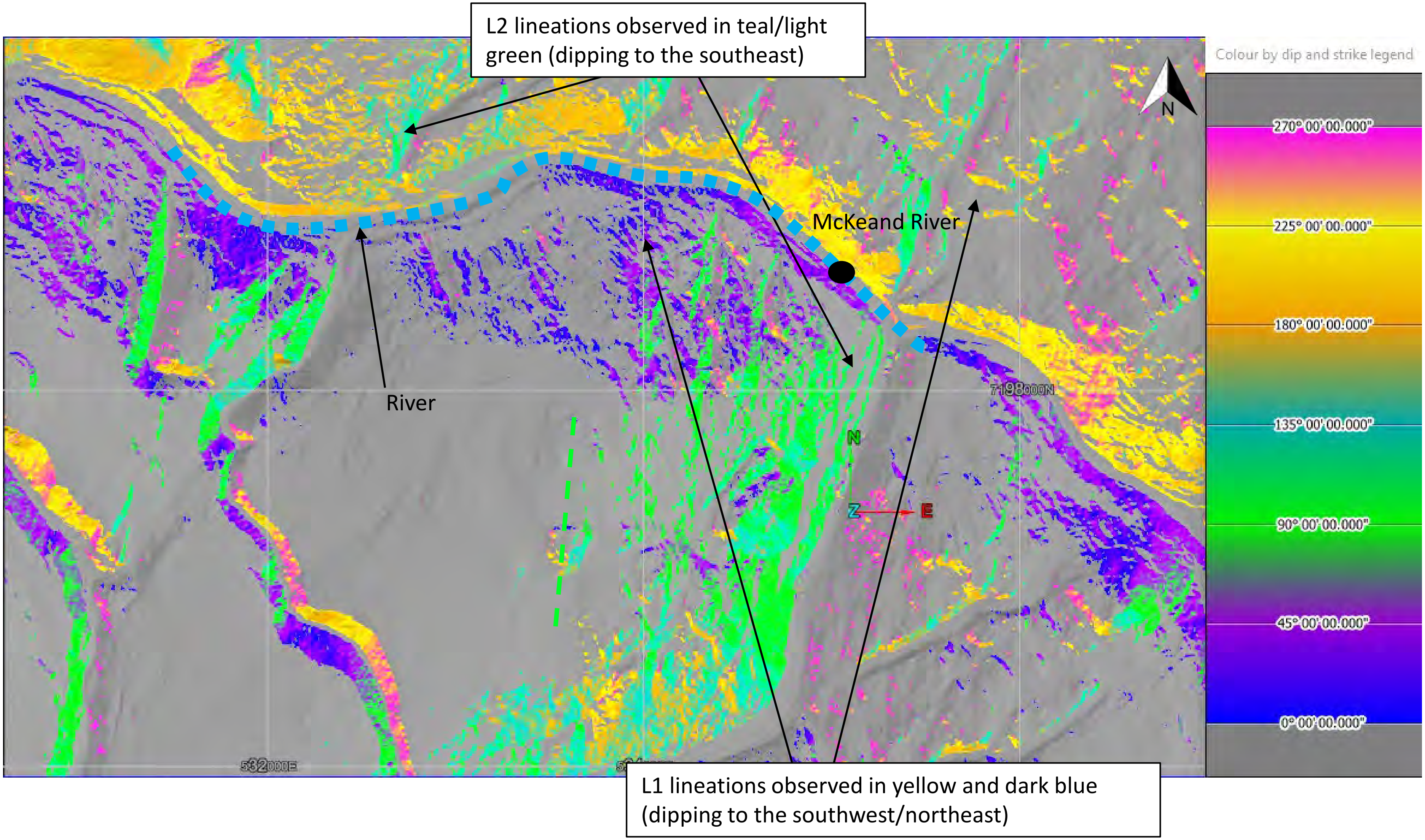
322.461m
314.728m
306.995m
299.262m
291.529m
283.796m

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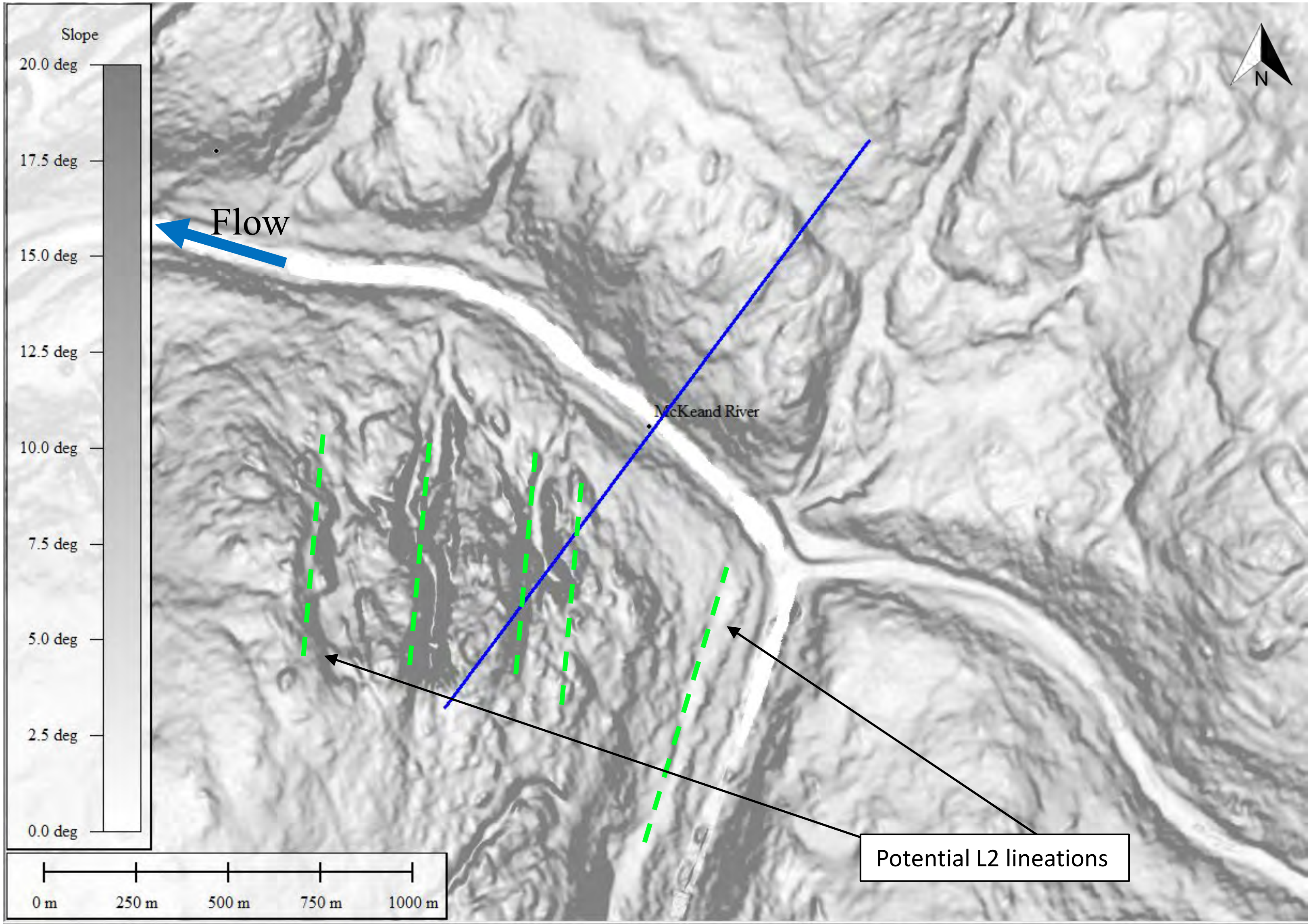
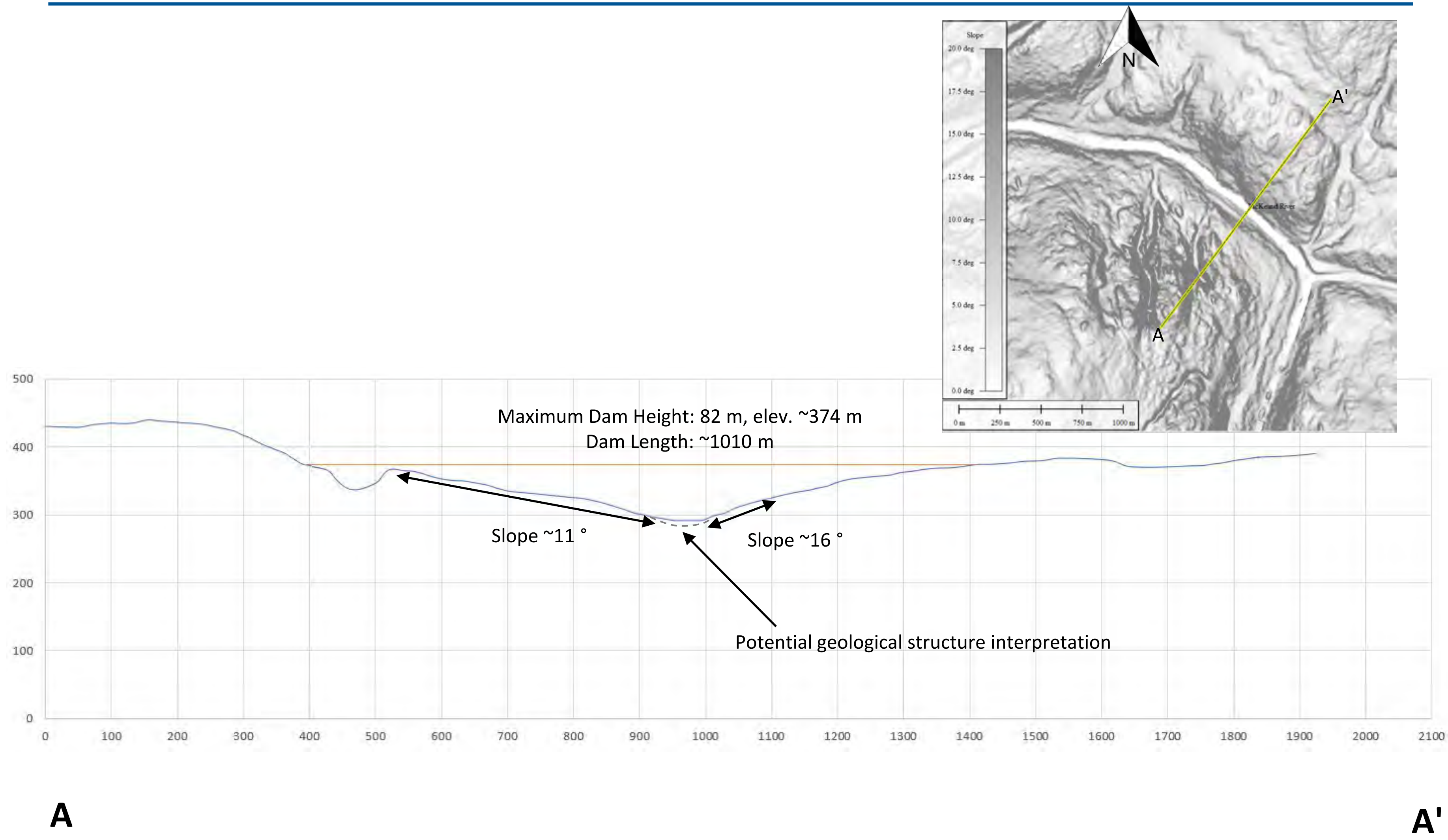

Slope
20.0 deg
17.5 deg
15.0 deg
12.5 deg
10.0 deg
7.5 deg
5.0 deg
2.5 deg
0.0 deg
Flow
McKeand River
N
Potential L2 lineations
0 m
250 m
500 m
750 m
1000 m

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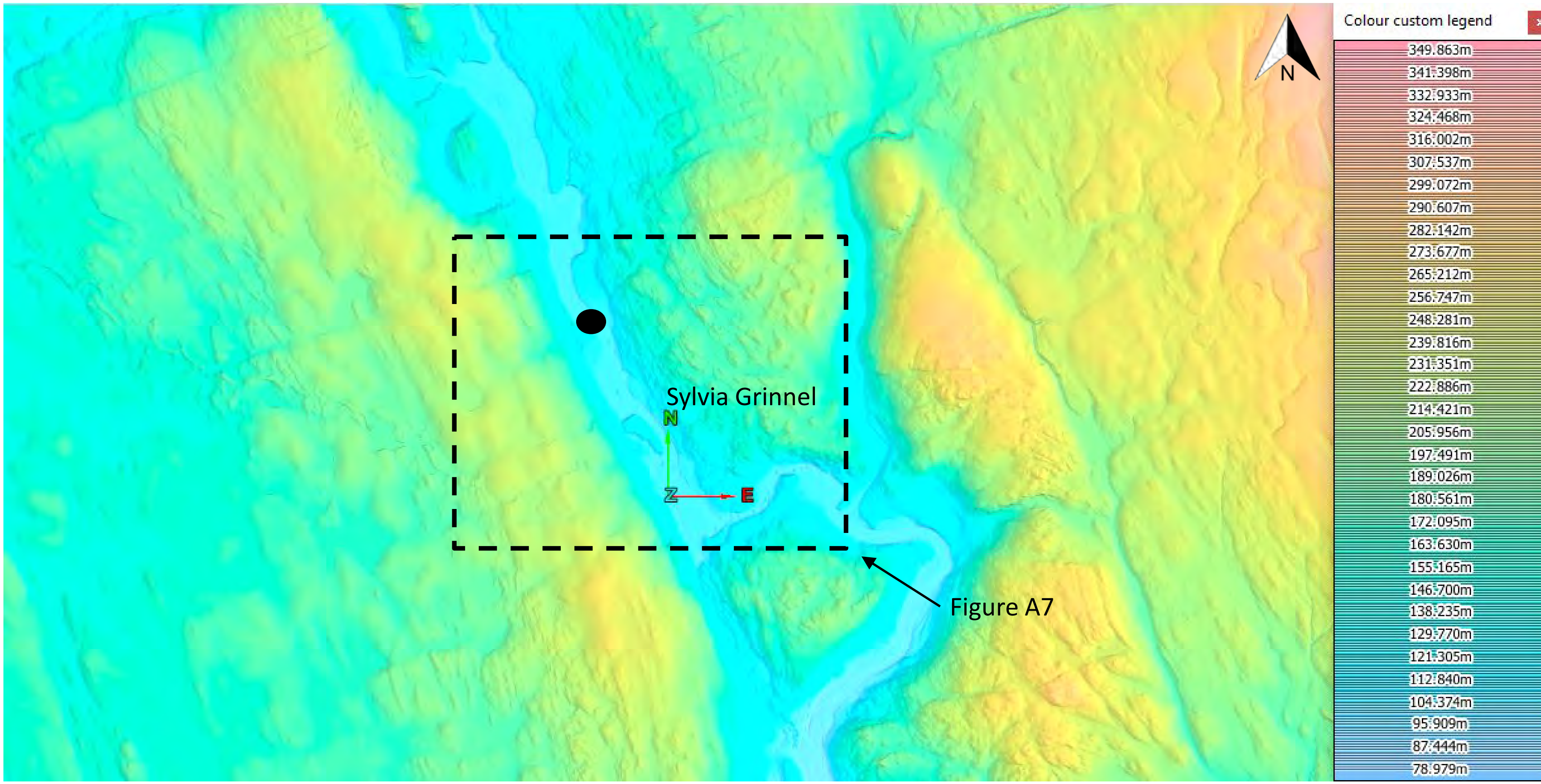
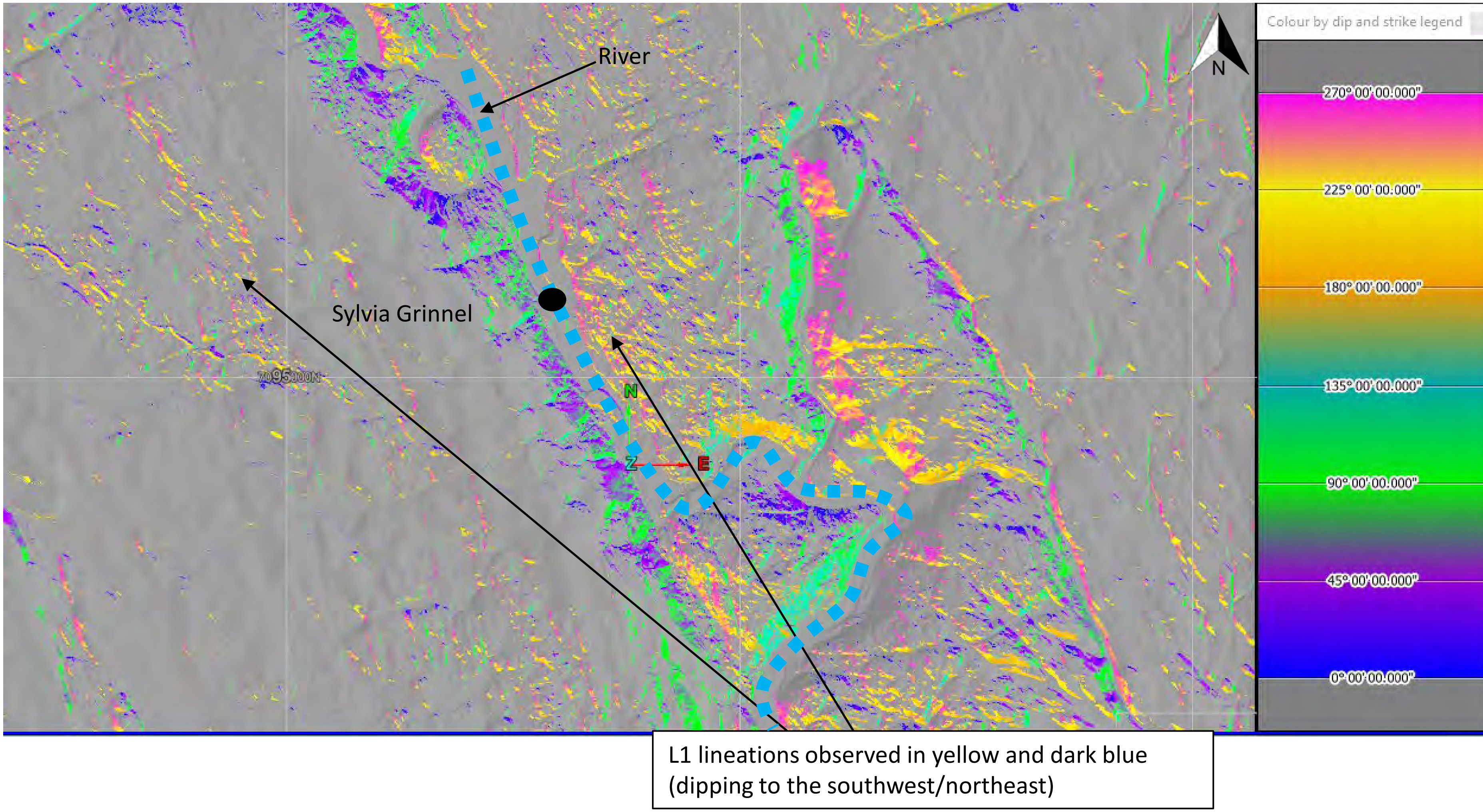
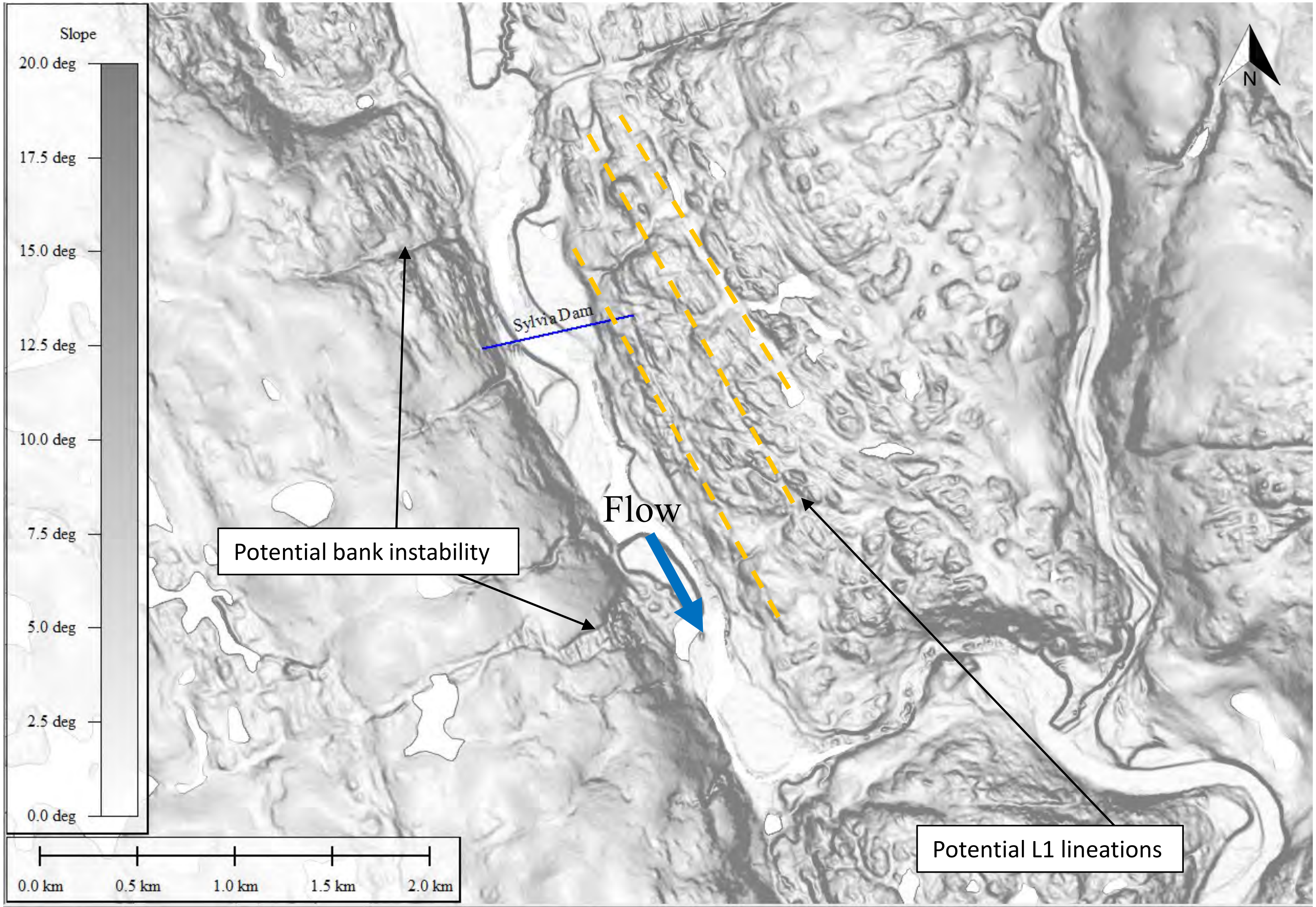
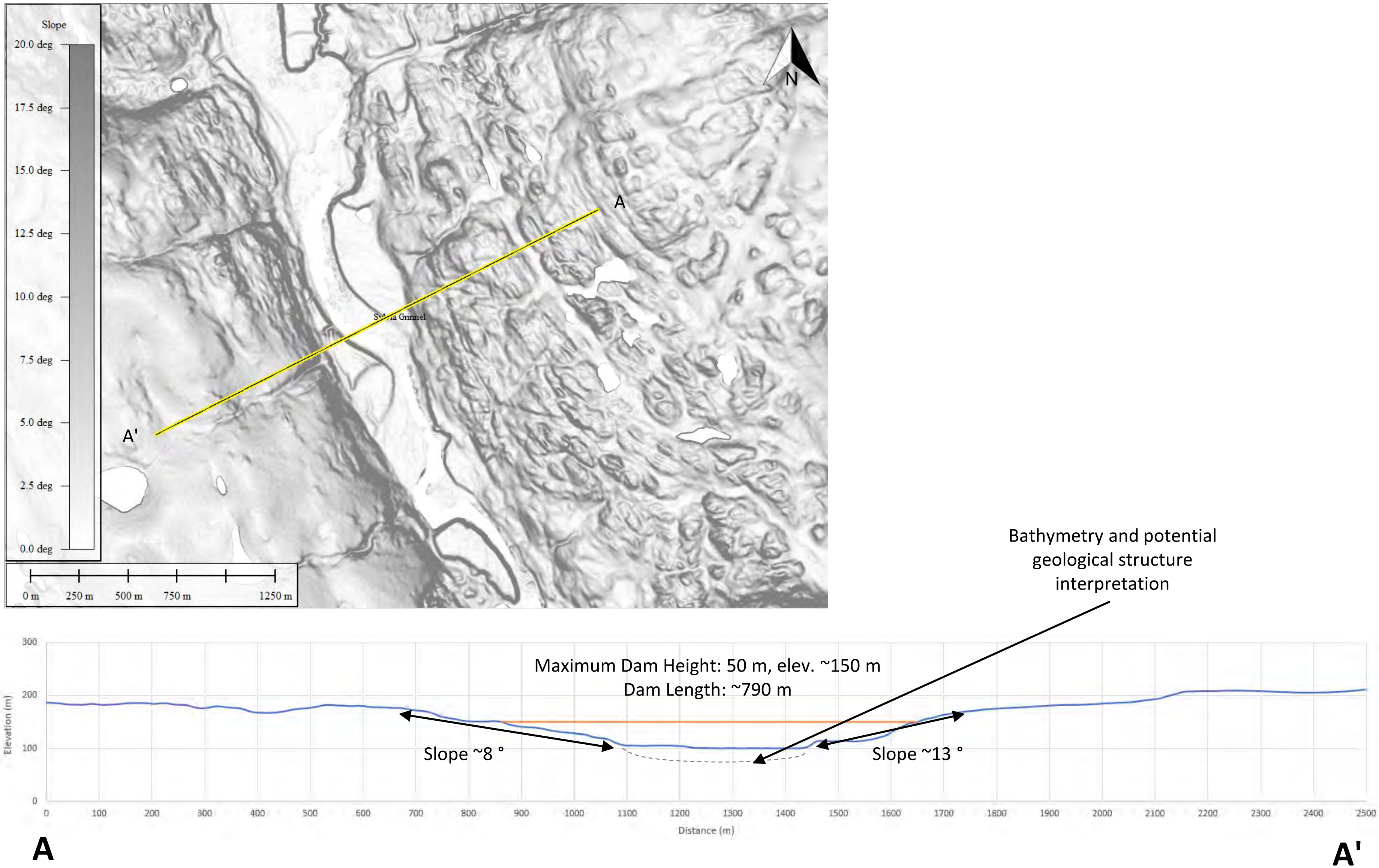

Colour custom legend
349.863m
341.398m
332.933m
324.468m
316.002m
307.537m
299.072m
290.607m
282.142m
273.677m
265.212m
256.747m
248.281m
239.816m
231.351m
222.886m
214.421m
205.956m
197.491m
189.026m
180.561m
172.095m
163.630m
155.165m
146.700m
138.235m
129.770m
121.305m
112.840m
104.374m
95.909m
87.444m
78.979m
N
Sylvia Grinnel
N
Z
E
Figure A7


River
Sylvia Grinnel
N
Colour by dip and strike legend
270° 00' 00.000"
225° 00' 00.000"
180° 00' 00.000"
135° 00' 00.000"
90° 00' 00.000"
45° 00' 00.000"
0° 00' 00.000"
L1 lineations observed in yellow and dark blue
(dipping to the southwest/northeast)


Slope
20.0 deg
17.5 deg
15.0 deg
12.5 deg
10.0 deg
7.5 deg
5.0 deg
2.5 deg
0.0 deg
0.0 km
0.5 km
1.0 km
1.5 km
2.0 km
Sylvia Dam
Flow
Potential bank instability
Potential L1 lineations
N

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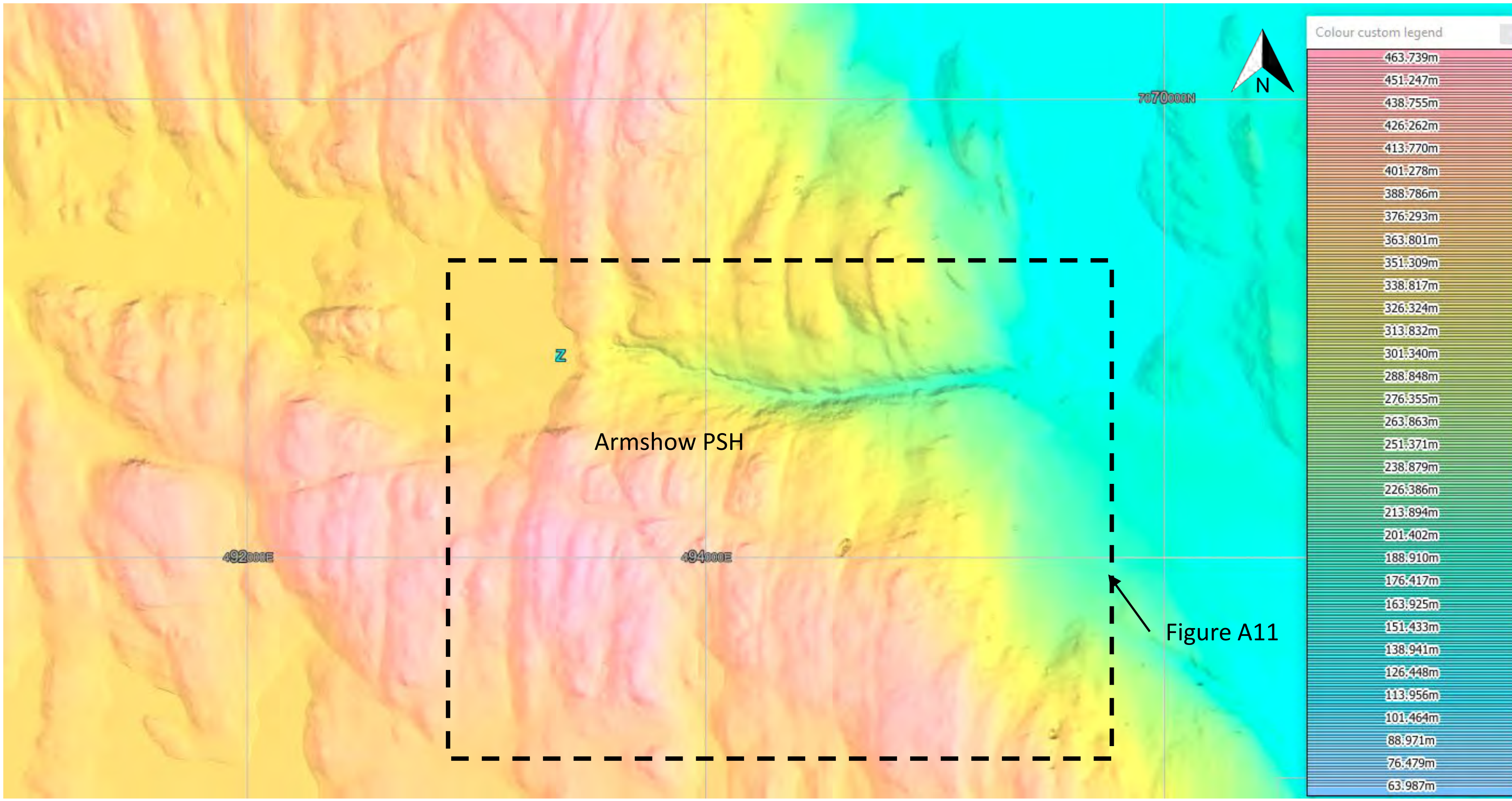


**Date:** August 2023 **Drawn by:** JLL **Checked by:** AEF **Approved by:** AEF

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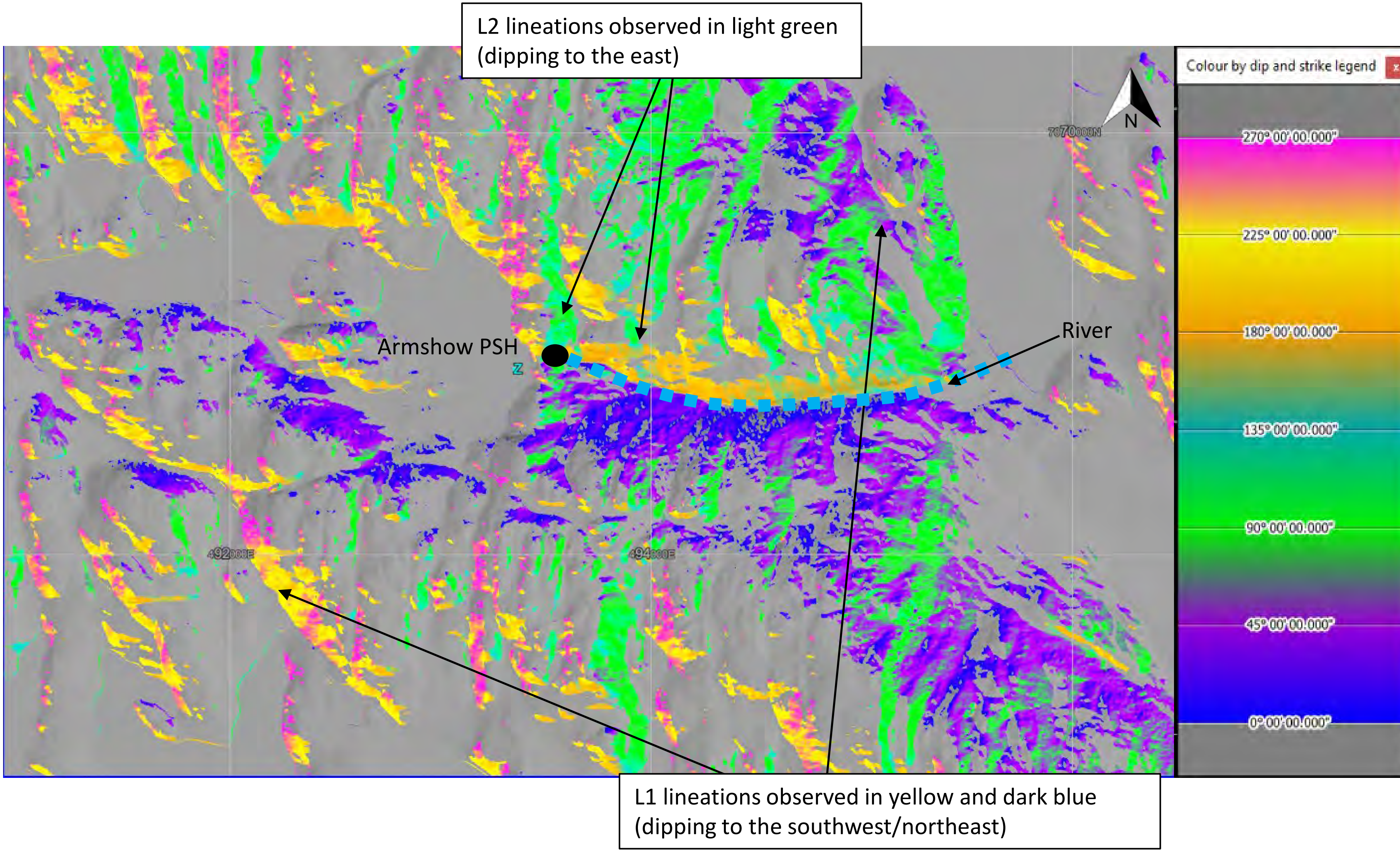
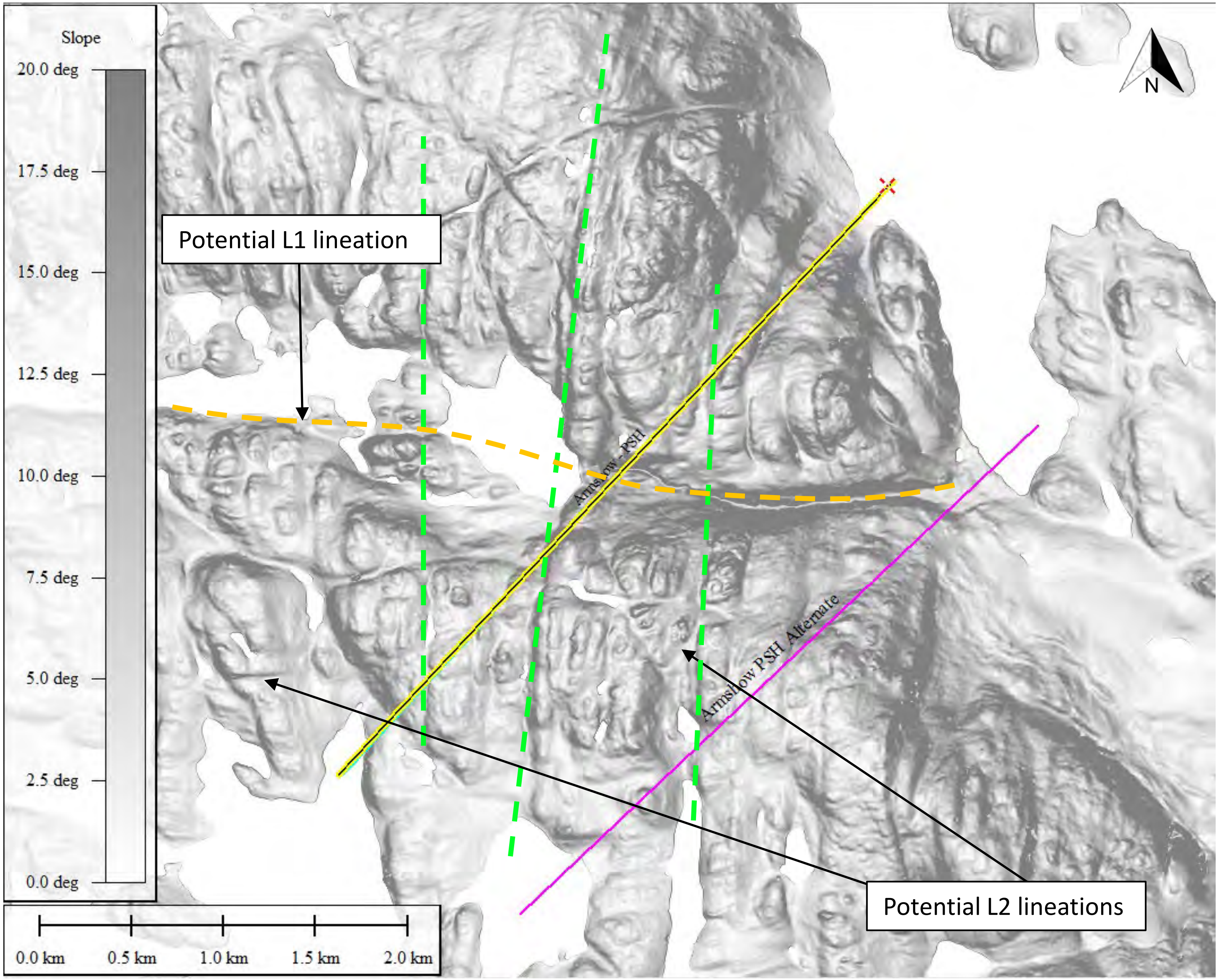
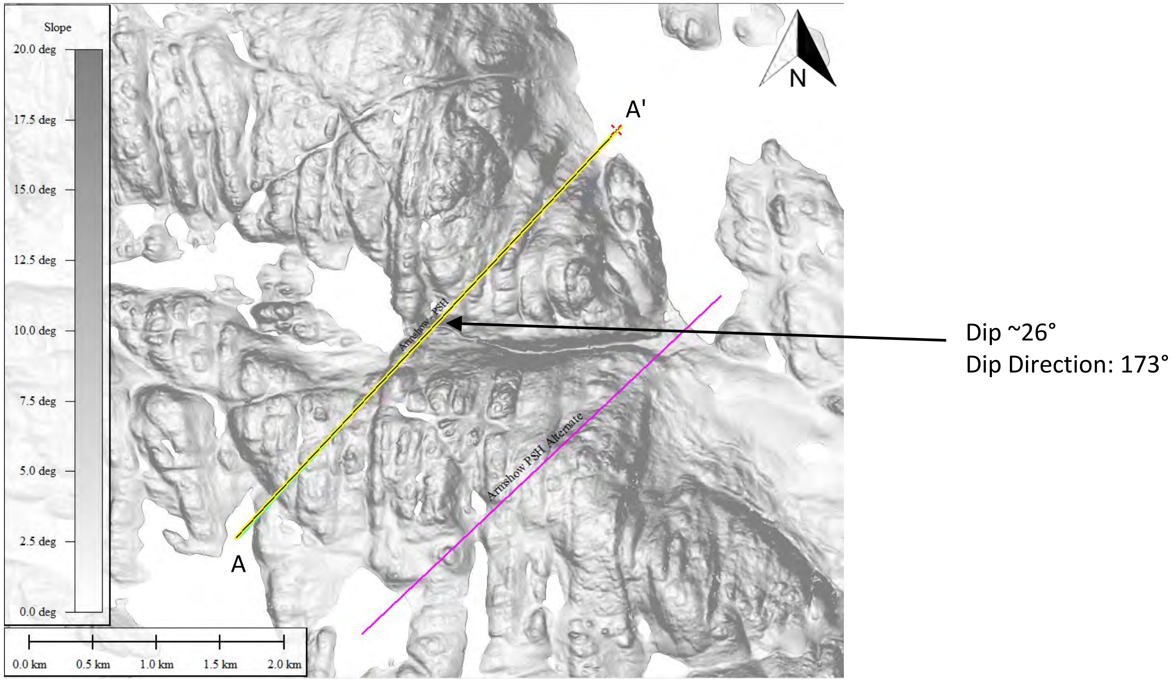
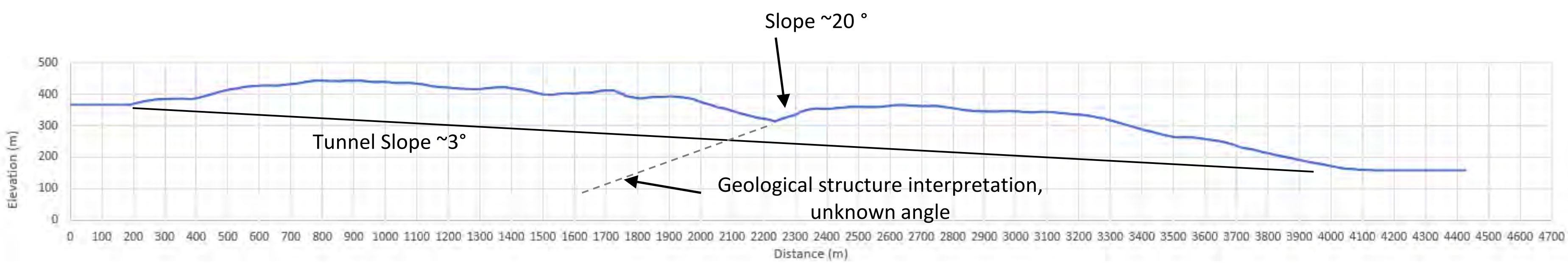
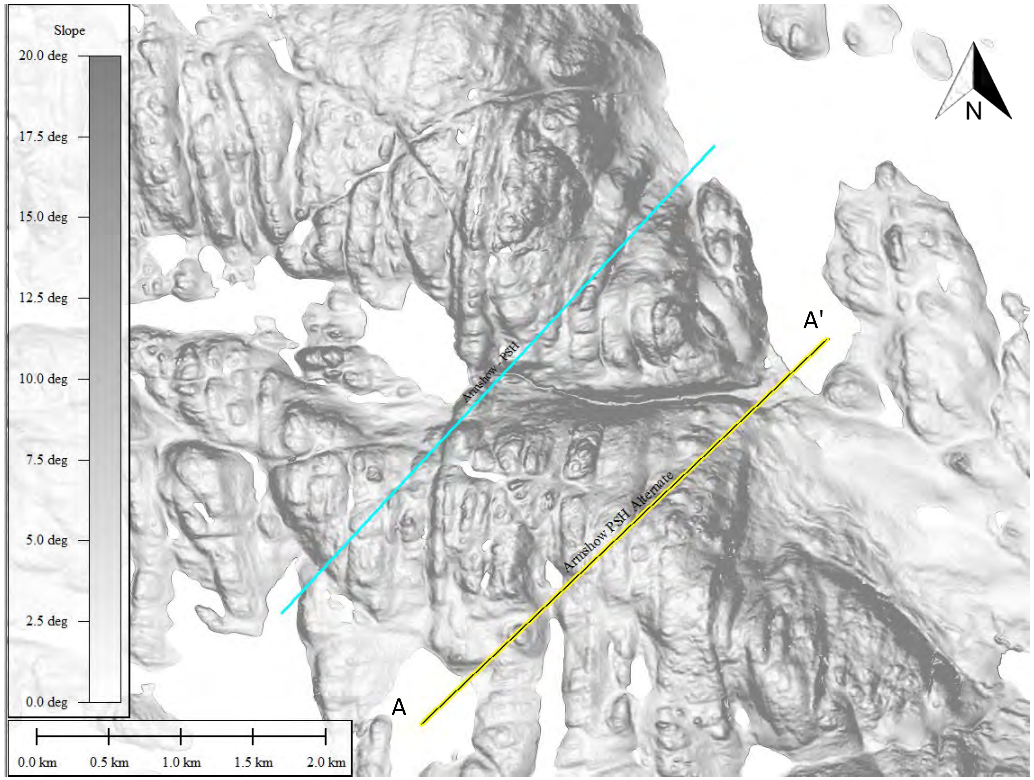

L2 lineations observed in light green (dipping to the east)
Armshow PSH
River
N
Colour by dip and strike legend
270° 00' 00.000"
225° 00' 00.000"
180° 00' 00.000"
135° 00' 00.000"
90° 00' 00.000"
45° 00' 00.000"
0° 00' 00.000"
L1 lineations observed in yellow and dark blue (dipping to the southwest/northeast)

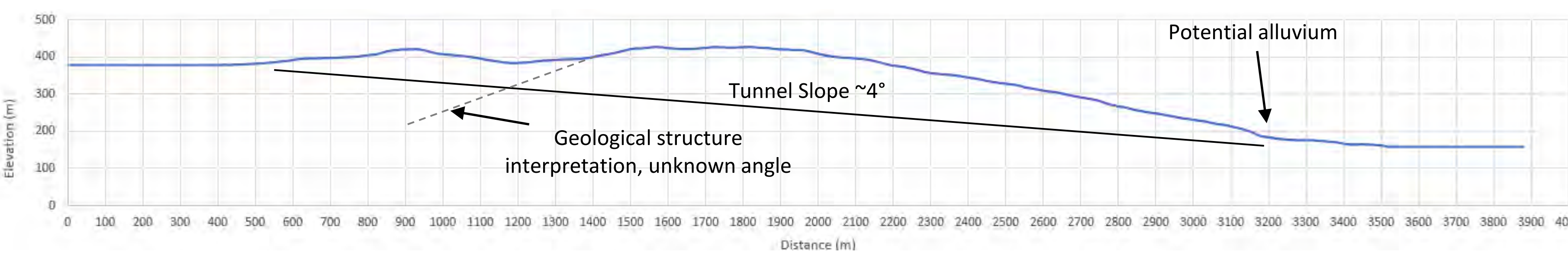

Slope
20.0 deg
17.5 deg
15.0 deg
12.5 deg
10.0 deg
7.5 deg
5.0 deg
2.5 deg
0.0 deg
0.0 km
0.5 km
1.0 km
1.5 km
2.0 km
N
Potential L1 lineation
Armslow - PSH
Armslow PSH Alternate
Potential L2 lineations

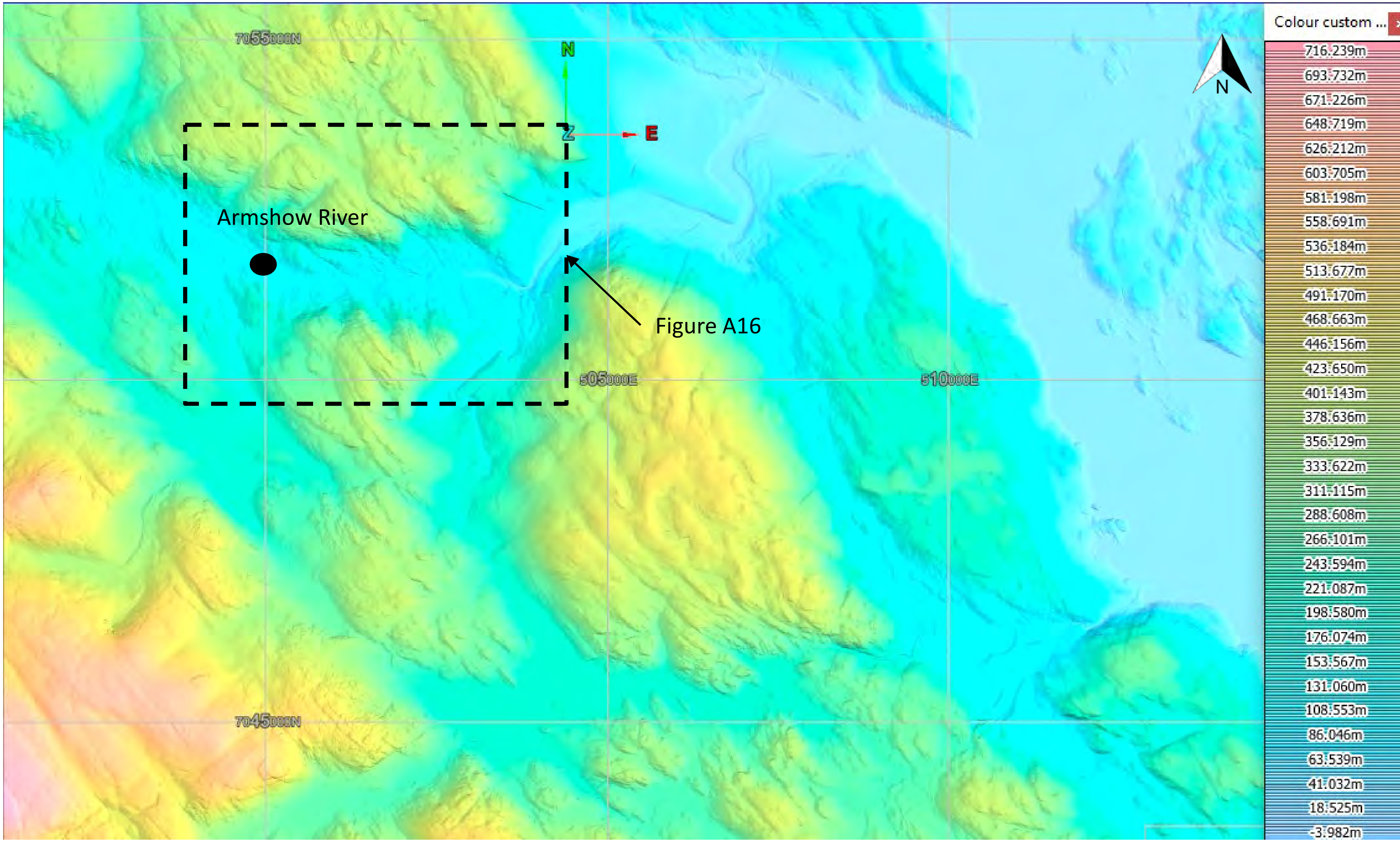

Slope
20.0 deg
17.5 deg
15.0 deg
12.5 deg
10.0 deg
7.5 deg
5.0 deg
2.5 deg
0.0 deg
0.0 km
0.5 km
1.0 km
1.5 km
2.0 km
N
A'
A
Armshow PSH
Armshow PSH Alternate
Dip ~26°
Dip Direction: 173°

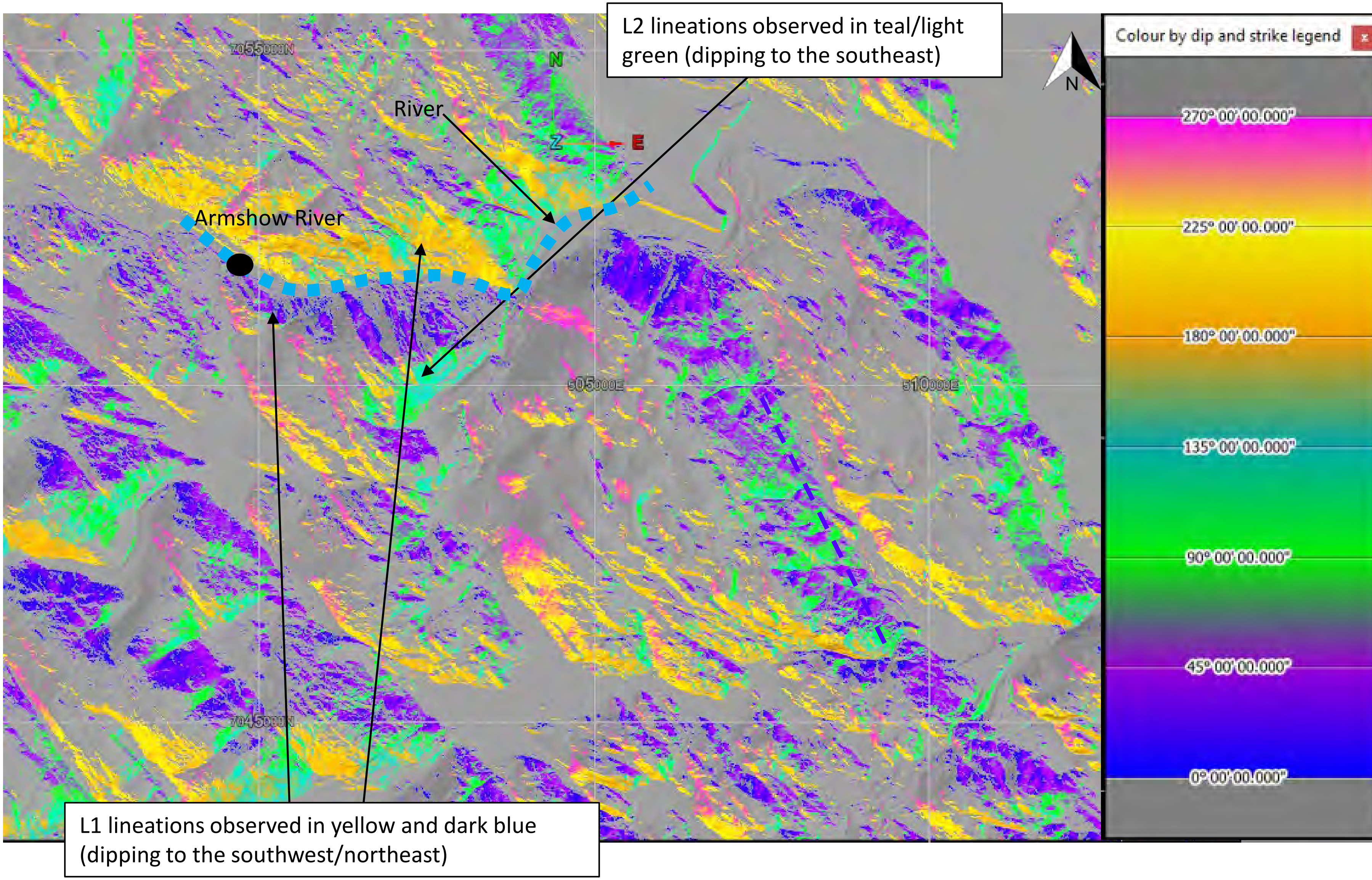

Slope ~20 °
Tunnel Slope ~3°
Geological structure interpretation,
unknown angle
Elevation (m)
Distance (m)
0
100
200
300
400
500
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000 2100 2200 2300 2400 2500 2600 2700 2800 2900 3000 3100 3200 3300 3400 3500 3600 3700 3800 3900 4000 4100 4200 4300 4400 4500 4600 4700

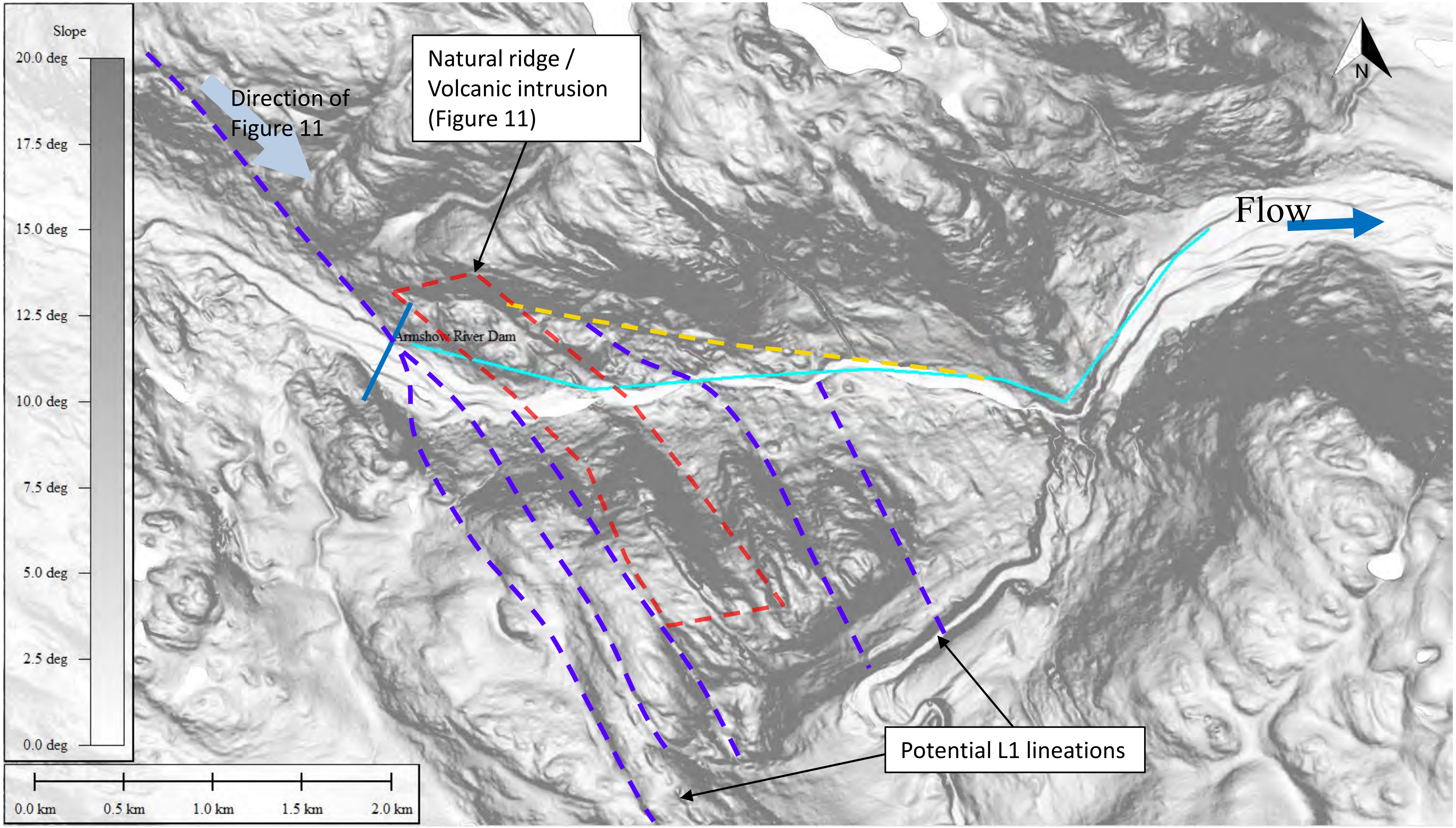


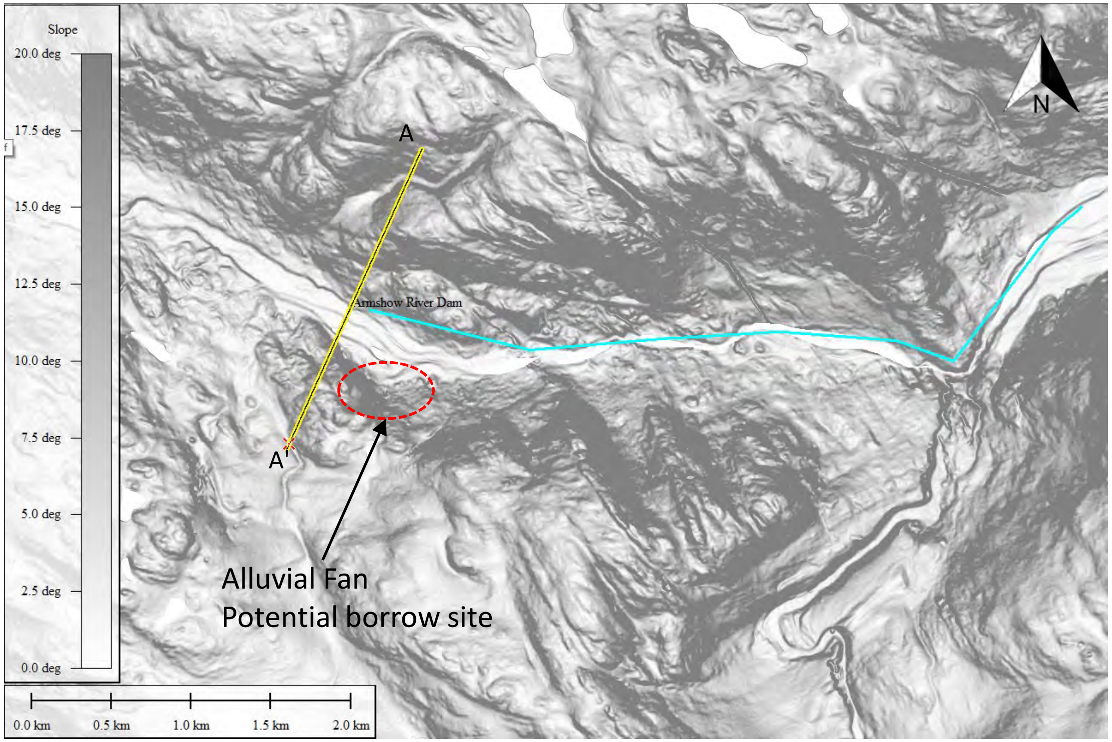

Alternative alignment to avoid the lineament



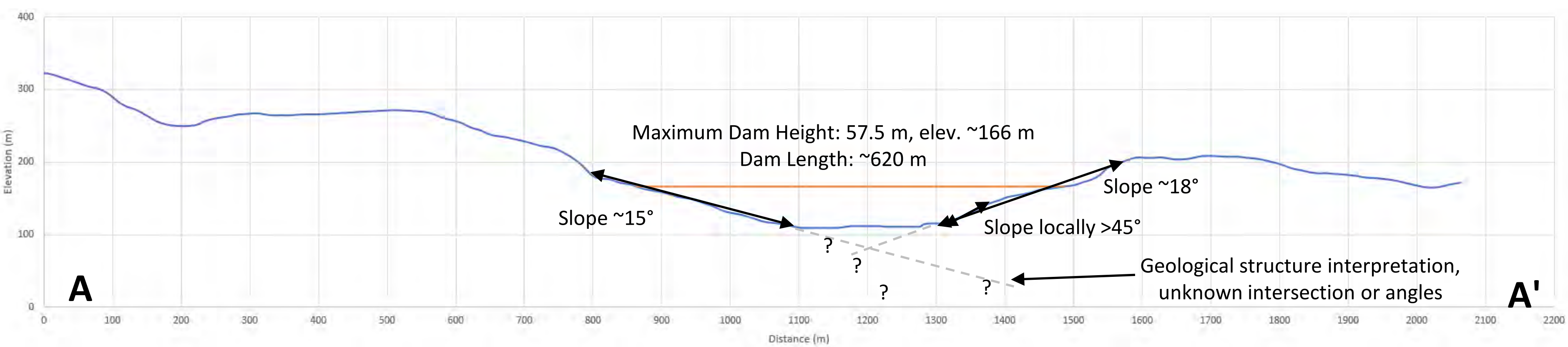

Colour custom ...
716.239m
693.732m
671.226m
648.719m
626.212m
603.705m
581.198m
558.691m
536.184m
513.677m
491.170m
468.663m
446.156m
423.650m
401.143m
378.636m
356.129m
333.622m
311.115m
288.608m
266.101m
243.594m
221.087m
198.580m
176.074m
153.567m
131.060m
108.553m
86.046m
63.539m
41.032m
18.525m
-3.982m
7055000N
7045000N
505000E
510000E
N
E
Z
N
Armshow River
Figure A16

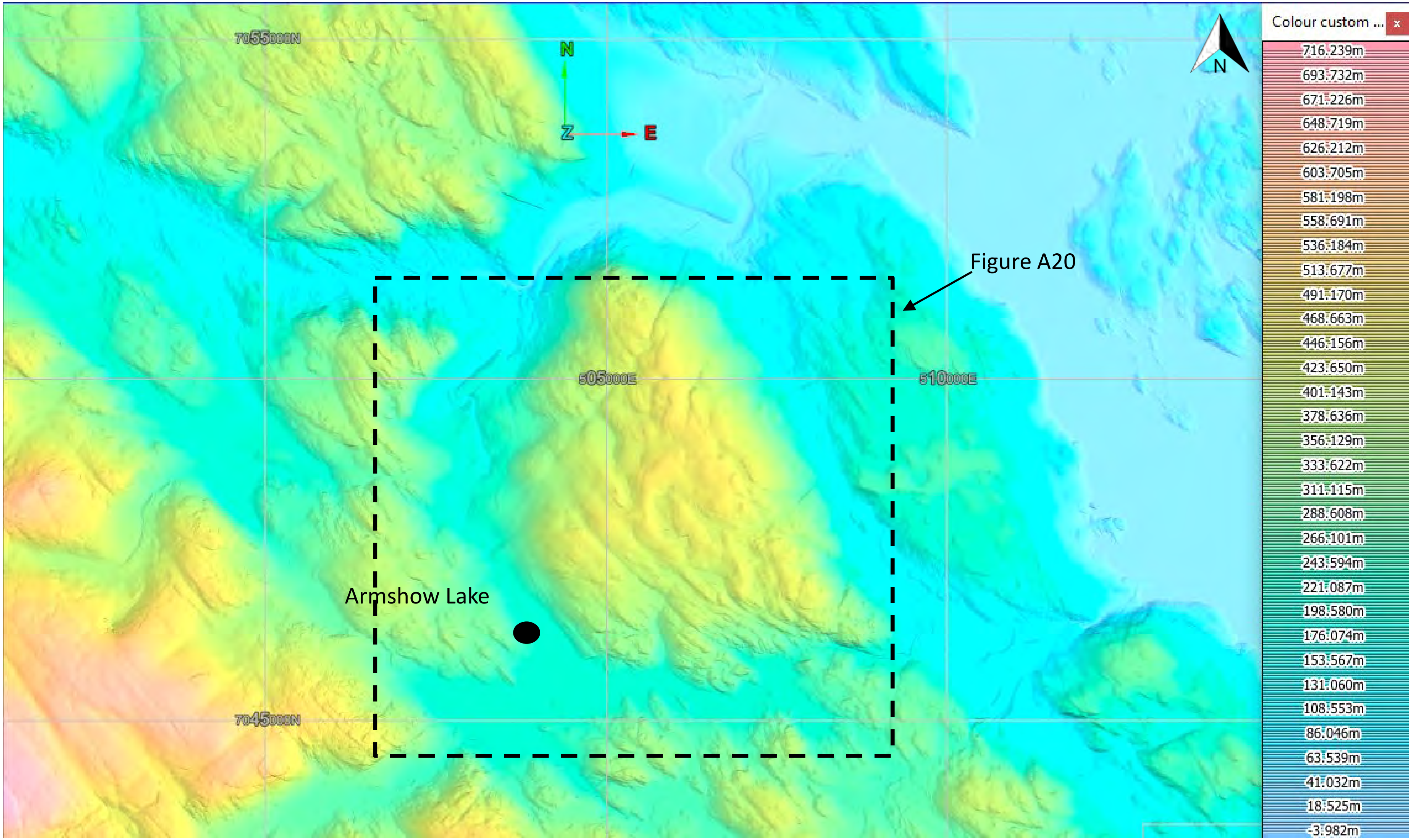

L2 lineations observed in teal/light green (dipping to the southeast)
River
Armshow River
N
Z
E
7055000N
7045000N
505000E
510000E
Colour by dip and strike legend
270° 00' 00.000"
225° 00' 00.000"
180° 00' 00.000"
135° 00' 00.000"
90° 00' 00.000"
45° 00' 00.000"
0° 00' 00.000"
L1 lineations observed in yellow and dark blue (dipping to the southwest/northeast)

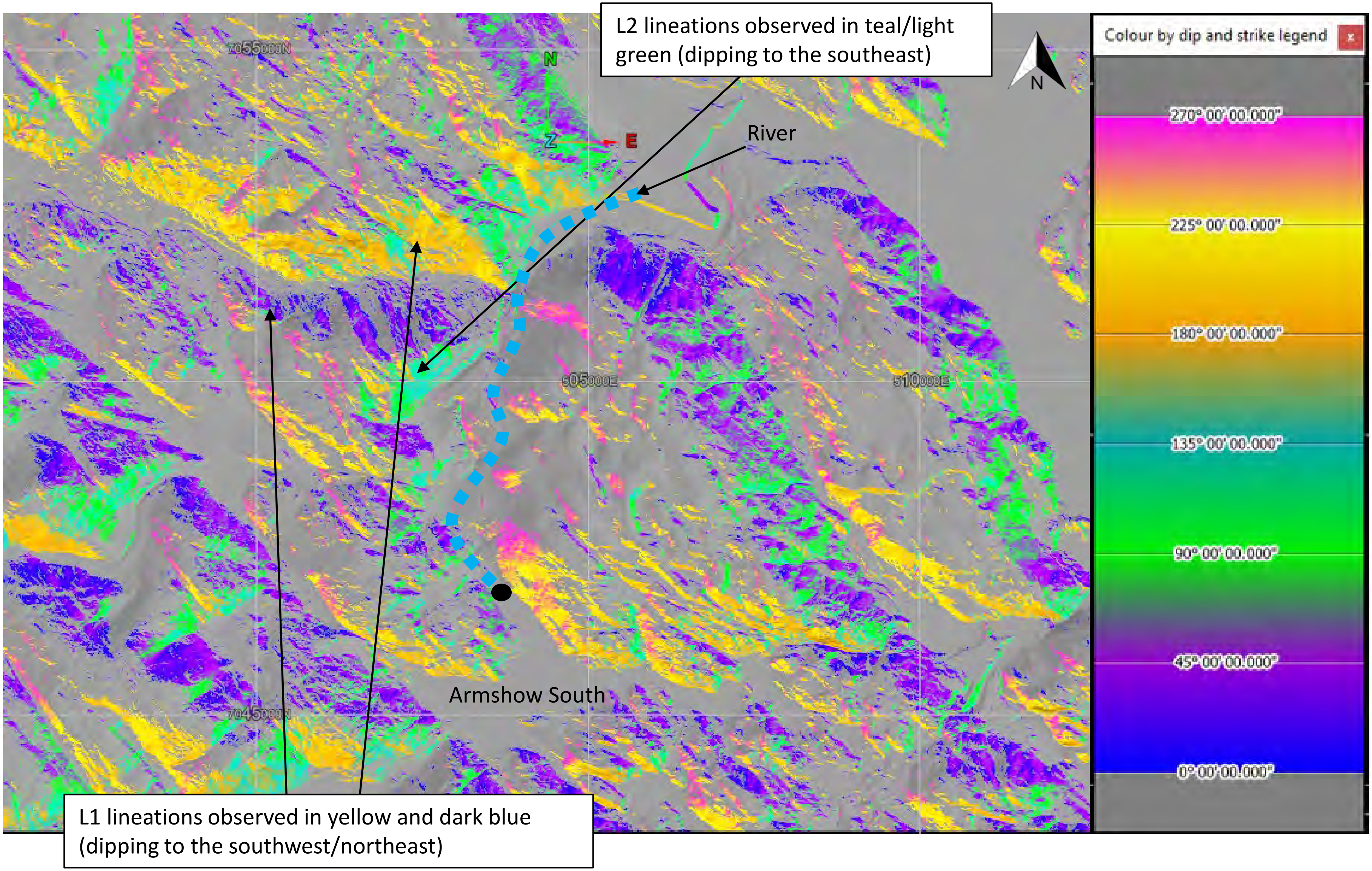

Slope
20.0 deg
17.5 deg
15.0 deg
12.5 deg
10.0 deg
7.5 deg
5.0 deg
2.5 deg
0.0 deg
0.0 km
0.5 km
1.0 km
1.5 km
2.0 km
Direction of Figure 11
Natural ridge / Volcanic intrusion (Figure 11)
Armshow River Dam
Flow
N
Potential L1 lineations

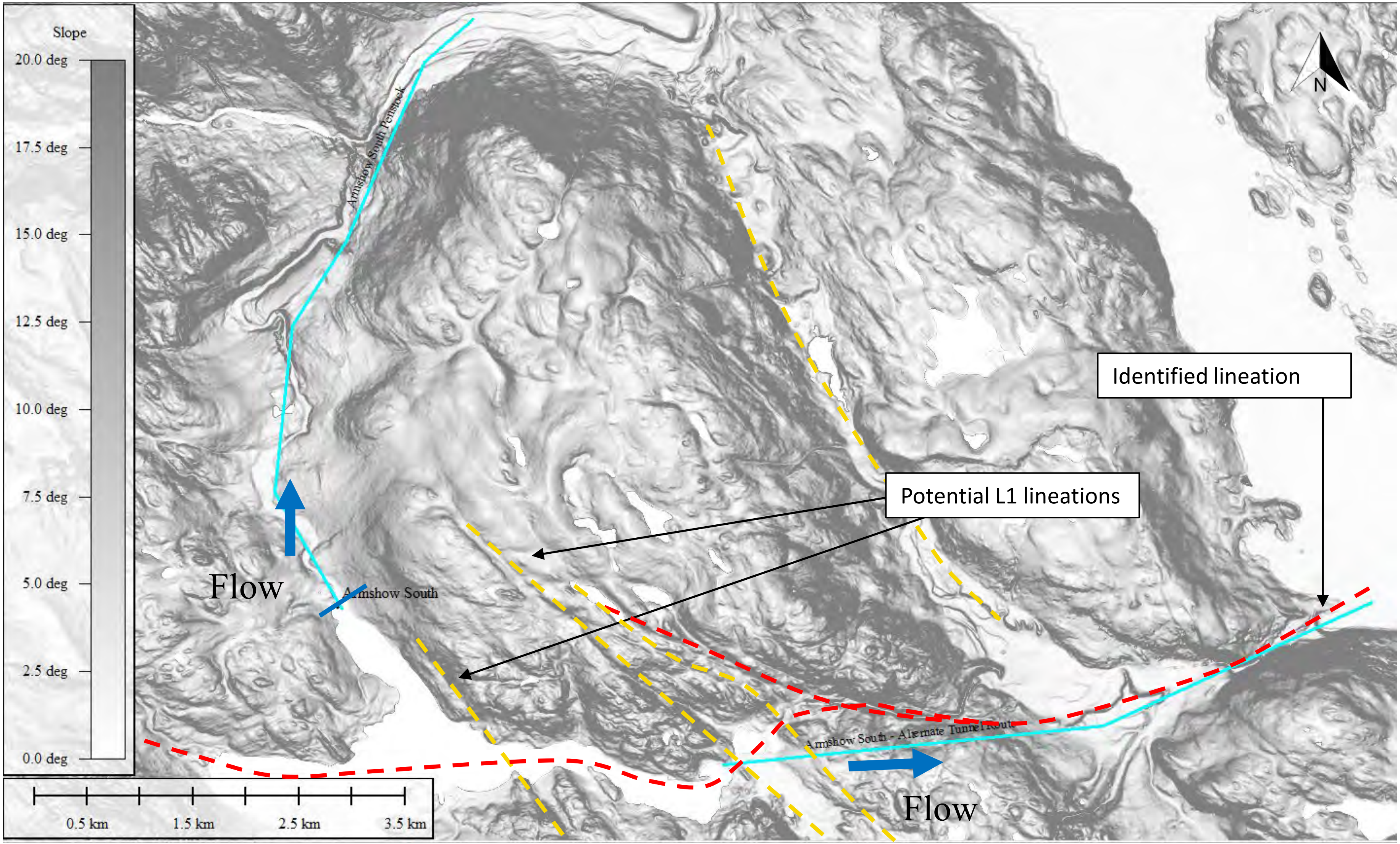


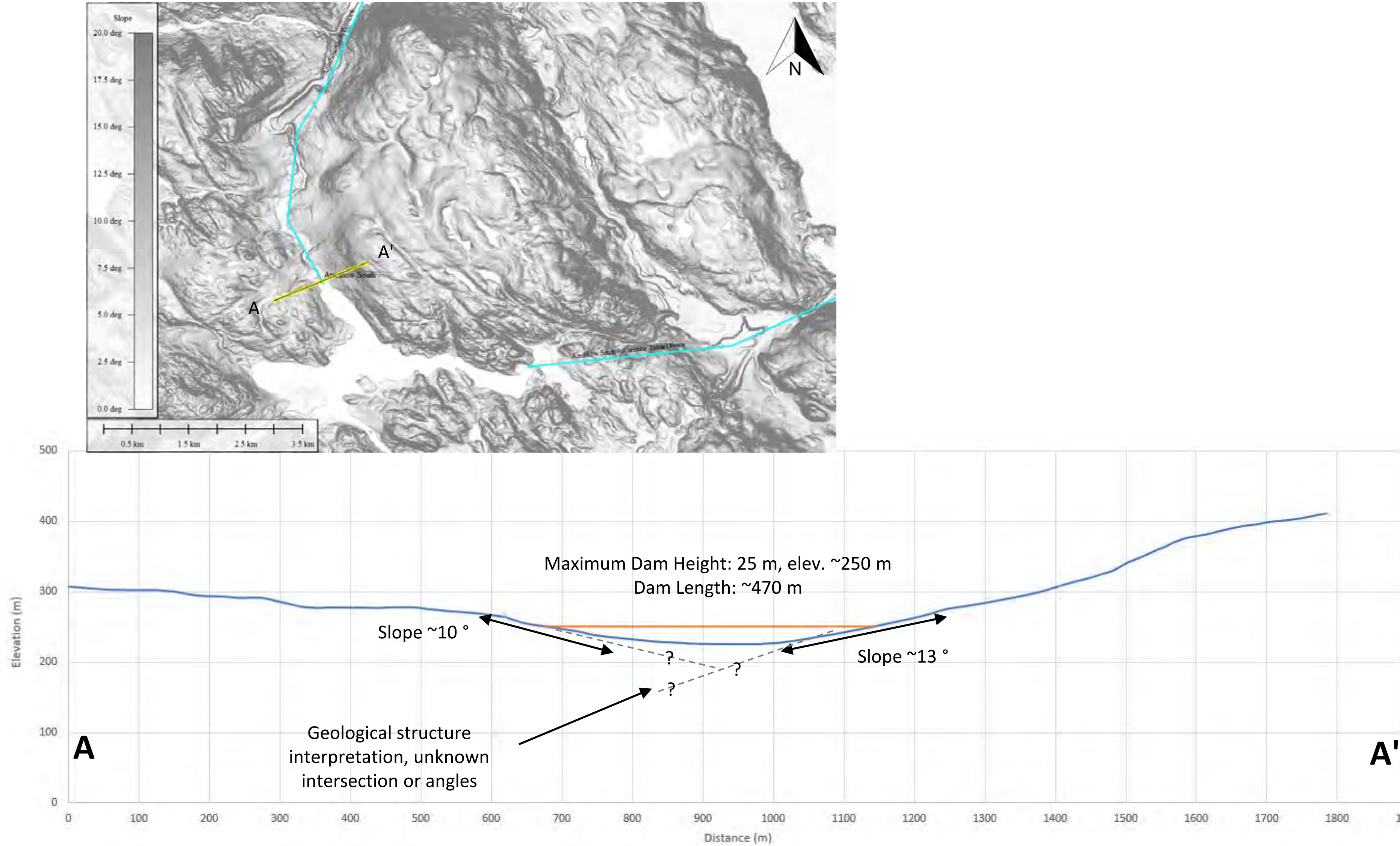

Possible bedrock-lineament structure sketched in the section below

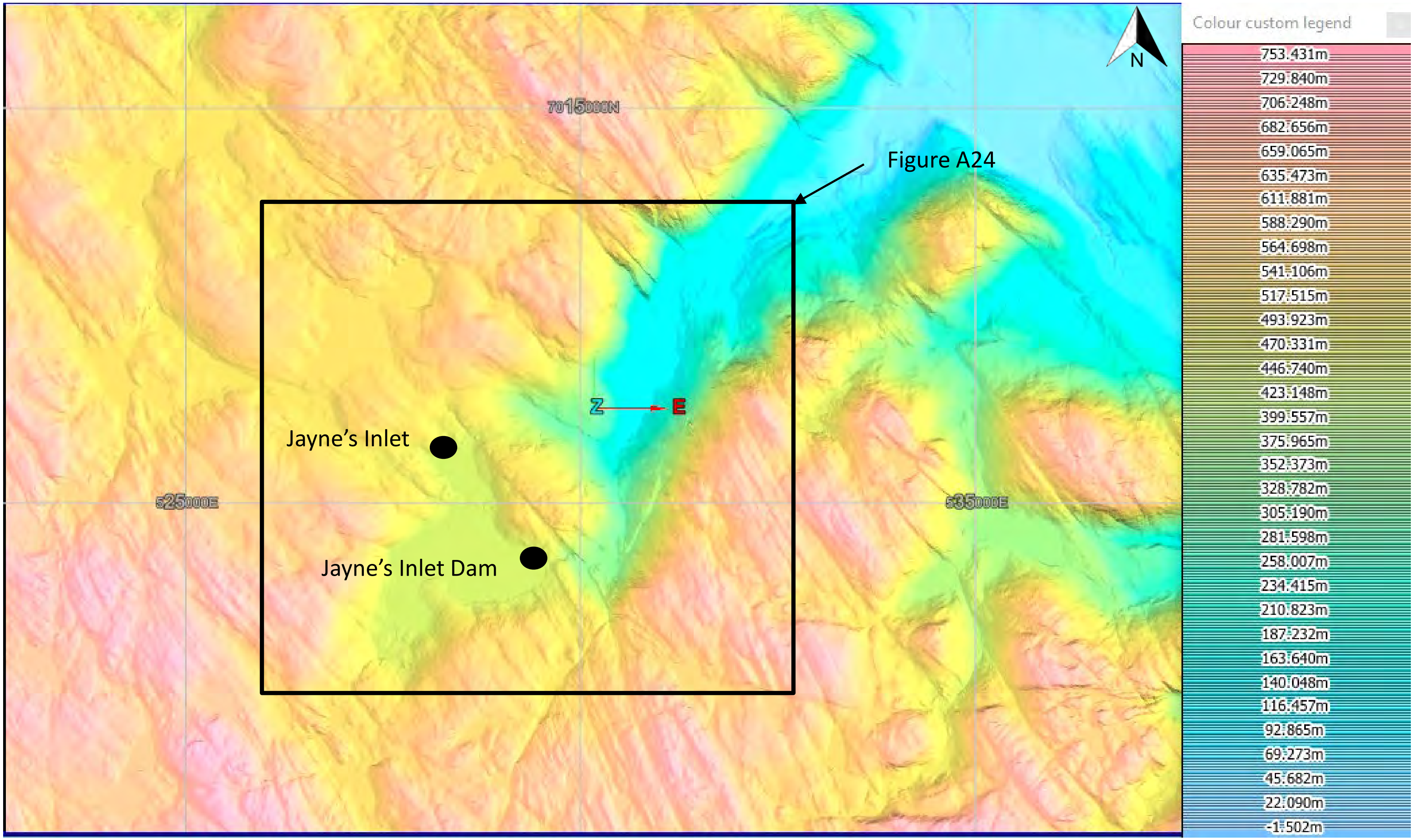


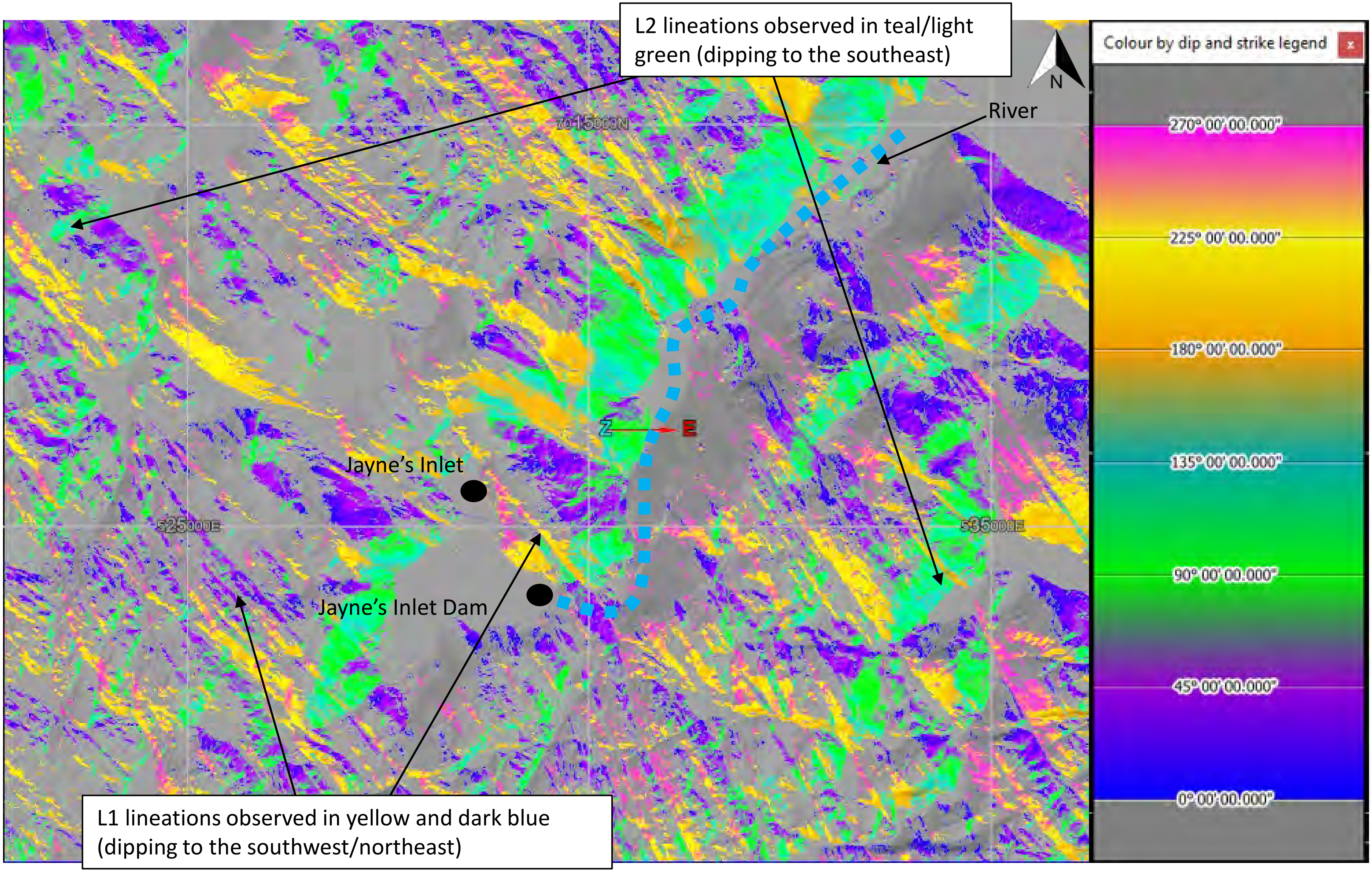

7055000N
N
Z
E
505000E
510000E
7045000N
Figure A20
Armshow Lake
N
Colour custom ...
716.239m
693.732m
671.226m
648.719m
626.212m
603.705m
581.198m
558.691m
536.184m
513.677m
491.170m
468.663m
446.156m
423.650m
401.143m
378.636m
356.129m
333.622m
311.115m
288.608m
266.101m
243.594m
221.087m
198.580m
176.074m
153.567m
131.060m
108.553m
86.046m
63.539m
41.032m
18.525m
-3.982m

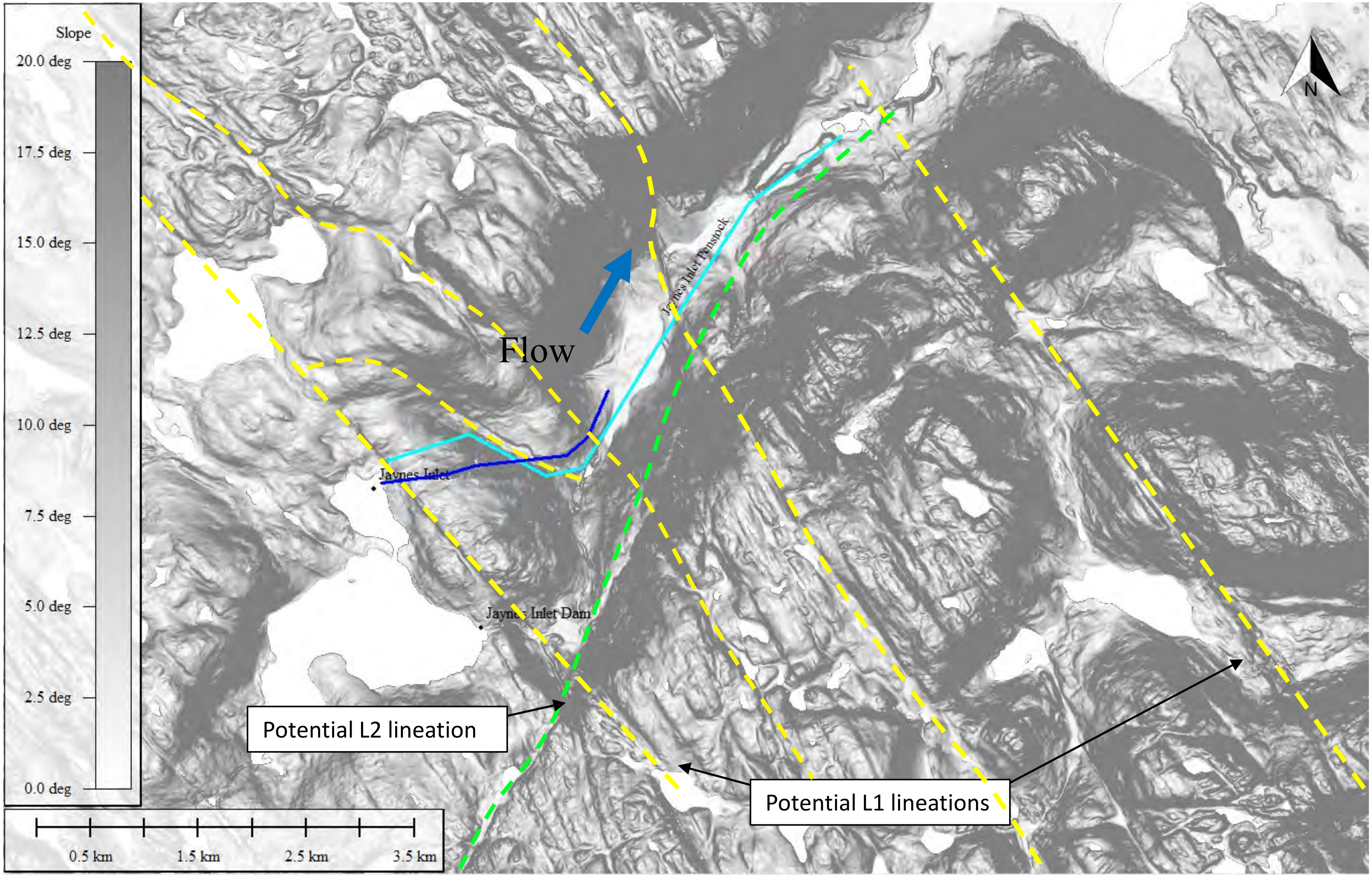

L2 lineations observed in teal/light green (dipping to the southeast)
River
N
E
Z
N
7055000N
505000E
510000E
7045000N
Armshow South
L1 lineations observed in yellow and dark blue (dipping to the southwest/northeast)
Colour by dip and strike legend
270° 00' 00.000"
225° 00' 00.000"
180° 00' 00.000"
135° 00' 00.000"
90° 00' 00.000"
45° 00' 00.000"
0° 00' 00.000"

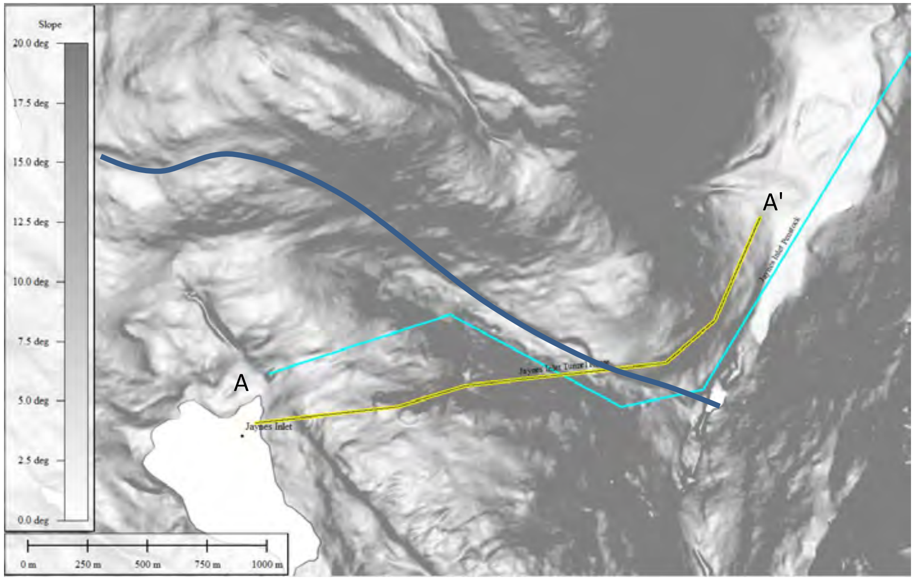

Slope
20.0 deg
17.5 deg
15.0 deg
12.5 deg
10.0 deg
7.5 deg
5.0 deg
2.5 deg
0.0 deg
0.5 km
1.5 km
2.5 km
3.5 km
N
Armshow South Penstock
Armshow South
Flow
Flow
Armshow South - Alternate Tunnel Route
Identified lineation
Potential L1 lineations

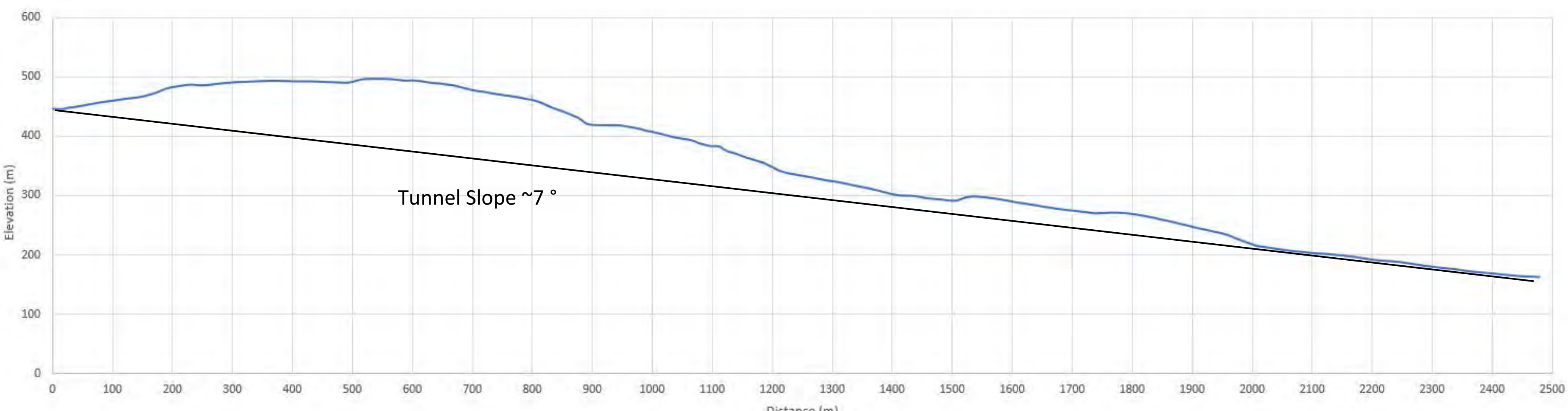

Slope
20.0 deg
17.5 deg
15.0 deg
12.5 deg
10.0 deg
7.5 deg
5.0 deg
2.5 deg
0.0 deg
0.5 km
1.5 km
2.5 km
3.5 km
N
A
A'
Maximum Dam Height: 25 m, elev. ~250 m
Dam Length: ~470 m
Slope ~10 °
Slope ~13 °
?
?
?
Geological structure interpretation, unknown intersection or angles
A
A'
Elevation (m)
0
100
200
300
400
500
Distance (m)
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900


N
7015000N
Figure A24
Jayne's Inlet
Jayne's Inlet Dam
525000E
535000E
Z
E
Colour custom legend
753.431m
729.840m
706.248m
682.656m
659.065m
635.473m
611.881m
588.290m
564.698m
541.106m
517.515m
493.923m
470.331m
446.740m
423.148m
399.557m
375.965m
352.373m
328.782m
305.190m
281.598m
258.007m
234.415m
210.823m
187.232m
163.640m
140.048m
116.457m
92.865m
69.273m
45.682m
22.090m
-1.502m


L2 lineations observed in teal/light green (dipping to the southeast)
River
N
Colour by dip and strike legend
270° 00' 00.000"
225° 00' 00.000"
180° 00' 00.000"
135° 00' 00.000"
90° 00' 00.000"
45° 00' 00.000"
0° 00' 00.000"
Z
E
Jayne's Inlet
Jayne's Inlet Dam
525000E
535000E
L1 lineations observed in yellow and dark blue (dipping to the southwest/northeast)


Slope
20.0 deg
17.5 deg
15.0 deg
12.5 deg
10.0 deg
7.5 deg
5.0 deg
2.5 deg
0.0 deg
0.5 km
1.5 km
2.5 km
3.5 km
N
Flow
Jaynes Inlet
Jaynes Inlet Dam
Jaynes Inlet Penstock
Potential L2 lineation
Potential L1 lineations

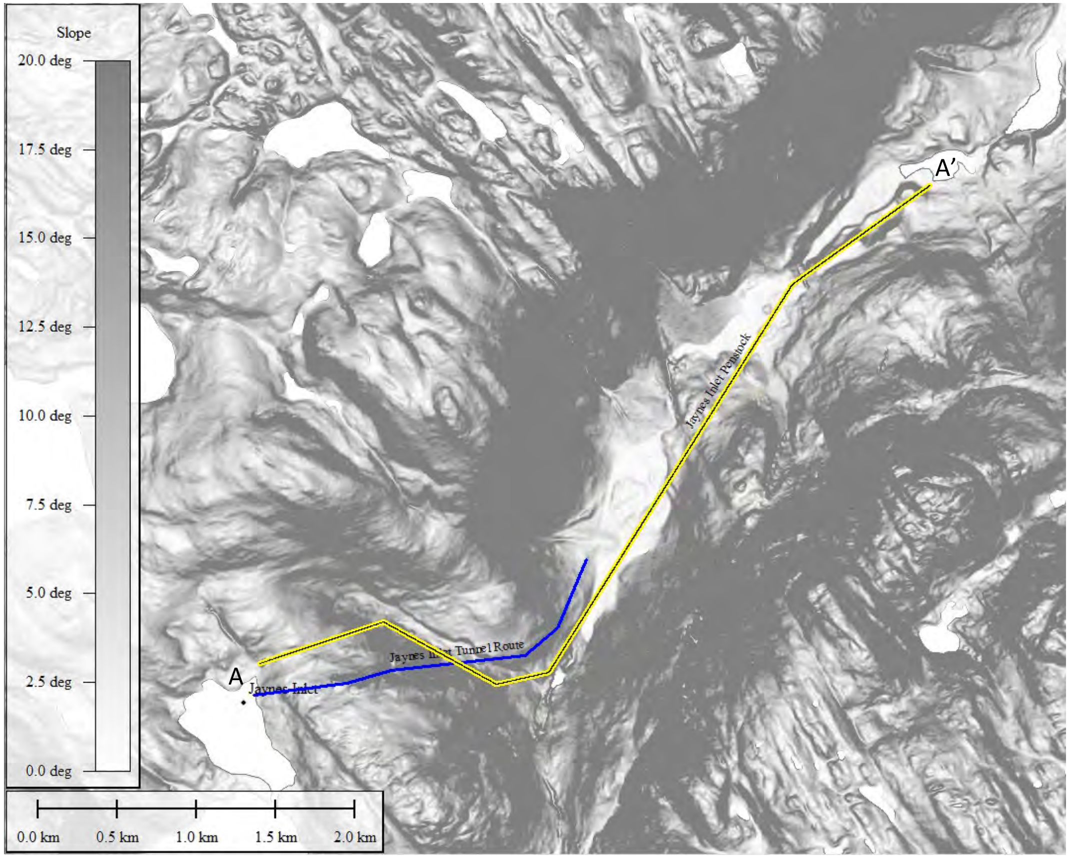


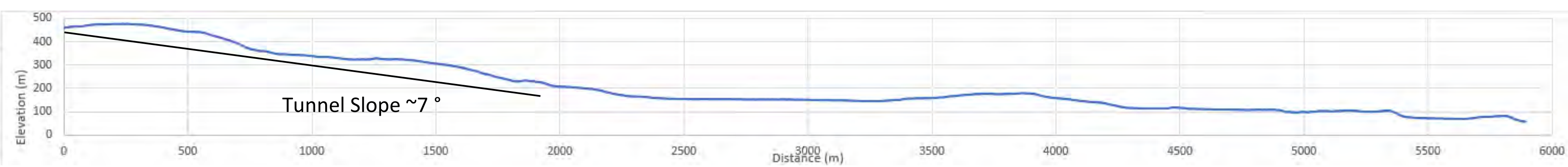




**A** **A'**

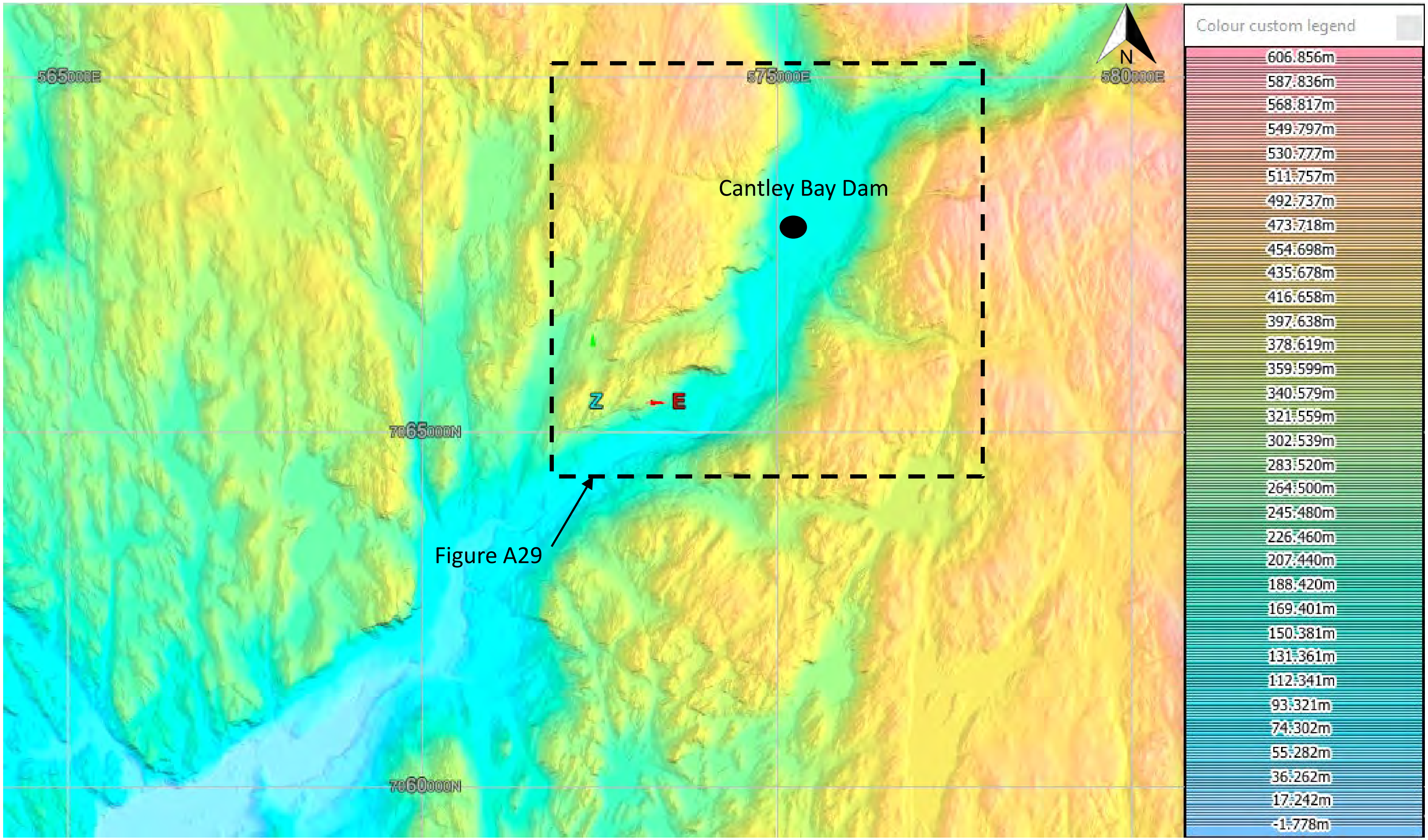
**Date:** August 2023 **Drawn by:** JLL **Checked by:** AEF **Approved by:** AEF

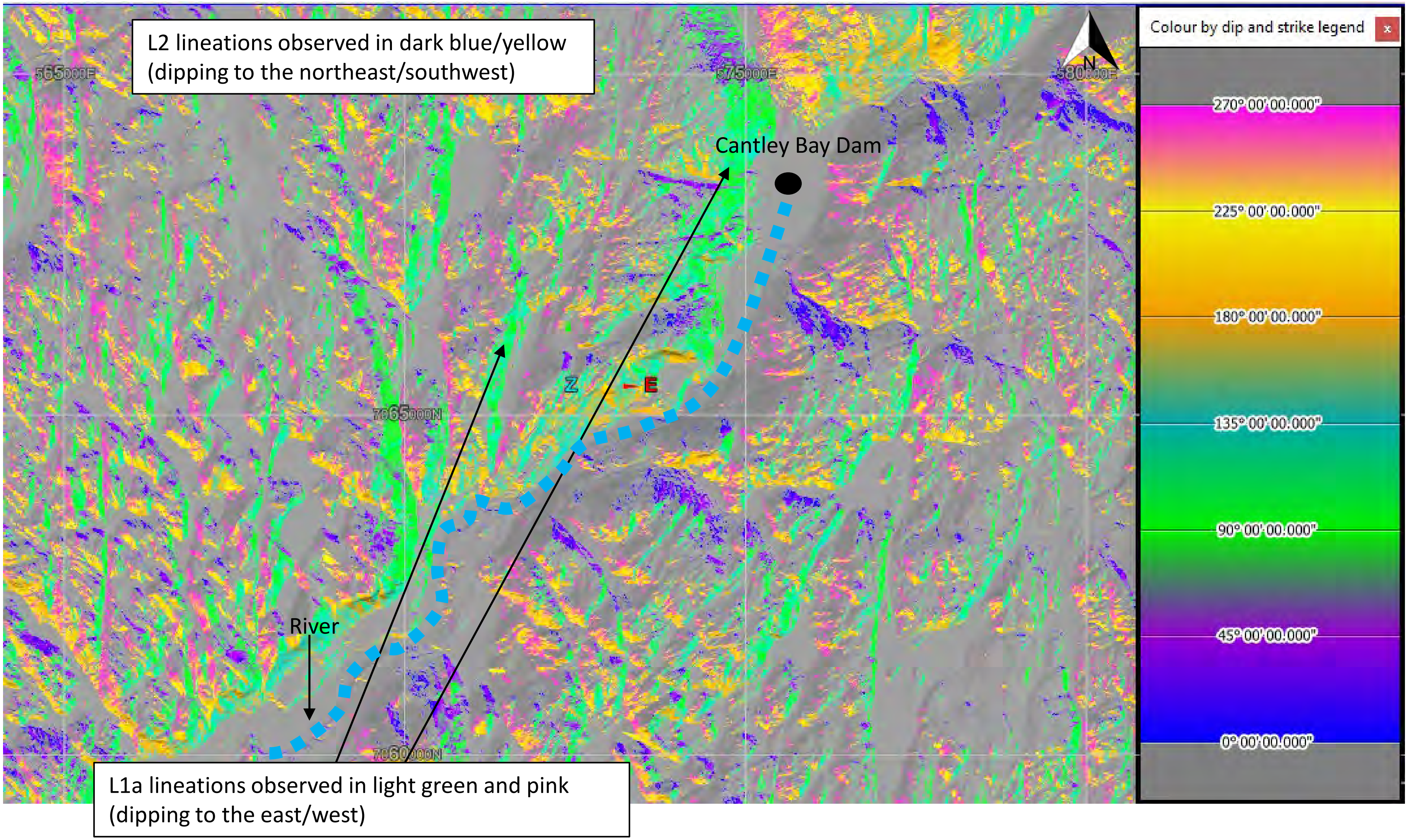
TETRA TECH

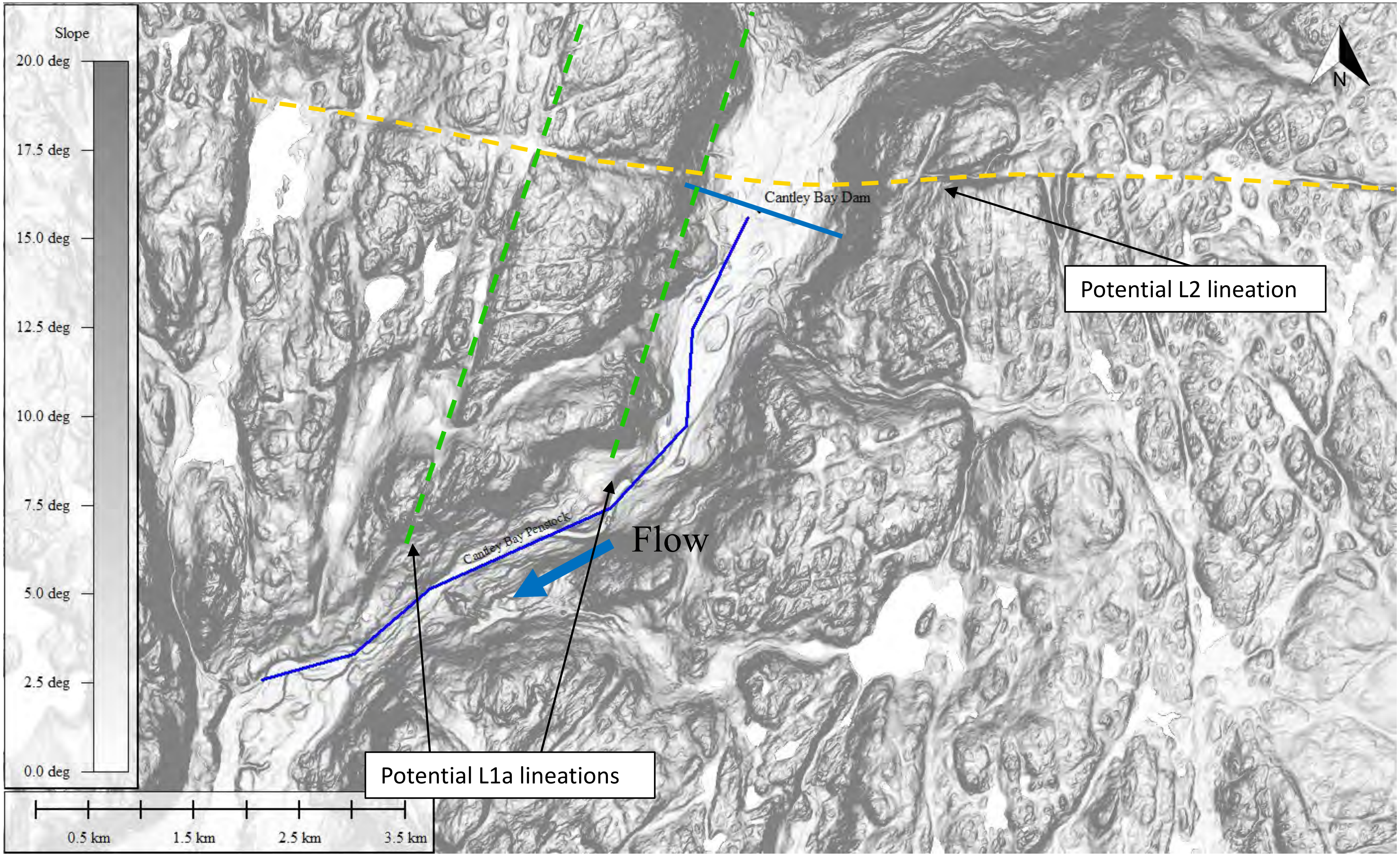

Slope
20.0 deg
17.5 deg
15.0 deg
12.5 deg
10.0 deg
7.5 deg
5.0 deg
2.5 deg
0.0 deg
0.0 km
0.5 km
1.0 km
1.5 km
2.0 km
A
A'
Jaynes Inlet Penstock
Tunnel Route
Jaynes Inlet

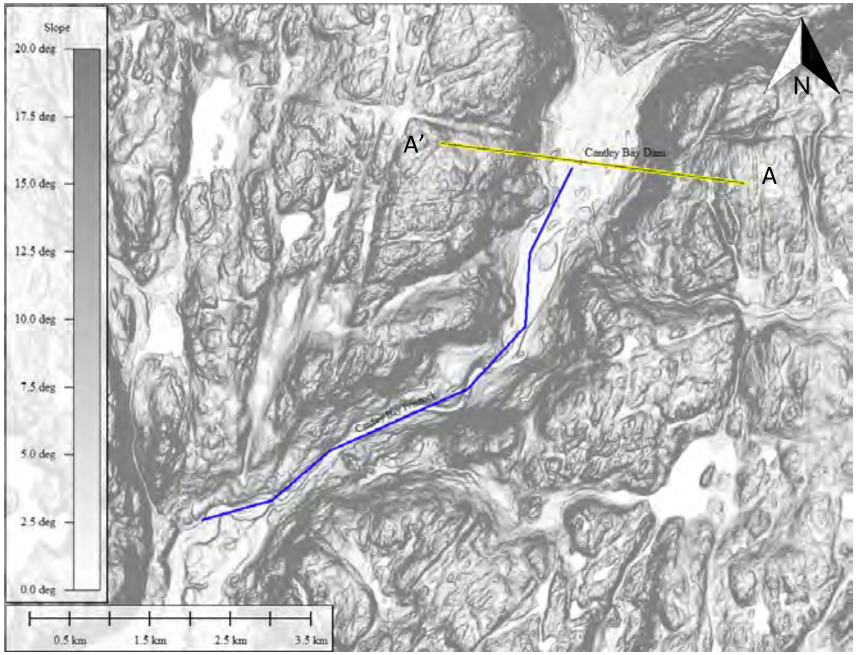

500
400
300
200
100
0
Elevation (m)
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000
Distance (m)
Tunnel Slope ~7 °

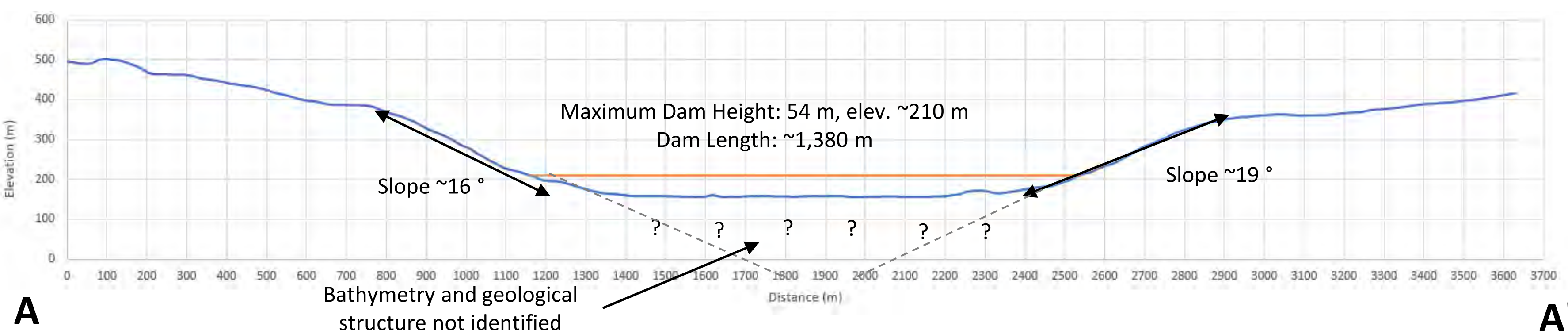
**A** **A'**


Colour custom legend
606.856m
587.836m
568.817m
549.797m
530.777m
511.757m
492.737m
473.718m
454.698m
435.678m
416.658m
397.638m
378.619m
359.599m
340.579m
321.559m
302.539m
283.520m
264.500m
245.480m
226.460m
207.440m
188.420m
169.401m
150.381m
131.361m
112.341m
93.321m
74.302m
55.282m
36.262m
17.242m
-1.778m
N
565000E
575000E
580000E
7865000N
7860000N
Cantley Bay Dam
Figure A29
Z
E

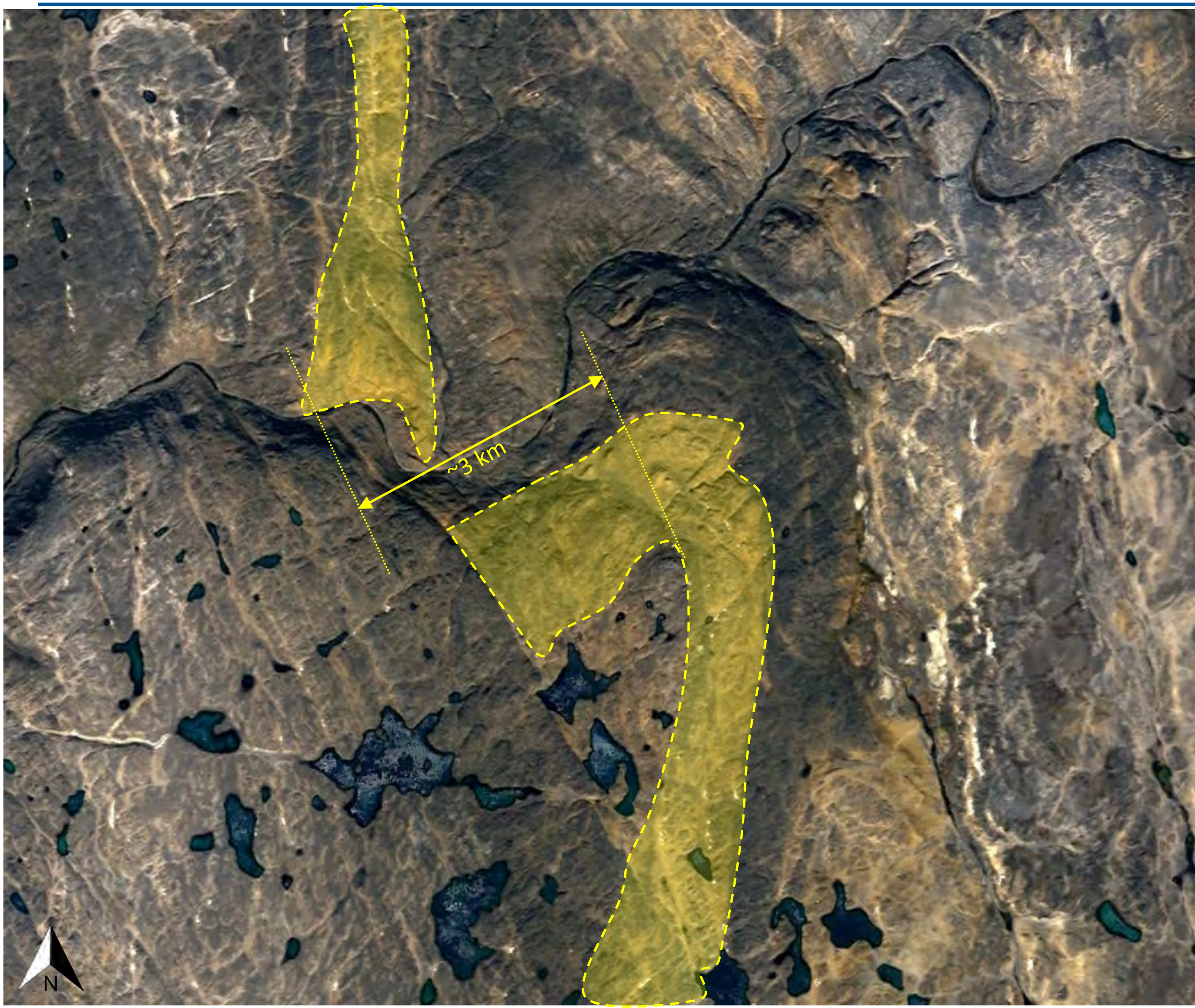

L2 lineations observed in dark blue/yellow (dipping to the northeast/southwest)
565000E
575000E
580000E
N
Cantley Bay Dam
Z
E
7865000N
River
7860000N
L1a lineations observed in light green and pink (dipping to the east/west)
Colour by dip and strike legend
270° 00' 00.000"
225° 00' 00.000"
180° 00' 00.000"
135° 00' 00.000"
90° 00' 00.000"
45° 00' 00.000"
0° 00' 00.000"


Slope
20.0 deg
17.5 deg
15.0 deg
12.5 deg
10.0 deg
7.5 deg
5.0 deg
2.5 deg
0.0 deg
0.5 km
1.5 km
2.5 km
3.5 km
N
Cantley Bay Dam
Potential L2 lineation
Cantley Bay Penstock
Flow
Potential L1a lineations


Slope
20.0 deg
17.5 deg
15.0 deg
12.5 deg
10.0 deg
7.5 deg
5.0 deg
2.5 deg
0.0 deg
0.5 km
1.5 km
2.5 km
3.5 km
N
A'
A
Cantley Bay Dam


Elevation (m)
600
500
400
300
200
100
0
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000 2100 2200 2300 2400 2500 2600 2700 2800 2900 3000 3100 3200 3300 3400 3500 3600 3700
Distance (m)
Maximum Dam Height: 54 m, elev. ~210 m
Dam Length: ~1,380 m
Slope ~16 °
Slope ~19 °
? ? ? ? ? ?
Bathymetry and geological structure not identified
A
A'


See Figure A32
N
Augustus Island
Frobisher's Farthest
Google




Possible contortion of a marker band showing about 3km of offset to potential fault movement

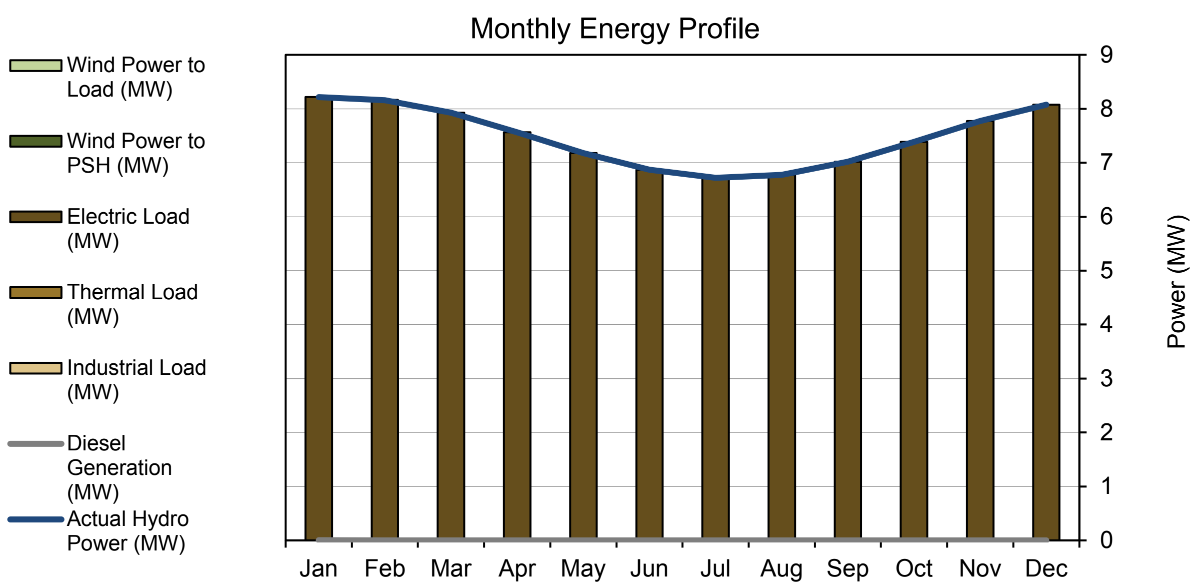
# Appendix B
# Power and Energy Results

# Summary

Iqaluit Renewable Energy Project
McKeand South Hydro - Electric Load Only

| Scenario Inputs | | | Demand | | |
|---|---|---|---|---|---|
| Wind Power Site | None | | Electrical Demand | 65.4 GWh | 100% |
| Wind Plant Capacity | 0 | MW | Thermal Demand | 0.0 GWh | 0% |
| Hydro Scenario Selection | McKeand River South | | Industrial Demand | 0.0 GWh | 0% |
| Hydro Plant Capacity | 10 | MW | Total Demand | 65.4 GWh | |
| Pumped Storage Hydro | No | | | | |
| PSH Turbine Power Capacity | 0.0 | MW | **Renewable Capital Costs** | | |
| PSH Type | None | | Hydro / PSH | $198,544,996 | |
| | | | Wind | $0 | |
| Diesel Base Load | 0.0 | MW | Total | $198,544,996 | |

| Energy Supply | | | Levelized Cost of Energy | | |
|---|---|---|---|---|---|
| **Renewable Supply** | 65.4 GWh | 100% | Diesel | $37,433 | /MWh |
| **Diesel Supply** | 0.0 GWh | 0% | Renewables | $339 | /MWh |
| | | | Aggregate | $342 | /MWh |
| Wind Supply | 0.0 GWh | | | | |
| Wind Capacity Factor | 0% | | | | |
| Hydro Supply | 65.4 GWh | | Diesel Run Time Hours | 364 hrs | 4% |
| Hydro Capacity Factor | 75% | | CO2 Emissions | 0.0 x 1000 ton/yr | |



# Hydro Calculations

Iqaluit Renewable Energy Project

McKeand South Hydro - Electric Load Only

**Penstock Hydraulics and Capacities**

| | | |
|---|---|---|
| Selected Power Capacity | 10.0 | MW |
| Maximum Gross Head | 90 | m |
| Target Headlosss at Capacit | 5.6 | m |
| Maximum Plant Flow Setting | 14.433 | m³/s |

**Low Flow Operations**

| | | |
|---|---|---|
| Turn Down Per Unit | 0% | |
| Number of Units | 3 | |
| Minimum Plant Flow | 0.00 | m³/s |

**Other Parameters**

| | | |
|---|---|---|
| Starting Reservoir Level | 50% | |
| Dam Slopes | 2 | H:1V |
| Freeboard | 5 | m |
| Design Flood to Mean Annual Discharge Ratio | 100 | |
| Transmission Voltage | 69 | kV |

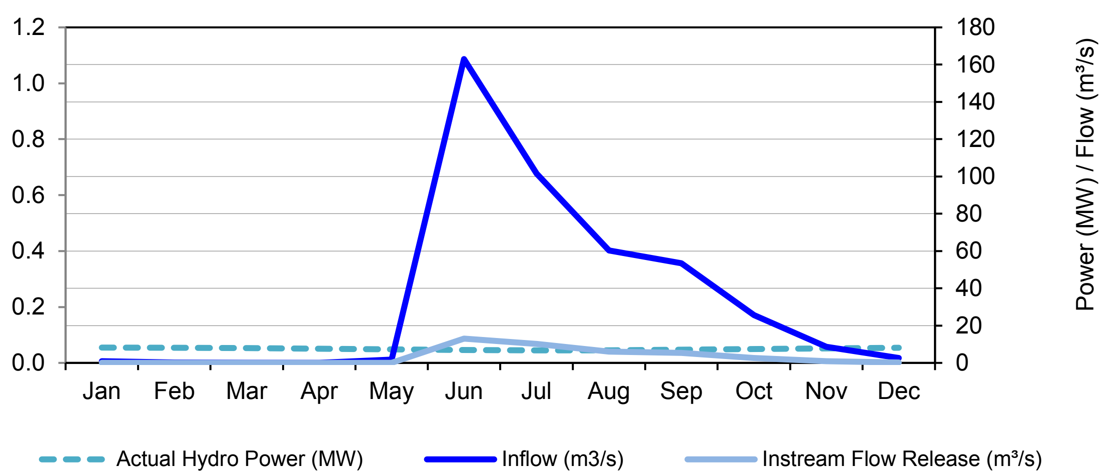
**Synthetic Inflows (Partial)**

**McKeand River South**

| | |
|---|---|
| Watershed Area (km²) | 3800 |
| Unit Runoff (l/s/km²) | 10.7 |
| Scaling Factor | 1.091 |
| Average Discharge | 34.87 |

| **Net Efficiency** | **83.4%** |
|---|---|
| Turbine | 90.0% |
| Generator | 97.5% |
| Transformer | 99.0% |
| Station Service Power Cons | 99.0% |
| Line Losses | 97.0% |

| Month | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Min | Avg | Max |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Actual Hydro Power (MW) | 8.22 | 8.16 | 7.93 | 7.57 | 7.18 | 6.87 | 6.72 | 6.78 | 7.02 | 7.39 | 7.77 | 8.08 | 5.46 | 7.47 | 9.71 |
| Inflow (m3/s) | 0.88 | 0.22 | 0.09 | 0.1 | 1.73 | 163 | 101 | 60.3 | 53.4 | 25.6 | 8.67 | 2.64 | 0 | 34.9 | 804 |
| Instream Flow Release (m³/s) | 0.04 | 0.01 | 0 | 0 | 0.07 | 13 | 10.1 | 6.03 | 5.34 | 2.56 | 0.85 | 0.2 | 0 | 3.2 | 16.3 |
| Hydro Spilled (MW) | 0 | 0 | 0 | 0 | 0 | 2.44 | 8.26 | 8.14 | 8.19 | 4.64 | 0.97 | 0 | 0 | 2.74 | 10 |
| Upper Reservoir Level (m) | -1.27 | -1.43 | -1.6 | -1.76 | -1.91 | -1.44 | -0.5 | -0.29 | -0.17 | -0.14 | -0.19 | -0.29 | -5.91 | -0.91 | 0 |
| Lower Reservoir Level (m) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |



CANADIAN PROJECTS LIMITED

# Hydro Costs

Iqaluit Renewable Energy Project
McKeand South Hydro - Electric Load Only

## Hydro / Pumped Storage

| Capital Cost | | Capex | | |
|---|---|---|---|---|
| Mobilization & Site Services | $ 7,066,300 | Civil | $ | 86,367 |
| Access Roads / Bridges / Barge landing | $ 24,750,000 | Electrical | $ | 120,099 |
| Civil / Siteworks / Foundations | $ 300,000 | Mechanical | $ | 59,772 |
| Reservoir Dam/Spillway/Intake Works | $ 41,282,641 | Contingency | $ | 53,248 |
| Tunnel/Shaft Works | $ - | | $ | - |
| Penstock Supply and Install Works | $ 37,893,680 | **Total Annualized CAPEX** | | **$319,486** |
| Turbine-Generator package supply | $ 6,050,000 | Percent of Capital Cost | | 0.2% |
| Turbine-Generator Install | $ 500,000 | | | |
| Powerhouse | $ 1,650,000 | **OPEX** | $ | - |
| Substation and BOP Electrical | $ 1,407,000 | Management/Operators/Service | $ | 501,000 |
| Transmission Line | $ 21,210,000 | Environmental & Regulatory | $ | 25,000 |
| Iqaluit Electrical System Upgrades | $ 500,000 | Stakeholder Benefit Agreements | $ | - |
| | | Landowner Payments | $ | - |
| Remote Labour Premium | 3.0% | Crown Land Lease Payments | $ | 20,000 |
| Engineering, PM, & CM | 4.2% | Insurance, Taxes, Utilities | $ | 1,634,601 |
| Environmental & Permitting | 2.2% | Contingency | | 10% |
| Owner's Cost | 6.5% | | | |
| Interest During Construction (IDC) | 5.0% | **Total Annual OPEX** | | **$2,398,661** |
| Debt Service Reserve | 5.0% | Percent of Capital Cost | | 1.2% |
| Bonding and Insurance | 2.0% | | | |
| | | | | |
| Contingency | 10.0% | | | |
| | | | | |
| **Total Capital Cost** | **$198,544,996** | | | |
| | **$19,854,500** | **/MW** | | |

## Renewables Cost Summary

| | Hydro / PSH | Wind | Total | |
|---|---|---|---|---|
| Capital Cost | $198,544,996 | $0 | $198,544,996 | |
| Average Annual Energy | | | 65,429 | MWh |
| Gross Energy Cost | | | $3,035 | /MWh |
| | | | | |
| Annualized Capex | $319,486 | $0 | $319,486 | |
| Annual Opex | $2,398,661 | $0 | $2,398,661 | |
| Total Annual Costs | $2,718,147 | $0 | $2,718,147 | |
| | | | | |
| Repowering Percent of Captial | 0% | 70% | | |
| Repowering Cost | $0 | $0 | | |
| Repowering Interval (years) | 0 | 20 | | |
| | | | | |
| Residual Value Percent of Capital | 0% | 0% | | |
| Residual Value | $0 | $0 | $0 | |

## General Economic Parameters

| | | |
|---|---|---|
| Estimate Basis Year | 2023 | |
| First Production Year | 2026 | |
| General Cost Escalation Rate | 2.0% | / year |
| Discount Rate | 10.0% | |
| Economic Planning Period | 50 | years |

## Levelized Cost of Energy

| | | | | | |
|---|---|---|---|---|---|
| Diesel | 0% | 5 | MWh | $37,433 | /MWh |
| Renewables | 100% | 65,429 | MWh | $339 | /MWh |
| Aggregate | 100% | 65,434 | MWh | $342 | /MWh |

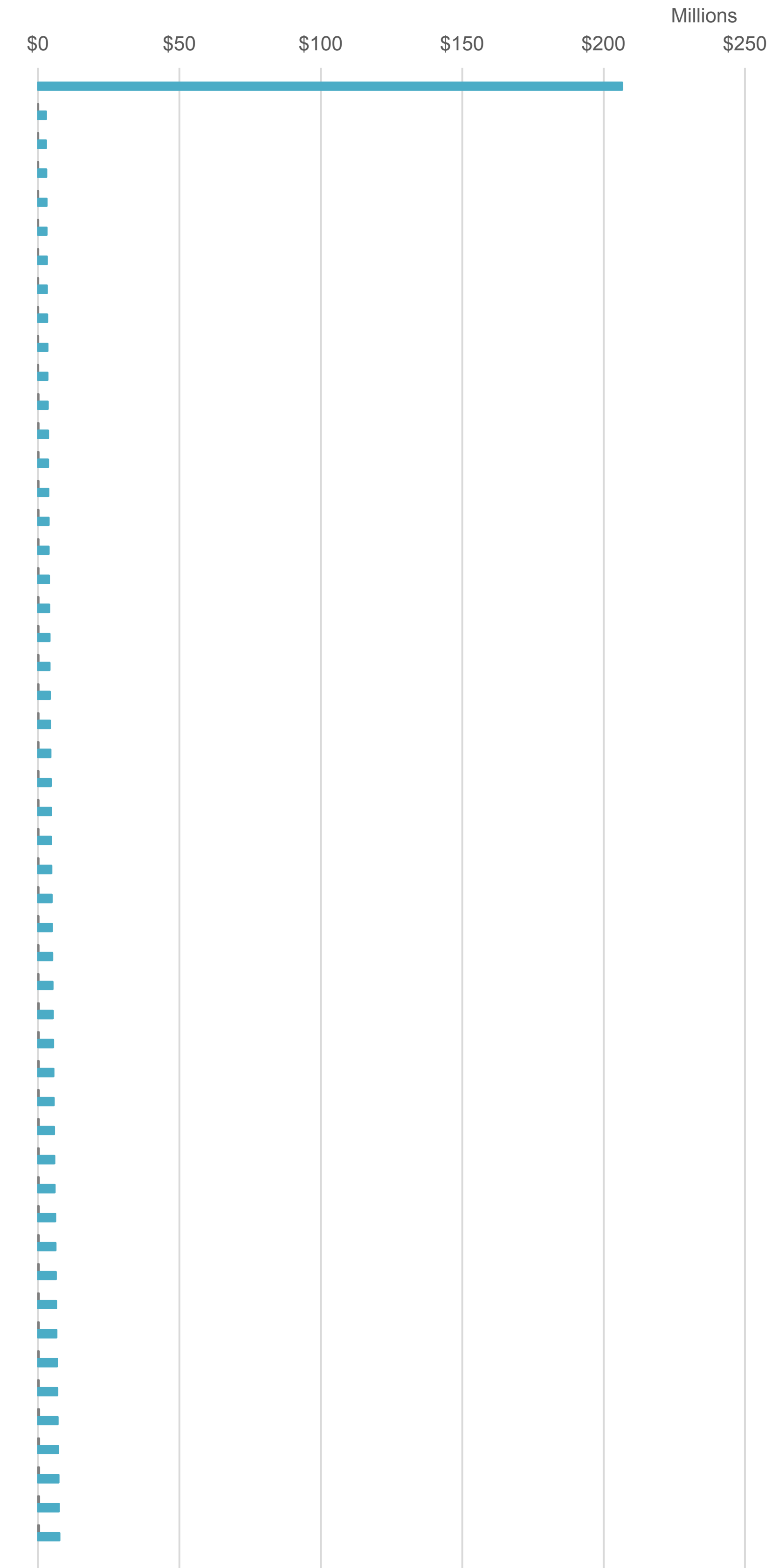
*LCOE is the Net Present Value of escalated cash flow exclusive of financing arrangements and income tax considerations / Net present value of average annual energy, all at the specified discount rate over the economic planning period. Initial capital costs considered to be fully expended at the beginning of the first operating year.*

CANADIAN PROJECTS LIMITED

# Cash Flows

Iqaluit Renewable Energy Project
McKeand South Hydro - Electric Load Only

| | | Diesel | | | | | Renewables | | | Combined |
|---|---|---|---|---|---|---|---|---|---|---|
| | Year | Diesel Capex and Opex | Fuel Cost | Fuel Subsidy | Carbon Tax | Total Diesel Cost | Capital, Repower, Residual Value | Capex and Opex | Total Renewables Cost | Total Cost |
| 0 | 2025 | | | | | $0 | $206,566,214 | | $206,566,214 | $206,566,214 |
| 1 | 2026 | $163,875 | $2,621 | -$627 | $192 | $166,062 | $0 | $2,884,519 | $2,884,519 | $3,050,581 |
| 2 | 2027 | $167,153 | $2,726 | -$614 | $197 | $169,462 | $0 | $2,942,210 | $2,942,210 | $3,111,671 |
| 3 | 2028 | $170,496 | $2,835 | -$602 | $202 | $172,931 | $0 | $3,001,054 | $3,001,054 | $3,173,985 |
| 4 | 2029 | $173,906 | $2,949 | -$590 | $207 | $176,471 | $0 | $3,061,075 | $3,061,075 | $3,237,546 |
| 5 | 2030 | $177,384 | $3,067 | -$578 | $212 | $180,084 | $0 | $3,122,296 | $3,122,296 | $3,302,381 |
| 6 | 2031 | $180,931 | $3,189 | -$566 | $217 | $183,772 | $0 | $3,184,742 | $3,184,742 | $3,368,514 |
| 7 | 2032 | $184,550 | $3,317 | -$555 | $223 | $187,535 | $0 | $3,248,437 | $3,248,437 | $3,435,972 |
| 8 | 2033 | $188,241 | $3,450 | -$544 | $228 | $191,375 | $0 | $3,313,406 | $3,313,406 | $3,504,781 |
| 9 | 2034 | $192,006 | $3,588 | -$533 | $234 | $195,294 | $0 | $3,379,674 | $3,379,674 | $3,574,968 |
| 10 | 2035 | $195,846 | $3,731 | -$522 | $240 | $199,294 | $0 | $3,447,268 | $3,447,268 | $3,646,562 |
| 11 | 2036 | $199,763 | $3,880 | -$512 | $246 | $203,377 | $0 | $3,516,213 | $3,516,213 | $3,719,590 |
| 12 | 2037 | $203,758 | $4,036 | -$502 | $252 | $207,544 | $0 | $3,586,537 | $3,586,537 | $3,794,081 |
| 13 | 2038 | $207,833 | $4,197 | -$492 | $258 | $211,797 | $0 | $3,658,268 | $3,658,268 | $3,870,065 |
| 14 | 2039 | $211,990 | $4,365 | -$482 | $265 | $216,138 | $0 | $3,731,433 | $3,731,433 | $3,947,571 |
| 15 | 2040 | $216,230 | $4,539 | -$472 | $272 | $220,568 | $0 | $3,806,062 | $3,806,062 | $4,026,630 |
| 16 | 2041 | $220,554 | $4,721 | -$463 | $278 | $225,091 | $0 | $3,882,183 | $3,882,183 | $4,107,274 |
| 17 | 2042 | $224,965 | $4,910 | -$454 | $285 | $229,707 | $0 | $3,959,827 | $3,959,827 | $4,189,534 |
| 18 | 2043 | $229,465 | $5,106 | -$445 | $292 | $234,419 | $0 | $4,039,023 | $4,039,023 | $4,273,442 |
| 19 | 2044 | $234,054 | $5,310 | -$436 | $300 | $239,228 | $0 | $4,119,804 | $4,119,804 | $4,359,032 |
| 20 | 2045 | $238,735 | $5,523 | -$427 | $307 | $244,138 | $0 | $4,202,200 | $4,202,200 | $4,446,338 |
| 21 | 2046 | $243,510 | $5,744 | -$418 | $315 | $249,150 | $0 | $4,286,244 | $4,286,244 | $4,535,394 |
| 22 | 2047 | $248,380 | $5,974 | -$410 | $323 | $254,266 | $0 | $4,371,969 | $4,371,969 | $4,626,235 |
| 23 | 2048 | $253,347 | $6,213 | -$402 | $331 | $259,489 | $0 | $4,459,408 | $4,459,408 | $4,718,897 |
| 24 | 2049 | $258,414 | $6,461 | -$394 | $339 | $264,821 | $0 | $4,548,596 | $4,548,596 | $4,813,417 |
| 25 | 2050 | $263,583 | $6,719 | -$386 | $348 | $270,264 | $0 | $4,639,568 | $4,639,568 | $4,909,832 |
| 26 | 2051 | $268,854 | $6,988 | -$378 | $356 | $275,821 | $0 | $4,732,360 | $4,732,360 | $5,008,180 |
| 27 | 2052 | $274,231 | $7,268 | -$371 | $365 | $281,494 | $0 | $4,827,007 | $4,827,007 | $5,108,501 |
| 28 | 2053 | $279,716 | $7,558 | -$363 | $374 | $287,286 | $0 | $4,923,547 | $4,923,547 | $5,210,833 |
| 29 | 2054 | $285,310 | $7,861 | -$356 | $384 | $293,199 | $0 | $5,022,018 | $5,022,018 | $5,315,217 |
| 30 | 2055 | $291,017 | $8,175 | -$349 | $393 | $299,236 | $0 | $5,122,458 | $5,122,458 | $5,421,695 |
| 31 | 2056 | $296,837 | $8,502 | -$342 | $403 | $305,400 | $0 | $5,224,907 | $5,224,907 | $5,530,308 |
| 32 | 2057 | $302,774 | $8,842 | -$335 | $413 | $311,694 | $0 | $5,329,406 | $5,329,406 | $5,641,100 |
| 33 | 2058 | $308,829 | $9,196 | -$328 | $423 | $318,120 | $0 | $5,435,994 | $5,435,994 | $5,754,114 |
| 34 | 2059 | $315,006 | $9,564 | -$322 | $434 | $324,682 | $0 | $5,544,714 | $5,544,714 | $5,869,396 |
| 35 | 2060 | $321,306 | $9,946 | -$315 | $445 | $331,382 | $0 | $5,655,608 | $5,655,608 | $5,986,990 |
| 36 | 2061 | $327,732 | $10,344 | -$309 | $456 | $338,223 | $0 | $5,768,720 | $5,768,720 | $6,106,943 |
| 37 | 2062 | $334,287 | $10,758 | -$303 | $467 | $345,209 | $0 | $5,884,094 | $5,884,094 | $6,229,304 |
| 38 | 2063 | $340,972 | $11,188 | -$297 | $479 | $352,343 | $0 | $6,001,776 | $6,001,776 | $6,354,119 |
| 39 | 2064 | $347,792 | $11,636 | -$291 | $491 | $359,628 | $0 | $6,121,812 | $6,121,812 | $6,481,440 |
| 40 | 2065 | $354,748 | $12,101 | -$285 | $503 | $367,067 | $0 | $6,244,248 | $6,244,248 | $6,611,315 |
| 41 | 2066 | $361,843 | $12,585 | -$279 | $516 | $374,665 | $0 | $6,369,133 | $6,369,133 | $6,743,798 |
| 42 | 2067 | $369,079 | $13,089 | -$274 | $529 | $382,423 | $0 | $6,496,516 | $6,496,516 | $6,878,939 |
| 43 | 2068 | $376,461 | $13,612 | -$268 | $542 | $390,347 | $0 | $6,626,446 | $6,626,446 | $7,016,793 |
| 44 | 2069 | $383,990 | $14,157 | -$263 | $556 | $398,440 | $0 | $6,758,975 | $6,758,975 | $7,157,415 |
| 45 | 2070 | $391,670 | $14,723 | -$258 | $570 | $406,705 | $0 | $6,894,154 | $6,894,154 | $7,300,859 |
| 46 | 2071 | $399,503 | $15,312 | -$252 | $584 | $415,147 | $0 | $7,032,037 | $7,032,037 | $7,447,184 |
| 47 | 2072 | $407,494 | $15,925 | -$247 | $598 | $423,769 | $0 | $7,172,678 | $7,172,678 | $7,596,447 |
| 48 | 2073 | $415,643 | $16,562 | -$242 | $613 | $432,576 | $0 | $7,316,132 | $7,316,132 | $7,748,708 |
| 49 | 2074 | $423,956 | $17,224 | -$238 | $629 | $441,571 | $0 | $7,462,454 | $7,462,454 | $7,904,026 |
| 50 | 2075 | $432,435 | $17,913 | -$233 | $644 | $450,760 | $0 | $7,611,704 | $7,611,704 | $8,062,463 |
| 51 | 2076 | | | | | $0 | $0 | | $0 | $0 |



# Summary

Iqaluit Renewable Energy Project

Niaqunguk Wind - Electric Load Only

| Scenario Inputs | | |
|---|---|---|
| Wind Power Site | Niaqunguk | |
| Wind Plant Capacity | 10 | MW |
| Hydro Scenario Selection | None | |
| Hydro Plant Capacity | 0 | MW |
| Pumped Storage Hydro | No | |
| PSH Turbine Power Capacity | 0.0 | MW |
| PSH Type | Open | |
| Diesel Base Load | 0.0 | MW |

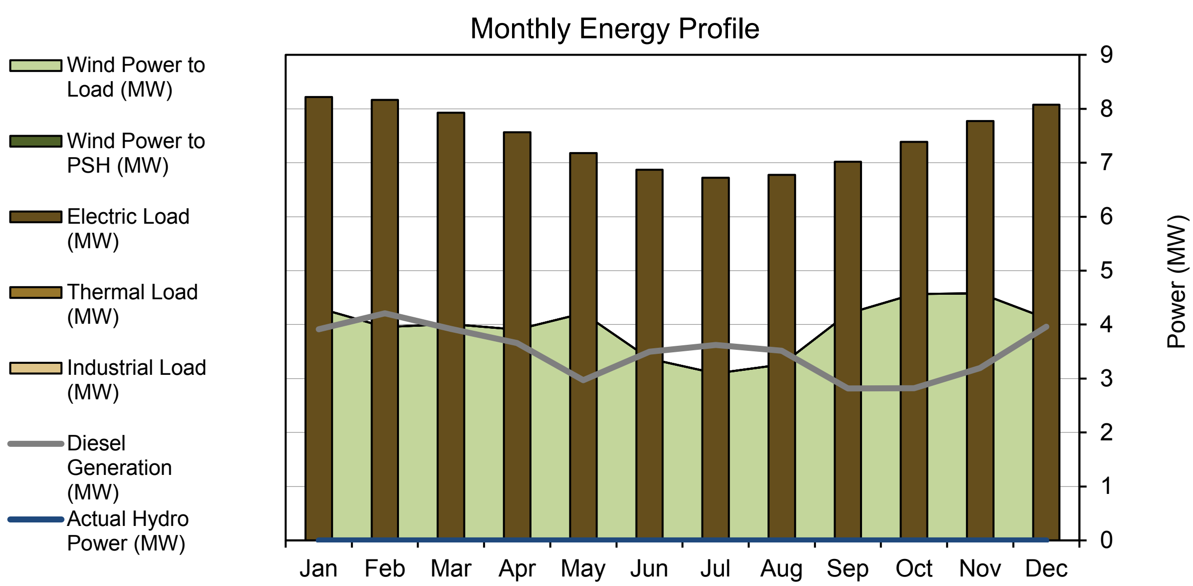
| Demand | | | |
|---|---|---|---|
| Electrical Demand | 65.4 | GWh | 100% |
| Thermal Demand | 0.0 | GWh | 0% |
| Industrial Demand | 0.0 | GWh | 0% |
| Total Demand | 65.4 | GWh | |

| Renewable Capital Costs | |
|---|---|
| Hydro / PSH | $0 |
| Wind | $56,922,039 |
| Total | $56,922,039 |

| Energy Supply | | | |
|---|---|---|---|
| **Renewable Supply** | 34.7 | GWh | 53% |
| **Diesel Supply** | 30.7 | GWh | 47% |
| Wind Supply | 34.7 | GWh | |
| Wind Capacity Factor | 40% | | |
| Hydro Supply | 0.0 | GWh | |
| Hydro Capacity Factor | 0% | | |

| Levelized Cost of Energy | | |
|---|---|---|
| Diesel | $934 | /MWh |
| Renewables | $250 | /MWh |
| Aggregate | $571 | /MWh |

| | | | |
|---|---|---|---|
| Diesel Run Time Hours | 6553 | hrs | 75% |
| CO2 Emissions | 21.9 | x 1000 ton/yr | |



# Wind Calculations

Iqaluit Renewable Energy Project
Niaqunguk Wind - Electric Load Only

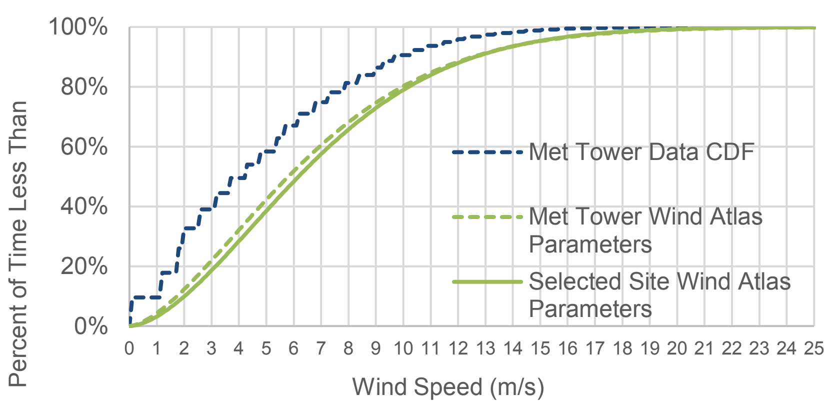
**Turbine Data**

| | | |
|---|---|---|
| Reference Turbine | Enercon E70 | |
| Rated Power | 2300 | kW |
| Hub Height | 75 | m |
| Cut-In Wind Speed | 2.0 | m/s |
| Cut-Out Wind Speed | 25.0 | m/s |
| Cut-Out Temperature | -40.0 | °C |
| IEC Wind Class | IA | |
| Rotor Diameter | 71 | m |

**Wind Speed Scaling**

| | | |
|---|---|---|
| Met Tower Average Wind Speed | 4.41 | m/s |
| Wind Site Average Wind Speed | 6.68 | m/s |
| Site Wind Speed Reference Height | 50 | m |
| Hellmann Coefficient | 0.10 | |
| Wind Speed Scale Factor | 1.577 | |
| Elevation Difference | 1.577 | m |

| | |
|---|---|
| **Net Efficiency** | **85.4%** |
| Power Curve Turbulence Variation | 100.0% |
| Topgraphic Efficiency | 100.0% |
| Wake Effects | 98.0% |
| Collector Losses | 97.0% |
| Station Service Consumption | 99.5% |
| Transmission Losses | 98.0% |
| Icing and Blade Degradation | 95.0% |
| Substation Maintenance | 100.0% |
| Effective Turbine Availability | 98.0% |
| Hysterysis | 99.5% |
| Sector Management | 99.5% |




**Power Curve**

| Wind Speed m/s | Turbine Power % | Turbine Power kW |
|---|---|---|
| 0 | 0% | 0 |
| 1 | 0% | 0 |
| 2 | 0% | 0 |
| 3 | 12% | 267 |
| 4 | 23% | 530 |
| 5 | 34% | 787 |
| 6 | 45% | 1032 |
| 7 | 55% | 1264 |
| 8 | 64% | 1478 |
| 9 | 73% | 1673 |
| 10 | 80% | 1845 |
| 11 | 87% | 1992 |
| 12 | 92% | 2112 |
| 13 | 96% | 2203 |
| 14 | 98% | 2265 |
| 15 | 100% | 2296 |
| 16 | 100% | 2300 |
| 17 | 100% | 2300 |
| 18 | 100% | 2300 |
| 19 | 100% | 2300 |
| 20 | 100% | 2300 |
| 21 | 100% | 2300 |
| 22 | 100% | 2300 |
| 23 | 100% | 2300 |
| 24 | 100% | 2300 |
| 25 | 100% | 2300 |
| 26 | 0% | 0 |
| 27 | 0% | 0 |
| 28 | 0% | 0 |
| 29 | 0% | 0 |
| 30 | 0% | 0 |
| 31 | 0% | 0 |
| 32 | 0% | 0 |
| 33 | 0% | 0 |
| 34 | 0% | 0 |

## Wind Costs

Iqaluit Renewable Energy Project
Niaqunguk Wind - Electric Load Only

**Wind**

| **Capital Cost** | | **Capex** | |
|---|---|---|---|
| Mobilization & Site Services | $ 2,332,963 | Civil | $6,035 |
| Access Roads | $ 4,800,000 | Electrical | $18,452 |
| Civil / Siteworks / Foundations | $ 2,060,870 | Mechanical / Turbine | $147,101 |
| Turbine Supply | $ 21,058,696 | Contingecy | 15% |
| Turbine Transport, Installation | $ 1,169,565 | | |
| Mobile Crane Purchase | $ 3,000,000 | **Total Annualized CAPEX** | **$197,327** |
| Substation & Elec BOP | $ 1,483,087 | Percent of Capital Cost | 0.35% |
| Transmission Line 69 kV DB | $ 4,242,000 | | |
| Iqaluit Electrical System Upgrades | $ 750,000 | **OPEX** | |
| Operations Building | $ 300,000 | Management/Operators/Service | $950,000 |
| | | Environmental & Regulartor | $10,000 |
| Remote Labour Premium | 2.0% | Land Lease Payments | $20,000 |
| Engineering, PM, & CM | 4.3% | Stakeholder Benefit Agreements | $0 |
| Environmental & Permitting | 2.3% | Insurance, Taxes, Utilities | $551,121 |
| Owner's Cost | 8.6% | Contingency | 10% |
| Interest During Construction (IDC) | 5.0% | | |
| Debt Service Reserve | 5.0% | **Total Annual OPEX** | **$1,684,233** |
| | 0.0% | Percent of Capital Cost | 3.0% |
| Contingency | 10.0% | | |
| | | | |
| **Total Capital Cost** | **$56,922,039** | | |
| | **$5,692,204** | **/MW** | |

CANADIAN PROJECTS LIMITED

# Economics

Iqaluit Renewable Energy Project
Niaqunguk Wind - Electric Load Only

## Renewables Cost Summary

| | Hydro / PSH | Wind | Total | |
|---|---|---|---|---|
| Capital Cost | $0 | $56,922,039 | $56,922,039 | |
| Average Annual Energy | | | 34,722 | MWh |
| Gross Energy Cost | | | $1,639 | /MWh |
| | | | | |
| Annualized Capex | $0 | $197,327 | $197,327 | |
| Annual Opex | $0 | $1,684,233 | $1,684,233 | |
| Total Annual Costs | $0 | $1,881,560 | $1,881,560 | |
| | | | | |
| Repowering Percent of Captial | 0% | 70% | | |
| Repowering Cost | $0 | $39,845,428 | | |
| Repowering Interval (years) | 0 | 20 | | |
| | | | | |
| Residual Value Percent of Capital | 0% | 0% | | |
| Residual Value | $0 | $0 | $0 | |

## General Economic Parameters

| | | |
|---|---|---|
| Estimate Basis Year | 2023 | |
| First Production Year | 2026 | |
| General Cost Escalation Rate | 2.0% | / year |
| Discount Rate | 10.0% | |
| Economic Planning Period | 50 | years |

## Levelized Cost of Energy

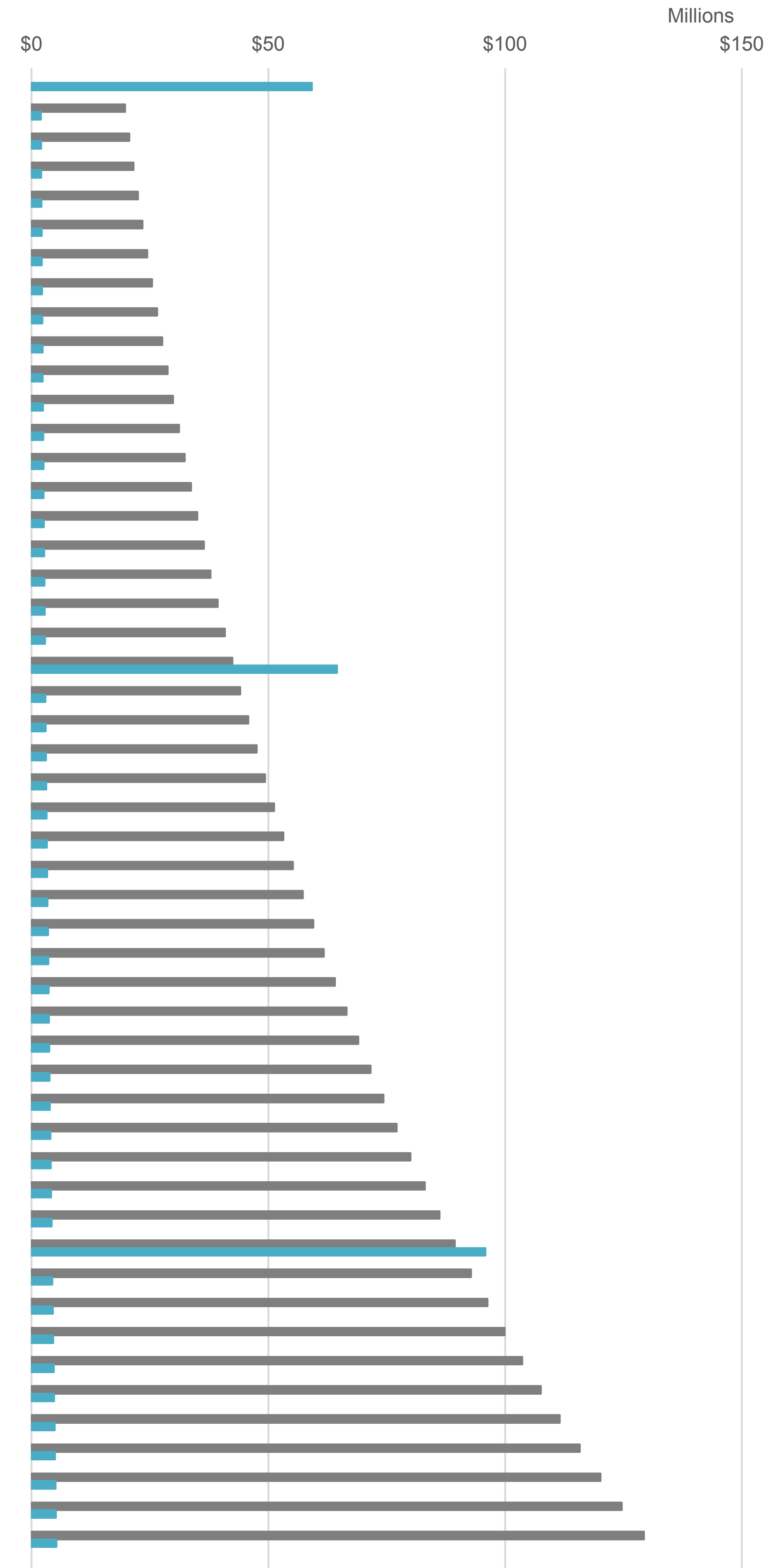
| | | | | | |
|---|---|---|---|---|---|
| Diesel | 47% | 30,711 | MWh | $934 | /MWh |
| Renewables | 53% | 34,722 | MWh | $250 | /MWh |
| Aggregate | 100% | 65,434 | MWh | $571 | /MWh |

*LCOE is the Net Present Value of escalated cash flow exclusive of financing arrangements and income tax considerations / Net present value of average annual energy, all at the specified discount rate over the economic planning period. Initial capital costs considered to be fully expended at the beginning of the first operating year.*

# Cash Flows

Iqaluit Renewable Energy Project
Niaqunguk Wind - Electric Load Only

| | | Diesel | | | | | Renewables | | | Combined |
|---|---|---|---|---|---|---|---|---|---|---|
| | Year | Diesel Capex and Opex | Fuel Cost | Fuel Subsidy | Carbon Tax | Total Diesel Cost | Capital, Repower, Residual Value | Capex and Opex | Total Renewables Cost | Total Cost |
| 0 | 2025 | | | | | $0 | $59,221,690 | | $59,221,690 | $59,221,690 |
| 1 | 2026 | $6,327,858 | $16,112,987 | -$3,851,999 | $1,181,175 | $19,770,021 | $0 | $1,996,726 | $1,996,726 | $21,766,747 |
| 2 | 2027 | $6,454,416 | $16,757,506 | -$3,774,959 | $1,210,705 | $20,647,667 | $0 | $2,036,661 | $2,036,661 | $22,684,328 |
| 3 | 2028 | $6,583,504 | $17,427,807 | -$3,699,460 | $1,240,972 | $21,552,823 | $0 | $2,077,394 | $2,077,394 | $23,630,216 |
| 4 | 2029 | $6,715,174 | $18,124,919 | -$3,625,471 | $1,271,997 | $22,486,618 | $0 | $2,118,942 | $2,118,942 | $24,605,560 |
| 5 | 2030 | $6,849,478 | $18,849,916 | -$3,552,962 | $1,303,797 | $23,450,228 | $0 | $2,161,321 | $2,161,321 | $25,611,549 |
| 6 | 2031 | $6,986,467 | $19,603,912 | -$3,481,902 | $1,336,392 | $24,444,868 | $0 | $2,204,547 | $2,204,547 | $26,649,415 |
| 7 | 2032 | $7,126,196 | $20,388,069 | -$3,412,264 | $1,369,801 | $25,471,802 | $0 | $2,248,638 | $2,248,638 | $27,720,440 |
| 8 | 2033 | $7,268,720 | $21,203,591 | -$3,344,019 | $1,404,046 | $26,532,339 | $0 | $2,293,611 | $2,293,611 | $28,825,950 |
| 9 | 2034 | $7,414,095 | $22,051,735 | -$3,277,139 | $1,439,147 | $27,627,839 | $0 | $2,339,483 | $2,339,483 | $29,967,321 |
| 10 | 2035 | $7,562,377 | $22,933,804 | -$3,211,596 | $1,475,126 | $28,759,711 | $0 | $2,386,273 | $2,386,273 | $31,145,984 |
| 11 | 2036 | $7,713,624 | $23,851,157 | -$3,147,364 | $1,512,004 | $29,929,421 | $0 | $2,433,998 | $2,433,998 | $32,363,419 |
| 12 | 2037 | $7,867,897 | $24,805,203 | -$3,084,417 | $1,549,804 | $31,138,487 | $0 | $2,482,678 | $2,482,678 | $33,621,165 |
| 13 | 2038 | $8,025,255 | $25,797,411 | -$3,022,728 | $1,588,550 | $32,388,487 | $0 | $2,532,331 | $2,532,331 | $34,920,818 |
| 14 | 2039 | $8,185,760 | $26,829,307 | -$2,962,274 | $1,628,263 | $33,681,057 | $0 | $2,582,978 | $2,582,978 | $36,264,035 |
| 15 | 2040 | $8,349,475 | $27,902,480 | -$2,903,028 | $1,668,970 | $35,017,896 | $0 | $2,634,638 | $2,634,638 | $37,652,534 |
| 16 | 2041 | $8,516,464 | $29,018,579 | -$2,844,968 | $1,710,694 | $36,400,770 | $0 | $2,687,330 | $2,687,330 | $39,088,100 |
| 17 | 2042 | $8,686,794 | $30,179,322 | -$2,788,068 | $1,753,461 | $37,831,509 | $0 | $2,741,077 | $2,741,077 | $40,572,586 |
| 18 | 2043 | $8,860,530 | $31,386,495 | -$2,732,307 | $1,797,298 | $39,312,016 | $0 | $2,795,899 | $2,795,899 | $42,107,914 |
| 19 | 2044 | $9,037,740 | $32,641,955 | -$2,677,661 | $1,842,230 | $40,844,264 | $0 | $2,851,817 | $2,851,817 | $43,696,081 |
| 20 | 2045 | $9,218,495 | $33,947,633 | -$2,624,108 | $1,888,286 | $42,430,306 | $61,600,221 | $2,908,853 | $64,509,074 | $106,939,380 |
| 21 | 2046 | $9,402,865 | $35,305,538 | -$2,571,626 | $1,935,493 | $44,072,271 | $0 | $2,967,030 | $2,967,030 | $47,039,301 |
| 22 | 2047 | $9,590,922 | $36,717,760 | -$2,520,193 | $1,983,881 | $45,772,370 | $0 | $3,026,371 | $3,026,371 | $48,798,740 |
| 23 | 2048 | $9,782,741 | $38,186,470 | -$2,469,789 | $2,033,478 | $47,532,899 | $0 | $3,086,898 | $3,086,898 | $50,619,797 |
| 24 | 2049 | $9,978,395 | $39,713,929 | -$2,420,393 | $2,084,315 | $49,356,246 | $0 | $3,148,636 | $3,148,636 | $52,504,882 |
| 25 | 2050 | $10,177,963 | $41,302,486 | -$2,371,986 | $2,136,423 | $51,244,887 | $0 | $3,211,609 | $3,211,609 | $54,456,495 |
| 26 | 2051 | $10,381,523 | $42,954,586 | -$2,324,546 | $2,189,833 | $53,201,396 | $0 | $3,275,841 | $3,275,841 | $56,477,236 |
| 27 | 2052 | $10,589,153 | $44,672,769 | -$2,278,055 | $2,244,579 | $55,228,446 | $0 | $3,341,358 | $3,341,358 | $58,569,804 |
| 28 | 2053 | $10,800,936 | $46,459,680 | -$2,232,494 | $2,300,693 | $57,328,816 | $0 | $3,408,185 | $3,408,185 | $60,737,000 |
| 29 | 2054 | $11,016,955 | $48,318,067 | -$2,187,844 | $2,358,211 | $59,505,389 | $0 | $3,476,348 | $3,476,348 | $62,981,737 |
| 30 | 2055 | $11,237,294 | $50,250,790 | -$2,144,087 | $2,417,166 | $61,761,163 | $0 | $3,545,875 | $3,545,875 | $65,307,038 |
| 31 | 2056 | $11,462,040 | $52,260,821 | -$2,101,205 | $2,477,595 | $64,099,251 | $0 | $3,616,793 | $3,616,793 | $67,716,044 |
| 32 | 2057 | $11,691,281 | $54,351,254 | -$2,059,181 | $2,539,535 | $66,522,889 | $0 | $3,689,129 | $3,689,129 | $70,212,017 |
| 33 | 2058 | $11,925,106 | $56,525,304 | -$2,017,998 | $2,603,023 | $69,035,436 | $0 | $3,762,911 | $3,762,911 | $72,798,348 |
| 34 | 2059 | $12,163,608 | $58,786,317 | -$1,977,638 | $2,668,099 | $71,640,386 | $0 | $3,838,170 | $3,838,170 | $75,478,556 |
| 35 | 2060 | $12,406,880 | $61,137,769 | -$1,938,085 | $2,734,801 | $74,341,366 | $0 | $3,914,933 | $3,914,933 | $78,256,299 |
| 36 | 2061 | $12,655,018 | $63,583,280 | -$1,899,323 | $2,803,171 | $77,142,146 | $0 | $3,993,232 | $3,993,232 | $81,135,378 |
| 37 | 2062 | $12,908,118 | $66,126,611 | -$1,861,337 | $2,873,251 | $80,046,644 | $0 | $4,073,096 | $4,073,096 | $84,119,740 |
| 38 | 2063 | $13,166,281 | $68,771,676 | -$1,824,110 | $2,945,082 | $83,058,929 | $0 | $4,154,558 | $4,154,558 | $87,213,487 |
| 39 | 2064 | $13,429,606 | $71,522,543 | -$1,787,628 | $3,018,709 | $86,183,230 | $0 | $4,237,649 | $4,237,649 | $90,420,880 |
| 40 | 2065 | $13,698,199 | $74,383,444 | -$1,751,875 | $3,094,177 | $89,423,945 | $91,534,688 | $4,322,402 | $95,857,090 | $185,281,035 |
| 41 | 2066 | $13,972,163 | $77,358,782 | -$1,716,838 | $3,171,531 | $92,785,638 | $0 | $4,408,850 | $4,408,850 | $97,194,489 |
| 42 | 2067 | $14,251,606 | $80,453,133 | -$1,682,501 | $3,250,820 | $96,273,058 | $0 | $4,497,027 | $4,497,027 | $100,770,085 |
| 43 | 2068 | $14,536,638 | $83,671,259 | -$1,648,851 | $3,332,090 | $99,891,136 | $0 | $4,586,968 | $4,586,968 | $104,478,104 |
| 44 | 2069 | $14,827,371 | $87,018,109 | -$1,615,874 | $3,415,392 | $103,644,998 | $0 | $4,678,707 | $4,678,707 | $108,323,705 |
| 45 | 2070 | $15,123,918 | $90,498,833 | -$1,583,556 | $3,500,777 | $107,539,972 | $0 | $4,772,281 | $4,772,281 | $112,312,254 |
| 46 | 2071 | $15,426,396 | $94,118,787 | -$1,551,885 | $3,588,297 | $111,581,594 | $0 | $4,867,727 | $4,867,727 | $116,449,321 |
| 47 | 2072 | $15,734,924 | $97,883,538 | -$1,520,848 | $3,678,004 | $115,775,619 | $0 | $4,965,082 | $4,965,082 | $120,740,701 |
| 48 | 2073 | $16,049,623 | $101,798,880 | -$1,490,431 | $3,769,954 | $120,128,026 | $0 | $5,064,383 | $5,064,383 | $125,192,409 |
| 49 | 2074 | $16,370,615 | $105,870,835 | -$1,460,622 | $3,864,203 | $124,645,031 | $0 | $5,165,671 | $5,165,671 | $129,810,702 |
| 50 | 2075 | $16,698,028 | $110,105,668 | -$1,431,410 | $3,960,808 | $129,333,094 | $0 | $5,268,984 | $5,268,984 | $134,602,079 |
| 51 | 2076 | | | | | $0 | $0 | | $0 | $0 |



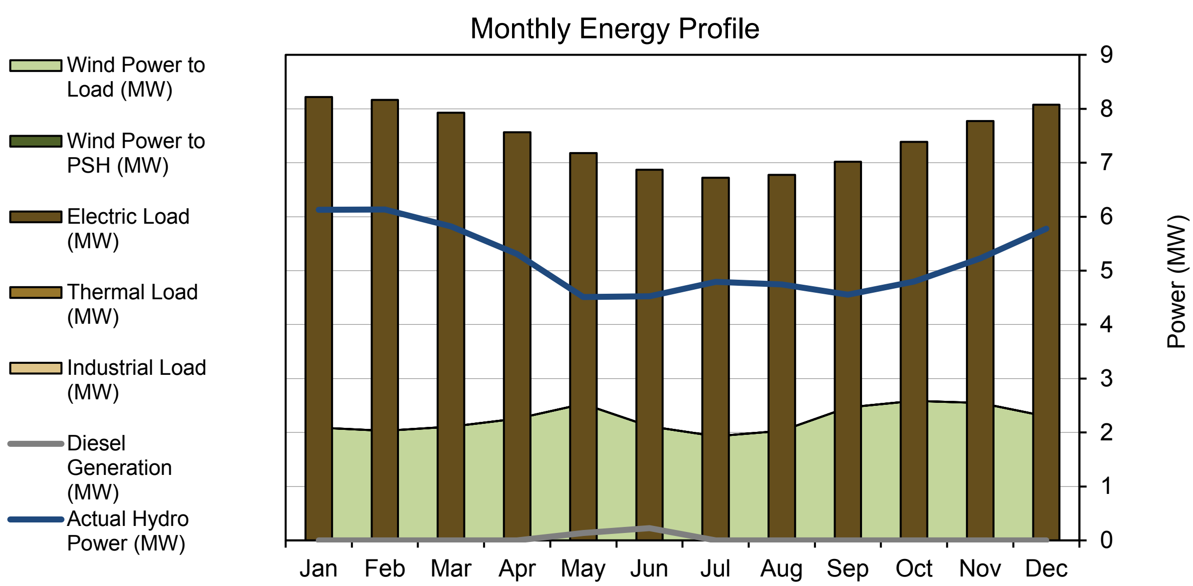
**Summary**

Iqaluit Renewable Energy Project

Jaynes Inlet Hydro & Wind - Electric Load Only

| **Scenario Inputs** | | | **Demand** | | |
|---|---|---|---|---|---|
| Wind Power Site | Jaynes Inlet | | Electrical Demand | 65.4 GWh | 100% |
| Wind Plant Capacity | 5 | MW | Thermal Demand | 0.0 GWh | 0% |
| Hydro Scenario Selection | Jaynes Inlet | | Industrial Demand | 0.0 GWh | 0% |
| Hydro Plant Capacity | 10 | MW | Total Demand | 65.4 GWh | |
| Pumped Storage Hydro | No | | | | |
| PSH Turbine Power Capacity | 0.0 | MW | **Renewable Capital Costs** | | |
| PSH Type | Open | | Hydro / PSH | $175,688,689 | |
| | | | Wind | $34,157,507 | |
| Diesel Base Load | 0.0 | MW | Total | $209,846,196 | |

| **Energy Supply** | | | **Levelized Cost of Energy** | | |
|---|---|---|---|---|---|
| **Renewable Supply** | 65.2 GWh | 100% | Diesel | $18,249 | /MWh |
| **Diesel Supply** | 0.3 GWh | 0% | Renewables | $390 | /MWh |
| | | | Aggregate | $463 | /MWh |
| Wind Supply | 19.7 GWh | | | | |
| Wind Capacity Factor | 45% | | | | |
| Hydro Supply | 45.5 GWh | | Diesel Run Time Hours | 244 hrs | 3% |
| Hydro Capacity Factor | 52% | | CO2 Emissions | 0.2 x 1000 ton/yr | |



## Hydro Calculations

Iqaluit Renewable Energy Project

Jaynes Inlet Hydro & Wind - Electric Load Only

**Penstock Hydraulics and Capacities**

| | | |
|---|---|---|
| Selected Power Capacity | 10.0 | MW |
| Maximum Gross Head | 437 | m |
| Target Headlosss at Capacit | 65.2 | m |
| Maximum Plant Flow Setting | 3.221 | m³/s |

**Low Flow Operations**

| | | |
|---|---|---|
| Turn Down Per Unit | 0% | |
| Number of Units | 3 | |
| Minimum Plant Flow | 0.00 | m³/s |

**Other Parameters**

| | | |
|---|---|---|
| Starting Reservoir Level | 50% | |
| Dam Slopes | 2 | H:1V |
| Freeboard | 5 | m |
| Design Flood to Mean Annual Discharge Ratio | 100 | |
| Transmission Voltage | 69 | kV |

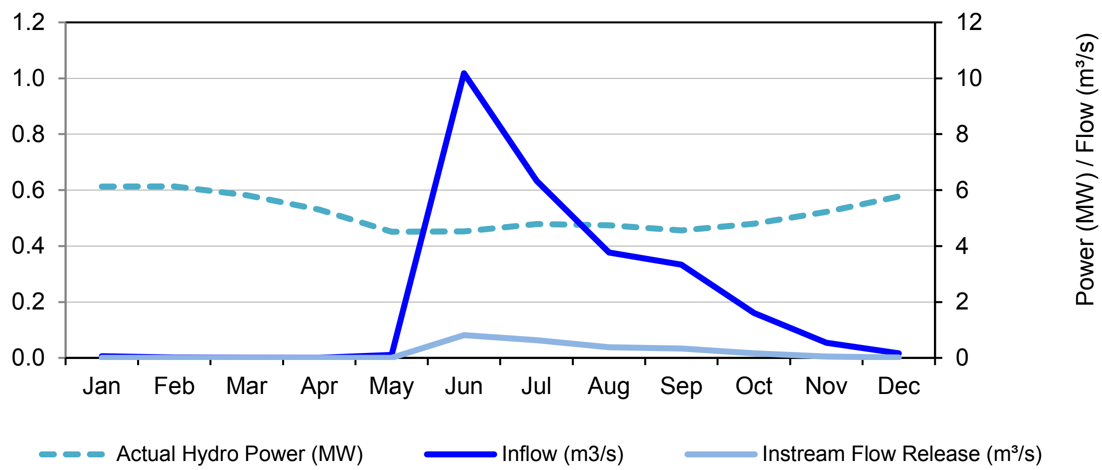
**Synthetic Inflows (Partial)**

**Jaynes Inlet**

| | |
|---|---|
| Watershed Area (km²) | 22.9 |
| Unit Runoff (l/s/km²) | 10.7 |
| Scaling Factor | 0.068 |
| Average Discharge | 2.18 |

| **Net Efficiency** | **83.4%** |
|---|---|
| Turbine | 90.0% |
| Generator | 97.5% |
| Transformer | 99.0% |
| Station Service Power Cons | 99.0% |
| Line Losses | 97.0% |

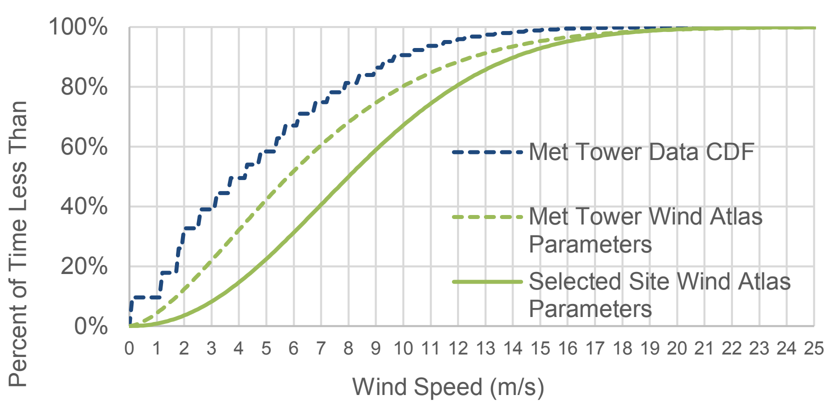
| Month | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Min | Avg | Max |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Actual Hydro Power (MW) | 6.13 | 6.13 | 5.82 | 5.31 | 4.51 | 4.53 | 4.79 | 4.75 | 4.56 | 4.8 | 5.23 | 5.78 | 0 | 5.19 | 9.71 |
| Inflow (m3/s) | 0.05 | 0.01 | 0.01 | 0.01 | 0.11 | 10.2 | 6.34 | 3.77 | 3.34 | 1.6 | 0.54 | 0.17 | 0 | 2.18 | 50.2 |
| Instream Flow Release (m³/s) | 0 | 0 | 0 | 0 | 0 | 0.81 | 0.63 | 0.38 | 0.33 | 0.16 | 0.05 | 0.01 | 0 | 0.2 | 1.02 |
| Hydro Spilled (MW) | 0 | 0 | 0 | 0 | 0 | 0 | 1.53 | 2.5 | 4.13 | 1.56 | 0 | 0 | 0 | 0.81 | 10 |
| Upper Reservoir Level (m) | -6.21 | -8.43 | -10.6 | -12.7 | -14.5 | -12.3 | -2.88 | -0.64 | -0.08 | -0.23 | -1.18 | -2.82 | -20 | -6.02 | 0 |
| Lower Reservoir Level (m) | -3 | -3 | -3 | -3 | -3 | -3 | -3 | -3 | -3 | -3 | -3 | -3 | -3 | -3 | -3 |



# Wind Calculations

Iqaluit Renewable Energy Project
Jaynes Inlet Hydro & Wind - Electric Load Only

| Turbine Data | | |
|---|---|---|
| Reference Turbine | Enercon E70 | |
| Rated Power | 2300 | kW |
| Hub Height | 75 | m |
| Cut-In Wind Speed | 2.0 | m/s |
| Cut-Out Wind Speed | 25.0 | m/s |
| Cut-Out Temperature | -40.0 | °C |
| IEC Wind Class | IA | |
| Rotor Diameter | 71 | m |
| **Wind Speed Scaling** | | |
| Met Tower Average Wind Speed | 4.41 | m/s |
| Wind Site Average Wind Speed | 8.42 | m/s |
| Site Wind Speed Reference Height | 50 | m |
| Hellmann Coefficient | 0.10 | |
| Wind Speed Scale Factor | 1.988 | |
| Elevation Difference | 1.988 | m |
| **Net Efficiency** | **85.4%** | |
| Power Curve Turbulence Variation | 100.0% | |
| Topgraphic Efficiency | 100.0% | |
| Wake Effects | 98.0% | |
| Collector Losses | 97.0% | |
| Station Service Consumption | 99.5% | |
| Transmission Losses | 98.0% | |
| Icing and Blade Degradation | 95.0% | |
| Substation Maintenance | 100.0% | |
| Effective Turbine Availability | 98.0% | |
| Hysterysis | 99.5% | |
| Sector Management | 99.5% | |




**Power Curve**

| Wind Speed m/s | Turbine Power % | Turbine Power kW |
|---|---|---|
| 0 | 0% | 0 |
| 1 | 0% | 0 |
| 2 | 0% | 0 |
| 3 | 12% | 267 |
| 4 | 23% | 530 |
| 5 | 34% | 787 |
| 6 | 45% | 1032 |
| 7 | 55% | 1264 |
| 8 | 64% | 1478 |
| 9 | 73% | 1673 |
| 10 | 80% | 1845 |
| 11 | 87% | 1992 |
| 12 | 92% | 2112 |
| 13 | 96% | 2203 |
| 14 | 98% | 2265 |
| 15 | 100% | 2296 |
| 16 | 100% | 2300 |
| 17 | 100% | 2300 |
| 18 | 100% | 2300 |
| 19 | 100% | 2300 |
| 20 | 100% | 2300 |
| 21 | 100% | 2300 |
| 22 | 100% | 2300 |
| 23 | 100% | 2300 |
| 24 | 100% | 2300 |
| 25 | 100% | 2300 |
| 26 | 0% | 0 |
| 27 | 0% | 0 |
| 28 | 0% | 0 |
| 29 | 0% | 0 |
| 30 | 0% | 0 |
| 31 | 0% | 0 |
| 32 | 0% | 0 |
| 33 | 0% | 0 |
| 34 | 0% | 0 |

# Hydro Costs

Iqaluit Renewable Energy Project
Jaynes Inlet Hydro & Wind - Electric Load Only

## Hydro / Pumped Storage

| Capital Cost | | Capex | |
|---|---|---|---|
| Mobilization & Site Services | $ 6,579,304 | Civil | $ 107,961 |
| Access Roads / Bridges / Barge landing | $ 4,450,000 | Electrical | $ 147,099 |
| Civil / Siteworks / Foundations | $ 300,000 | Mechanical | $ 35,479 |
| Reservoir Dam/Spillway/Intake Works | $ 8,181,224 | Contingency | $ 58,108 |
| Tunnel/Shaft Works | $ 22,449,248 | | $ - |
| Penstock Supply and Install Works | $ 41,621,677 | **Total Annualized CAPEX** | **$348,647** |
| Turbine-Generator package supply | $ 4,315,000 | Percent of Capital Cost | 0.2% |
| Turbine-Generator Install | $ 500,000 | | |
| Powerhouse | $ 1,650,000 | **OPEX** | $ - |
| Substation and BOP Electrical | $ 1,407,000 | Management/Operators/Service | $ 501,000 |
| Transmission Line | $ 33,936,000 | Environmental & Regulatory | $ 25,000 |
| Iqaluit Electrical System Upgrades | $ 500,000 | Stakeholder Benefit Agreements | $ - |
| | | Landowner Payments | $ - |
| Remote Labour Premium | 3.0% | Crown Land Lease Payments | $ 20,000 |
| Engineering, PM, & CM | 4.3% | Insurance, Taxes, Utilities | $ 1,414,702 |
| Environmental & Permitting | 2.3% | Contingency | 10% |
| Owner's Cost | 6.7% | | |
| Interest During Construction (IDC) | 5.0% | **Total Annual OPEX** | **$2,156,772** |
| Debt Service Reserve | 5.0% | Percent of Capital Cost | 1.2% |
| Bonding and Insurance | 2.0% | | |
| | | | |
| Contingency | 10.0% | | |
| | | | |
| **Total Capital Cost** | **$175,688,689** | | |
| | **$17,568,869** | **/MW** | |

# Wind Costs

Iqaluit Renewable Energy Project
Jaynes Inlet Hydro & Wind - Electric Load Only

**Wind**

| **Capital Cost** | | **Capex** | |
|---|---|---|---|
| Mobilization & Site Services | $ 2,081,607 | Civil | $3,017 |
| Access Roads | $ 3,700,000 | Electrical | $9,226 |
| Civil / Siteworks / Foundations | $ 1,030,435 | Mechanical / Turbine | $73,551 |
| Turbine Supply | $ 10,529,348 | Contingecy | 15% |
| Turbine Transport, Installation | $ 684,783 | | |
| Mobile Crane Purchase | $ 3,000,000 | **Total Annualized CAPEX** | **$98,663** |
| Substation & Elec BOP | $ 1,095,043 | Percent of Capital Cost | 0.29% |
| Transmission Line 69 kV DB | $ 1,767,500 | | |
| Iqaluit Electrical System Upgrades | $ - | **OPEX** | |
| Operations Building | $ 300,000 | Management/Operators/Service | $935,000 |
| | | Environmental & Regulartor | $5,000 |
| Remote Labour Premium | 2.0% | Land Lease Payments | $10,000 |
| Engineering, PM, & CM | 5.3% | Stakeholder Benefit Agreements | $0 |
| Environmental & Permitting | 3.3% | Insurance, Taxes, Utilities | $340,475 |
| Owner's Cost | 10.5% | Contingency | 10% |
| Interest During Construction (IDC) | 5.0% | | |
| Debt Service Reserve | 5.0% | **Total Annual OPEX** | **$1,419,522** |
| | 0.0% | Percent of Capital Cost | 4.2% |
| Contingency | 10.0% | | |
| | | | |
| **Total Capital Cost** | **$34,157,507** | | |
| | **$6,831,501** | **/MW** | |

CANADIAN PROJECTS LIMITED

# Economics

Iqaluit Renewable Energy Project
Jaynes Inlet Hydro & Wind - Electric Load Only

## Renewables Cost Summary

| | Hydro / PSH | Wind | Total | |
|---|---|---|---|---|
| Capital Cost | $175,688,689 | $34,157,507 | $209,846,196 | |
| Average Annual Energy | | | 65,168 | MWh |
| Gross Energy Cost | | | $3,220 | /MWh |
| | | | | |
| Annualized Capex | $348,647 | $98,663 | $447,310 | |
| Annual Opex | $2,156,772 | $1,419,522 | $3,576,294 | |
| Total Annual Costs | $2,505,419 | $1,518,186 | $4,023,604 | |
| | | | | |
| Repowering Percent of Captial | 0% | 70% | | |
| Repowering Cost | $0 | $23,910,255 | | |
| Repowering Interval (years) | 0 | 20 | | |
| | | | | |
| Residual Value Percent of Capital | 0% | 0% | | |
| Residual Value | $0 | $0 | $0 | |

## General Economic Parameters

| | | |
|---|---|---|
| Estimate Basis Year | 2023 | |
| First Production Year | 2026 | |
| General Cost Escalation Rate | 2.0% | / year |
| Discount Rate | 10.0% | |
| Economic Planning Period | 50 | years |

## Levelized Cost of Energy

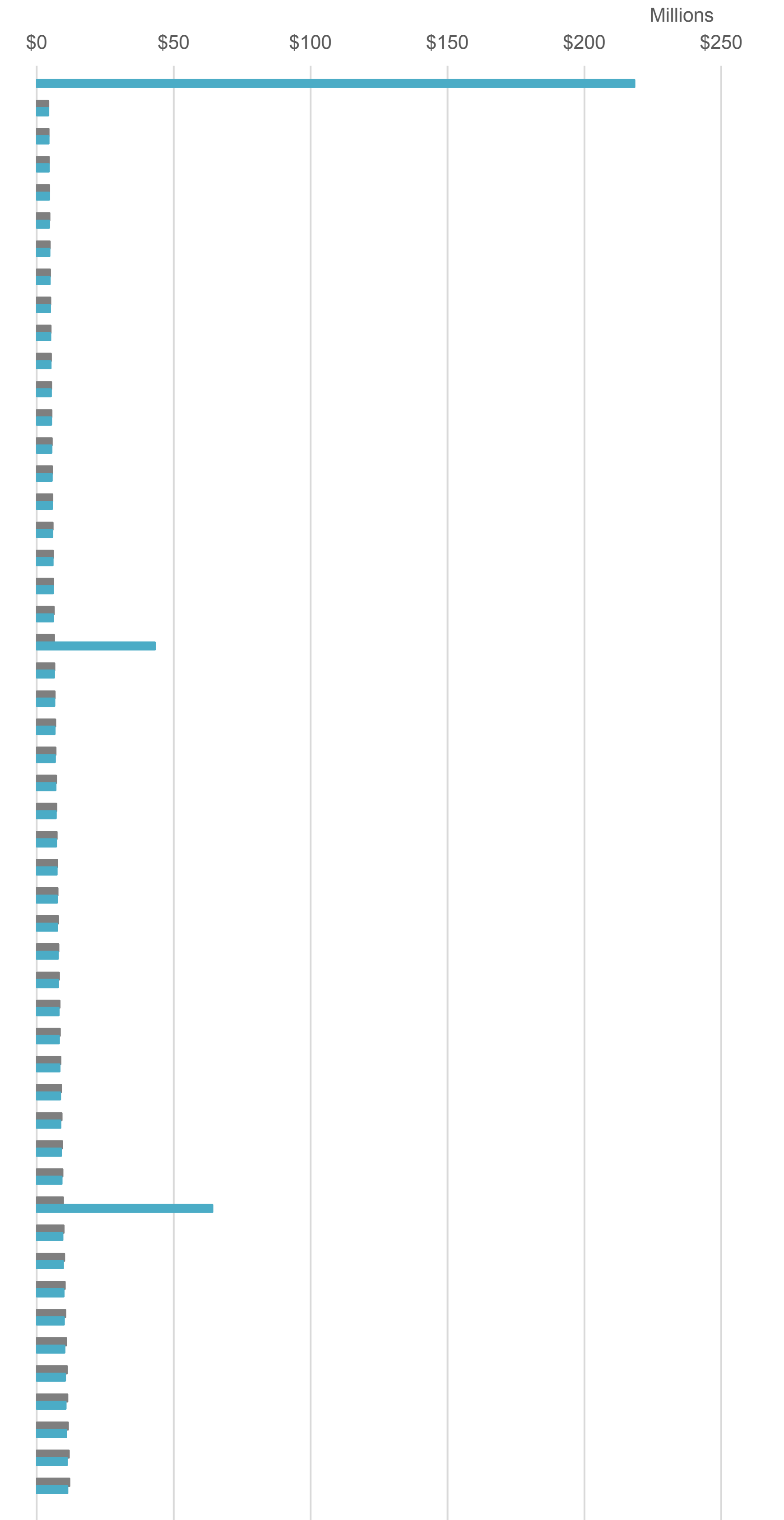
| | | | | | |
|---|---|---|---|---|---|
| Diesel | 0% | 266 | MWh | $18,249 | /MWh |
| Renewables | 100% | 65,168 | MWh | $390 | /MWh |
| Aggregate | 100% | 65,434 | MWh | $463 | /MWh |

*LCOE is the Net Present Value of escalated cash flow exclusive of financing arrangements and income tax considerations / Net present value of average annual energy, all at the specified discount rate over the economic planning period. Initial capital costs considered to be fully expended at the beginning of the first operating year.*

# Cash Flows

Iqaluit Renewable Energy Project
Jaynes Inlet Hydro & Wind - Electric Load Only

| | | Diesel | | | | | Renewables | | | Combined |
|---|---|---|---|---|---|---|---|---|---|---|
| | Year | Diesel Capex and Opex | Fuel Cost | Fuel Subsidy | Carbon Tax | Total Diesel Cost | Capital, Repower, Residual Value | Capex and Opex | Total Renewables Cost | Total Cost |
| 0 | 2025 | | | | | $0 | $218,323,982 | | $218,323,982 | $218,323,982 |
| 1 | 2026 | $4,166,907 | $139,534 | -$33,357 | $10,229 | $4,283,312 | $0 | $4,269,881 | $4,269,881 | $8,553,193 |
| 2 | 2027 | $4,250,245 | $145,115 | -$32,690 | $10,484 | $4,373,155 | $0 | $4,355,279 | $4,355,279 | $8,728,433 |
| 3 | 2028 | $4,335,250 | $150,920 | -$32,036 | $10,746 | $4,464,880 | $0 | $4,442,384 | $4,442,384 | $8,907,264 |
| 4 | 2029 | $4,421,955 | $156,957 | -$31,396 | $11,015 | $4,558,531 | $0 | $4,531,232 | $4,531,232 | $9,089,763 |
| 5 | 2030 | $4,510,394 | $163,235 | -$30,768 | $11,291 | $4,654,152 | $0 | $4,621,857 | $4,621,857 | $9,276,009 |
| 6 | 2031 | $4,600,602 | $169,764 | -$30,152 | $11,573 | $4,751,787 | $0 | $4,714,294 | $4,714,294 | $9,466,081 |
| 7 | 2032 | $4,692,614 | $176,555 | -$29,549 | $11,862 | $4,851,482 | $0 | $4,808,580 | $4,808,580 | $9,660,061 |
| 8 | 2033 | $4,786,466 | $183,617 | -$28,958 | $12,159 | $4,953,284 | $0 | $4,904,751 | $4,904,751 | $9,858,035 |
| 9 | 2034 | $4,882,196 | $190,962 | -$28,379 | $12,463 | $5,057,241 | $0 | $5,002,846 | $5,002,846 | $10,060,087 |
| 10 | 2035 | $4,979,840 | $198,600 | -$27,812 | $12,774 | $5,163,402 | $0 | $5,102,903 | $5,102,903 | $10,266,306 |
| 11 | 2036 | $5,079,436 | $206,544 | -$27,255 | $13,094 | $5,271,819 | $0 | $5,204,961 | $5,204,961 | $10,476,780 |
| 12 | 2037 | $5,181,025 | $214,806 | -$26,710 | $13,421 | $5,382,542 | $0 | $5,309,060 | $5,309,060 | $10,691,602 |
| 13 | 2038 | $5,284,646 | $223,398 | -$26,176 | $13,756 | $5,495,624 | $0 | $5,415,242 | $5,415,242 | $10,910,866 |
| 14 | 2039 | $5,390,339 | $232,334 | -$25,652 | $14,100 | $5,611,121 | $0 | $5,523,546 | $5,523,546 | $11,134,667 |
| 15 | 2040 | $5,498,145 | $241,628 | -$25,139 | $14,453 | $5,729,086 | $0 | $5,634,017 | $5,634,017 | $11,363,104 |
| 16 | 2041 | $5,608,108 | $251,293 | -$24,637 | $14,814 | $5,849,578 | $0 | $5,746,698 | $5,746,698 | $11,596,276 |
| 17 | 2042 | $5,720,270 | $261,344 | -$24,144 | $15,184 | $5,972,655 | $0 | $5,861,632 | $5,861,632 | $11,834,287 |
| 18 | 2043 | $5,834,676 | $271,798 | -$23,661 | $15,564 | $6,098,377 | $0 | $5,978,864 | $5,978,864 | $12,077,241 |
| 19 | 2044 | $5,951,369 | $282,670 | -$23,188 | $15,953 | $6,226,805 | $0 | $6,098,442 | $6,098,442 | $12,325,246 |
| 20 | 2045 | $6,070,397 | $293,977 | -$22,724 | $16,352 | $6,358,002 | $36,964,768 | $6,220,410 | $43,185,179 | $49,543,180 |
| 21 | 2046 | $6,191,805 | $305,736 | -$22,270 | $16,761 | $6,492,032 | $0 | $6,344,819 | $6,344,819 | $12,836,851 |
| 22 | 2047 | $6,315,641 | $317,965 | -$21,824 | $17,180 | $6,628,962 | $0 | $6,471,715 | $6,471,715 | $13,100,677 |
| 23 | 2048 | $6,441,954 | $330,684 | -$21,388 | $17,609 | $6,768,859 | $0 | $6,601,149 | $6,601,149 | $13,370,009 |
| 24 | 2049 | $6,570,793 | $343,911 | -$20,960 | $18,050 | $6,911,794 | $0 | $6,733,172 | $6,733,172 | $13,644,966 |
| 25 | 2050 | $6,702,208 | $357,668 | -$20,541 | $18,501 | $7,057,836 | $0 | $6,867,836 | $6,867,836 | $13,925,672 |
| 26 | 2051 | $6,836,253 | $371,975 | -$20,130 | $18,963 | $7,207,061 | $0 | $7,005,193 | $7,005,193 | $14,212,253 |
| 27 | 2052 | $6,972,978 | $386,854 | -$19,727 | $19,437 | $7,359,541 | $0 | $7,145,296 | $7,145,296 | $14,504,838 |
| 28 | 2053 | $7,112,437 | $402,328 | -$19,333 | $19,923 | $7,515,355 | $0 | $7,288,202 | $7,288,202 | $14,803,558 |
| 29 | 2054 | $7,254,686 | $418,421 | -$18,946 | $20,421 | $7,674,582 | $0 | $7,433,966 | $7,433,966 | $15,108,548 |
| 30 | 2055 | $7,399,780 | $435,158 | -$18,567 | $20,932 | $7,837,302 | $0 | $7,582,646 | $7,582,646 | $15,419,948 |
| 31 | 2056 | $7,547,775 | $452,564 | -$18,196 | $21,455 | $8,003,599 | $0 | $7,734,299 | $7,734,299 | $15,737,897 |
| 32 | 2057 | $7,698,731 | $470,666 | -$17,832 | $21,992 | $8,173,557 | $0 | $7,888,985 | $7,888,985 | $16,062,541 |
| 33 | 2058 | $7,852,705 | $489,493 | -$17,475 | $22,541 | $8,347,265 | $0 | $8,046,764 | $8,046,764 | $16,394,029 |
| 34 | 2059 | $8,009,759 | $509,073 | -$17,126 | $23,105 | $8,524,812 | $0 | $8,207,700 | $8,207,700 | $16,732,511 |
| 35 | 2060 | $8,169,955 | $529,436 | -$16,783 | $23,683 | $8,706,290 | $0 | $8,371,854 | $8,371,854 | $17,078,143 |
| 36 | 2061 | $8,333,354 | $550,613 | -$16,448 | $24,275 | $8,891,794 | $0 | $8,539,291 | $8,539,291 | $17,431,085 |
| 37 | 2062 | $8,500,021 | $572,638 | -$16,119 | $24,882 | $9,081,421 | $0 | $8,710,076 | $8,710,076 | $17,791,498 |
| 38 | 2063 | $8,670,021 | $595,543 | -$15,796 | $25,504 | $9,275,272 | $0 | $8,884,278 | $8,884,278 | $18,159,550 |
| 39 | 2064 | $8,843,422 | $619,365 | -$15,480 | $26,141 | $9,473,447 | $0 | $9,061,963 | $9,061,963 | $18,535,411 |
| 40 | 2065 | $9,020,290 | $644,140 | -$15,171 | $26,795 | $9,676,054 | $54,927,701 | $9,243,203 | $64,170,904 | $73,846,957 |
| 41 | 2066 | $9,200,696 | $669,905 | -$14,867 | $27,465 | $9,883,198 | $0 | $9,428,067 | $9,428,067 | $19,311,265 |
| 42 | 2067 | $9,384,710 | $696,701 | -$14,570 | $28,151 | $10,094,992 | $0 | $9,616,628 | $9,616,628 | $19,711,620 |
| 43 | 2068 | $9,572,404 | $724,569 | -$14,279 | $28,855 | $10,311,550 | $0 | $9,808,961 | $9,808,961 | $20,120,510 |
| 44 | 2069 | $9,763,852 | $753,552 | -$13,993 | $29,576 | $10,532,988 | $0 | $10,005,140 | $10,005,140 | $20,538,127 |
| 45 | 2070 | $9,959,129 | $783,694 | -$13,713 | $30,316 | $10,759,426 | $0 | $10,205,243 | $10,205,243 | $20,964,669 |
| 46 | 2071 | $10,158,312 | $815,042 | -$13,439 | $31,074 | $10,990,988 | $0 | $10,409,348 | $10,409,348 | $21,400,336 |
| 47 | 2072 | $10,361,478 | $847,644 | -$13,170 | $31,850 | $11,227,802 | $0 | $10,617,535 | $10,617,535 | $21,845,337 |
| 48 | 2073 | $10,568,708 | $881,549 | -$12,907 | $32,647 | $11,469,997 | $0 | $10,829,885 | $10,829,885 | $22,299,882 |
| 49 | 2074 | $10,780,082 | $916,811 | -$12,649 | $33,463 | $11,717,707 | $0 | $11,046,483 | $11,046,483 | $22,764,190 |
| 50 | 2075 | $10,995,683 | $953,484 | -$12,396 | $34,299 | $11,971,071 | $0 | $11,267,413 | $11,267,413 | $23,238,484 |
| 51 | 2076 | | | | | $0 | $0 | | $0 | $0 |



# Appendix C
# Screening Matrix

## Alternatives Screening Matrix

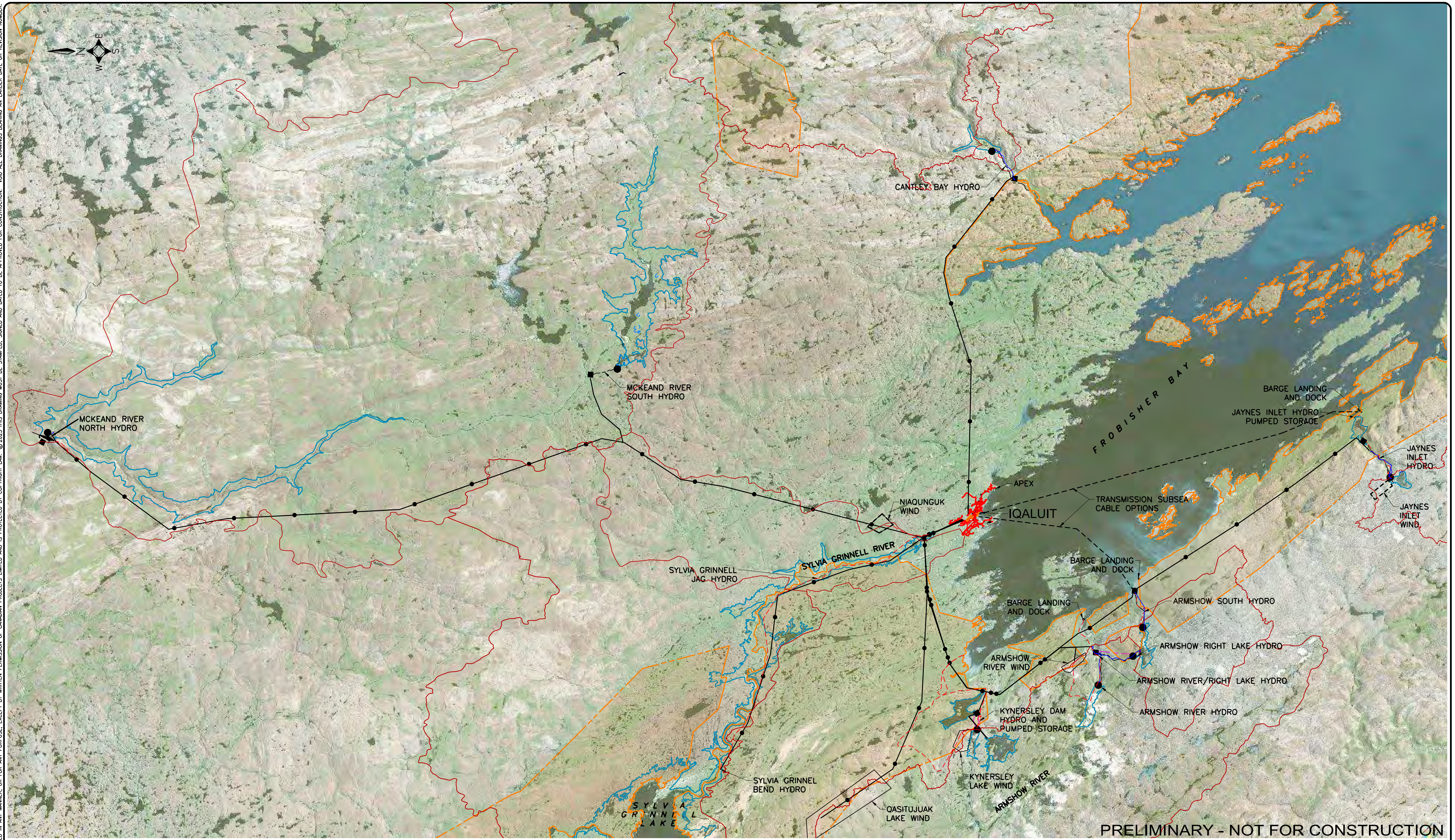
| Criterion | Description | Value | Goal Type | Weighting Scenario A | Weighting Scenario B | Weighting Scenario C | Weighting Scenario D | Weighting Scenario E | Weighting Scenario F |
|---|---|---|---|---|---|---|---|---|---|
| Capacity (Electric Load) | Total Installed capacity. | MW | Min | 0% | 0% | 0% | 0% | 0% | 0% |
| Average Energy (Electric Load) | Average annual energy from the project which is consumed by load, excludes surplus energy. | MWh | Max | 0% | 0% | 0% | 0% | 0% | 0% |
| Renewable Supply (Electric Load) | Percentage of total energy demand met by renewables. | % | Max | 0% | 0% | 0% | 0% | 0% | 0% |
| Capital Cost (Electric Load) | Capital cost as a separate criterion from LCOE is intended to capture ability to finance / cost of capital. Projects may be too large to secure financing | $ millions | Min | 0% | 0% | 0% | 0% | 0% | 0% |
| LCOE Aggregate (Electric Load) | Levelized cost of energy in 2023 dollars, 50 year economic life, 8% discount rate, no residual value, 2% inflation on operating and sustaining capex (hydro generator replacement, turbine overhauls, wind project repowering) and project energy pricing, effective 5% inflation on total cost of fossil fuel energy inclusive of fuel price projections and future carbon taxation, net of subsidies and capital cost offsets. Evaluated on total scenario load with no value for surplus renewable generation. | $/MWh | Min | 15% | 0% | 100% | 0% | 0% | 0% |
| LCOE Renewable (Electric Load) | Same as above excluding diesel generation costs. | $/MWh | Min | 0% | 100% | 0% | 0% | 0% | 0% |
| Emissions (Electric Load) | Carbon emission in tons of CO2 per year assuming heating fuel conversion to electric. Intended to capture significance beyond real cost accounted for in LCOE, which includes an estimate of escalation for carbon tax and fuel base pricing. Canada's target of net-zero emissions by 2050 or public / stakeholder perception of the same. | tons CO2 / year | Min | 1% | 0% | 0% | 0% | 0% | 1% |
| Capacity (Electric, Thermal, Industrial Loads) | Per above | MW | Min | 0% | 0% | 0% | 0% | 0% | 0% |
| Average Energy (Electric, Thermal, Industrial Loads) | Per above | MWh | Max | 0% | 0% | 0% | 0% | 0% | 0% |
| Renewable Supply (Electric, Thermal, Industrial Loads) | Per above | % | Max | 0% | 0% | 0% | 0% | 0% | 0% |
| Capital Cost (Electric, Thermal, Industrial Loads) | Per above | $ millions | Min | 0% | 0% | 0% | 0% | 0% | 0% |
| LCOE Aggregate (Electric, Thermal, Industrial Loads) | Per above | $/MWh | Min | 15% | 0% | 0% | 0% | 100% | 0% |
| LCOE Renewable (Electric, Thermal, Industrial Loads) | Per above | $/MWh | Min | 0% | 0% | 0% | 100% | 0% | 0% |
| Emissions (Electric, Thermal, Industrial Loads) | Per above | tons CO2 / year | Min | 0% | 0% | 0% | 0% | 0% | 0% |
| Cold Climate Risks | Technical risks focusing on cold weather nature of projects. Ice management, cold weather adaptations. | Rating<br>1 = Low<br>5 = High | Min | 3% | 0% | 0% | 0% | 0% | 4% |
| Geotechnical | Technical risks related to geotechnical conditions. Rock quality for tunnelling, availability of material for dam construction. | Rating<br>1 = Low<br>5 = High | Min | 1% | 0% | 0% | 0% | 0% | 1% |
| Resource Availability | Technical risks associated with wind and water with respect to uncertainty and climate change). | Rating<br>1 = Low<br>5 = High | Min | 1% | 0% | 0% | 0% | 0% | 1% |
| Reliability | Technology associated risks with respect to outages, spare parts, maintenance, MTBF, repair time. | Rating<br>1 = Low<br>5 = High | Min | 1% | 0% | 0% | 0% | 0% | 1% |
| System Integration | Difficulty of system integration and control issues. | Rating<br>1 = Low<br>5 = High | Min | 1% | 0% | 0% | 0% | 0% | 1% |
| Access | Potential access issues risk. | Rating<br>1 = Low<br>5 = High | Min | 1% | 0% | 0% | 0% | 0% | 1% |
| Transmission Length | Longer transmission line increases risk of outages. | km | Min | 1% | 0% | 0% | 0% | 0% | 1% |
| Schedule | Approximate development years to operation considering scope of the project, equipment supply, regulatory approvals, contractor availability. | years | Min | 2% | 0% | 0% | 0% | 0% | 3% |
| Constructability | Complexity, availability of specialized equipment, reliance on weather windows, level of interfacing required, experience. | Rating<br>1 = normal challenges<br>5 = major challenges | Min | 1% | 0% | 0% | 0% | 0% | 1% |
| Scalability | Ability to accommodate scaled deployment. | Degree in Percent | Max | 10% | 0% | 0% | 0% | 0% | 14% |
| Health and Safety | Perceived or actual risk to project personnel and the public during construction and operations. Electrical safety, reservoir fluctuations during ice covered period, wind turbine noise, visual health impacts | Rating<br>1 = limited issues<br>5 = major issues | Min | 5% | 0% | 0% | 0% | 0% | 7% |
| Biophysical Environment | Interactions including vegetation/habitat as well as aquatic, terrestrial, and avian species. Include potential adverse effects on Species at Risk, contaminant uptake (ecological risk), population dynamics and habitat disturbance / disruption / destruction. Consider the potential for residual adverse effects to be Significant. Exclude consideration of induced effects (harvesting / resource use, economy, tourism). | Rating<br>1 = no negative residual effects, no mitigation measures required.<br>5 = Several predicted negative residual effects, some requiring custom-designed (unproven) mitigation and monitoring measures and/or compensation requirements. | Min | 10% | 0% | 0% | 0% | 0% | 14% |
| Local Infrastructure | Degree to which new local infrastructure is required to support the development including electrical system upgrades, substations, roads, fabrication facilities. | Rating<br>1 = limited<br>5 = significant | Min | 0% | 0% | 0% | 0% | 0% | 0% |
| Economic Benefits | Direct and indirect contributions to the local economy during construction and throughout the project lifecycle including employment, service industry benefits, growth potential associated with any inherent surplus sustainable energy supply. | Rating<br>1 = limited<br>5 = significant | Max | 5% | 0% | 0% | 0% | 0% | 7% |
| Stakeholder Support | Perceived or actual support (or opposition) from the public, utility, government and regulators. Consider "social license" and how many intervenors are likely. | Rating<br>1 = opposition<br>5 = support | Max | 2% | 0% | 0% | 0% | 0% | 3% |
| Rightsholder Support | Perceived or actual support (or opposition) from the land rights holders. | Rating<br>1 = opposition<br>5 = support | Max | 2% | 0% | 0% | 0% | 0% | 3% |
| Size Perception | Perceived negative view associated with a large footprint / large appearance viewed from Iqaluit and commonly travelled routes. | Rating<br>1 = limited visual<br>5 = significant visual | Min | 3% | 0% | 0% | 0% | 0% | 4% |
| Resource Use | Impacts to terrestrial, aquatic, or marine resource use. Impacts to fishing and harvesting patterns, hunting, foraging, use for recreation and tourism. | Rating<br>1 = limited<br>5 = significant | Min | 15% | 0% | 0% | 0% | 0% | 21% |
| Protected Areas | Parks or wildlife, ecological, conservation reserves potentially affected by the project | Number of different areas affected | Min | 2% | 0% | 0% | 0% | 0% | 3% |
| Permits and Approvals General | Perceived or actual level of effort, risks, issues with lack of framework or possible changes, number of required permits and approvals. Impact to land use planning process. | Rating<br>1 = normal effort, no new processes<br>5 = significant effort, new processes required | Min | 3% | 0% | 0% | 0% | 0% | 4% |
| NIRB | Project is the same scope as current NIRB file 13UN006 either in part or completely. | Percentage of similarity, e.g. same site, but different conveyance = 70% | Max | 0% | 0% | 0% | 0% | 0% | 0% |
| Inuit Owned Lands | Percentage of the project footprint on Inuit Owned Lands, including transmission line. | Percentage | Max | 0% | 0% | 0% | 0% | 0% | 0% |

| Criterion | Armshow River | Armshow South | Jaynes Inlet | Cantley Bay | McKeand North | McKeand South | Sylvia Grinnell Bend | Sylvia Grinnell Jag | Niaqunguk Wind | Qasitujuak Wind | Kynersley Wind | Armshow Wind | Jaynes Inlet Wind | Jaynes + Wind | Jaynes PSH + Wind | KI PSH + Wind |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Capacity (Electric Load) | 10 | 5 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 15 | 15 | 30 |
| Average Energy (Electric Load) | 65,000 | 40,600 | 53,800 | 65,300 | 64,700 | 65,400 | 64,700 | 65,400 | 34,700 | 36,700 | 35,300 | 38,100 | 36,700 | 65,200 | 65,100 | 40,200 |
| Renewable Supply (Electric Load) | 99% | 62% | 82% | 100% | 99% | 100% | 99% | 100% | 53% | 56% | 54% | 58% | 56% | 100% | 100% | 61% |
| Capital Cost (Electric Load) | $310 | $140 | $180 | $410 | $1,710 | $200 | $410 | $910 | $60 | $60 | $60 | $80 | $100 | $210 | $220 | $170 |
| LCOE Aggregate (Electric Load) | $590 | $603 | $521 | $692 | $2,783 | $338 | $693 | $1,472 | $571 | $561 | $574 | $570 | $624 | $462 | $489 | $710 |
| LCOE Renewable (Electric Load) | $516 | $387 | $368 | $682 | $2,781 | $335 | $679 | $1,469 | $250 | $258 | $264 | $292 | $371 | $389 | $416 | $544 |
| Emissions (Electric Load) | 300 | 17,700 | 8,300 | 100 | 500 | 0 | 500 | 0 | 21,900 | 20,600 | 21,600 | 19,500 | 20,500 | 200 | 200 | 18,000 |
| Capacity (Electric, Thermal, Industrial Loads) | 15 | 5 | 10 | 20 | 50 | 30 | 30 | 40 | 30 | 30 | 30 | 30 | 30 | 45 | 45 | 120 |
| Average Energy (Electric, Thermal, Industrial Loads) | 108,000 | 40,600 | 54,000 | 83,900 | 207,000 | 186,000 | 144,700 | 231,100 | 106,600 | 111,900 | 108,000 | 116,400 | 111,000 | 173,000 | 148,100 | 203,100 |
| Renewable Supply (Electric, Thermal, Industrial Loads) | 46% | 17% | 23% | 35% | 88% | 79% | 61% | 98% | 45% | 47% | 46% | 49% | 47% | 73% | 63% | 86% |
| Capital Cost (Electric, Thermal, Industrial Loads) | $330 | $140 | $180 | $410 | $1,760 | $270 | $460 | $950 | $130 | $130 | $130 | $150 | $170 | $310 | $290 | $430 |
| LCOE Aggregate (Electric, Thermal, Industrial Loads) | $650 | $796 | $782 | $771 | $982 | $378 | $622 | $479 | $607 | $594 | $606 | $587 | $614 | $462 | $544 | $464 |
| LCOE Renewable (Electric, Thermal, Industrial Loads) | $335 | $387 | $366 | $532 | $903 | $163 | $348 | $444 | $170 | $169 | $173 | $177 | $207 | $226 | $245 | $279 |
| Emissions (Electric, Thermal, Industrial Loads) | 91,800 | 139,900 | 130,400 | 109,100 | 21,100 | 36,100 | 65,600 | 3,900 | 92,800 | 89,000 | 91,800 | 85,800 | 89,700 | 45,400 | 63,200 | 23,900 |
| Cold Climate Risks | 2 | 2 | 2 | 2 | 2 | 4 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 2 | 4 | 4 |
| Geotechnical | 2 | 1 | 1 | 4 | 4 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Resource Availability | 1 | 3 | 1 | 1 | 3 | 1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Reliability | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 3 | 3 | 3 | 3 | 3 | 5 | 5 |
| System Integration | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 3 | 4 | 5 |
| Access | 2 | 2 | 3 | 1 | 5 | 3 | 2 | 2 | 1 | 2 | 2 | 2 | 4 | 4 | 4 | 2 |
| Transmission Length | 45 | 45 | 96 | 52 | 140 | 60 | 29 | 14 | 7 | 30 | 1 | 1 | 5 | 96 | 96 | 30 |
| Schedule | 5 | 5 | 5 | 6 | 7 | 6 | 6 | 6 | 4 | 4 | 4 | 4 | 4 | 5 | 5 | 5 |
| Constructability | 2 | 4 | 4 | 2 | 3 | 3 | 2 | 4 | 1 | 2 | 2 | 2 | 3 | 4 | 4 | 3 |
| Scalability | 1 | 1 | 1 | 3 | 1 | 3 | 1 | 1 | 5 | 5 | 5 | 5 | 5 | 2 | 2 | 2 |
| Health and Safety | 3 | 1 | 1 | 3 | 2 | 1 | 5 | 5 | 3 | 2 | 2 | 1 | 1 | 1 | 1 | 2 |
| Biophysical Environment | 5 | 5 | 4 | 5 | 5 | 5 | 5 | 5 | 2 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| Local Infrastructure | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| Economic Benefits | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 4 | 4 | 4 |
| Stakeholder Support | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Rightsholder Support | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Size Perception | 3 | 1 | 1 | 3 | 3 | 2 | 5 | 5 | 3 | 2 | 2 | 2 | 1 | 1 | 1 | 2 |
| Resource Use | 5 | 2 | 2 | 2 | 2 | 2 | 5 | 5 | 2 | 3 | 3 | 3 | 2 | 2 | 2 | 2 |
| Protected Areas | 3 | 3 | 2 | 1 | 1 | 1 | 4 | 4 | 1 | 1 | 1 | 5 | 2 | 2 | 2 | 1 |
| Permits and Approvals General | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 3 | 3 | 3 | 4 | 4 | 5 | 5 | 5 |
| NIRB | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Inuit Owned Lands | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Notes
1. Projects includ related transmission lines to Iqaluit.
2. Total weighting is 100%. Weighting provided by Growler Energy / NNC January 25, 2023.
3. Scores displayed as "99" have yet to be determined/provided.

# Appendix D
# Drawings

| DWG | Component - Discipline | Element | Drawing Type | Rev | % | CAD File | Firm |
|---|---|---|---|---|---|---|---|
| | **PROJECT DRAWINGS** | | **Overall Total** | **32** | **70%** | | |
| **100** | **GENERAL** | | **Total** | **2** | **75%** | | |
| 111 | General - Project | Alternatives Overview | Plan | C | 75% | 4.3.010-A | CPL |
| 112 | General - Project | Alternatives Overview | Plan | C | 75% | 4.3.010 | CPL |
| **300** | **JAYNES INLET** | | **Total** | **5** | **75%** | | |
| 311 | Jaynes Inlet | Watersheds | Plan | C | 75% | 4.3.012 | CPL |
| 312 | Jaynes Inlet | Hydro and PSH Options | Plan | C | 75% | 4.3.002 | CPL |
| 321 | Jaynes Inlet | Project Layout | Plan & Profile | C | 75% | 4.3.002 | CPL |
| 341 | Jaynes Inlet | Upper Lake | Plan | C | 75% | 4.3.002 | CPL |
| 342 | Jaynes Inlet | Lower Lake | Plan | C | 75% | 4.3.002 | CPL |
| **500** | **McKEAND RIVER** | | **Total** | **6** | **75%** | | |
| 511 | McKeand River | Watersheds | Plan | B | 75% | 4.3.024 | CPL |
| 531 | McKeand River South | Overall Area | Plan | A | 75% | 4.3.023 | CPL |
| 532 | McKeand River South | Project Layout | Plan & Profile | B | 75% | 4.3.020 | CPL |
| 533 | McKeand River South | Storage Dam | Plan | B | 75% | 4.3.021 | CPL |
| **800** | **Wind Sites** | | **Total** | **3** | **75%** | | |
| 811 | Iqaluit | Overall Area | Plan | C | 75% | 4.3.015 | CPL |
| 821 | Niaqunguk Wind | Project Layout | Plan & Profile | B | 75% | 4.3.015 | CPL |




PRELIMINARY - NOT FOR CONSTRUCTION

## NOTES

1. ALL DIMENSIONS AND ELEVATIONS ARE IN METRES, UNLESS NOTED OTHERWISE.
2. BASE MAPPING IS CANVEC VECTOR MAPPING OBTAINED FROM THE GOVERNMENT OF CANADA IN FEBRUARY, 2023.
3. HORIZONTAL DATUM: NAD83 (CSRS) UTM ZONE 19.
4. VERTICAL DATUM: WGS84 ELLIPSOID.

## LEGEND

- INTAKE
- POWERHOUSE
- PENSTOCK
- ROAD
- TUNNEL
- HEADPOND/STORAGE AREAS
- INUIT OWNED LANDS
- TRANSMISSION LINE

Growler Energy

Landsvirkjun Power

SCALE 1:500 000

0 5 10 15 20 25

KILOMETRES

| REV | Y | M | D | REVISION DESCRIPTION | DES | CHK | DRN | CHK |
|---|---|---|---|---|---|---|---|---|
| C | 24 | 01 | 03 | GENERAL UPDATES – REMOVED STORAGE DAM | GS | GS | MH | CPB |
| B | 23 | 09 | 01 | GENERAL UPDATES | GS | GS | AM | CPB |
| A | 23 | 03 | 02 | NEW DRAWING | JG | JG | AM | CPB |

Canadian Projects Limited

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NNC

# GROWLER ENERGY

IQALUIT RENEWABLE ENERGY PROJECT
GENERAL - PROJECT ALTERNATIVES OVERVIEW
PLAN

PROJECT NUMBER 1096-006

CADD NUMBER 4.3.010

DRAWING NUMBER 111

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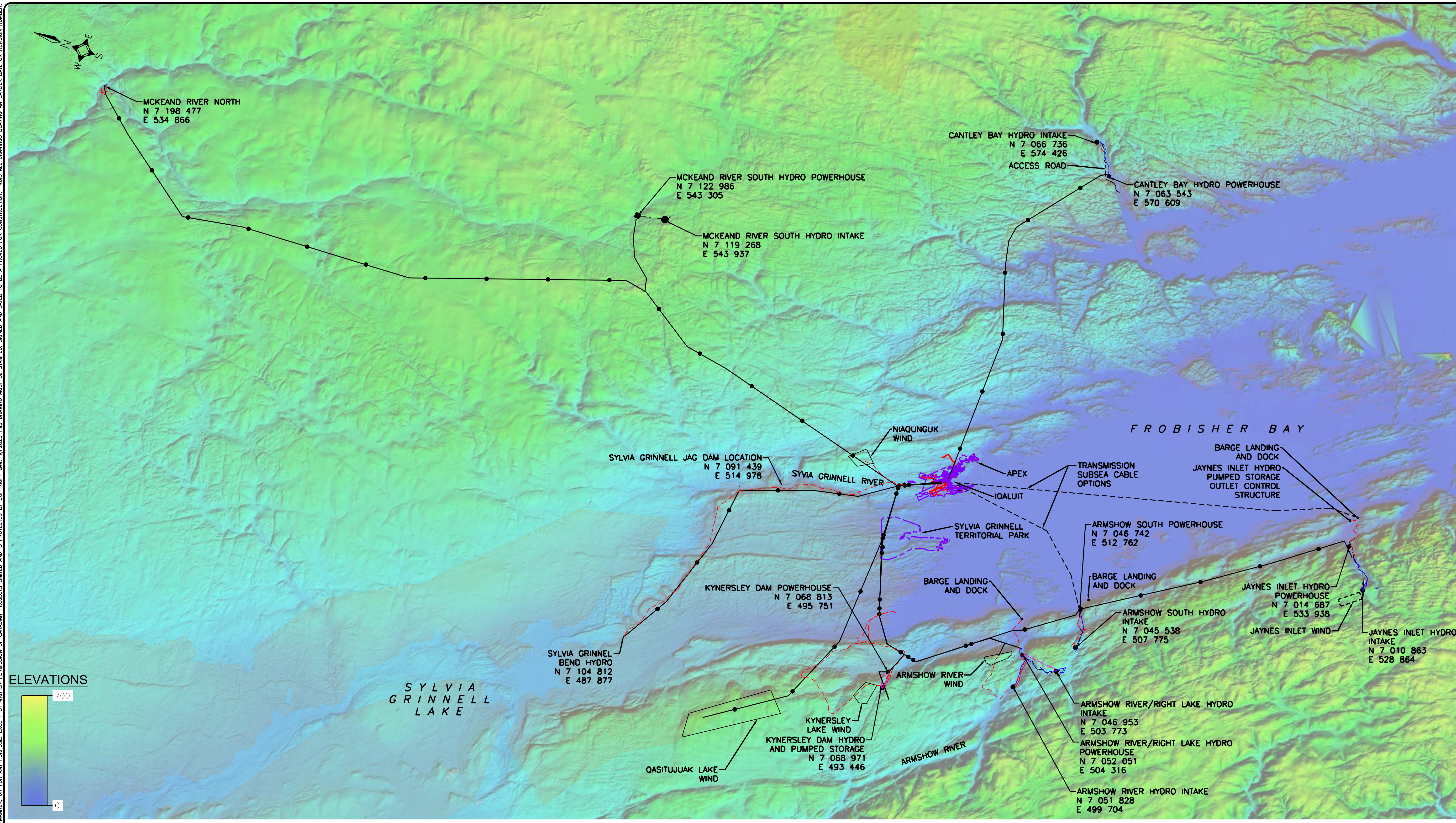


PRELIMINARY - NOT FOR CONSTRUCTION

## NOTES

1. ALL DIMENSIONS AND ELEVATIONS ARE IN METRES, UNLESS NOTED OTHERWISE.
2. SHADED ELEVATION MAP GENERATED BY CPL FROM DEM DATA FROM THE ARCTICDEM POLAR GEOSPATIAL CENTER DATED APRIL 15 TO JUNE 17, 2017
3. BASE MAPPING IS CANVEC VECTOR MAPPING OBTAINED FROM THE GOVERNMENT OF CANADA IN FEBRUARY, 2023.
4. HORIZONTAL DATUM: NAD83 (CSRS) UTM ZONE 19.
5. VERTICAL DATUM: WGS84 ELLIPSOID.

## LEGEND

- INTAKE
- POWERHOUSE
- GOVT. PARCELS
- PENSTOCK
- ROAD
- TUNNEL
- INUIT OWNED LANDS
- TRANSMISSION LINE
- TRANSMISSION SUBSEA LINE

Growler Energy

Landsvirkjun Power

SCALE 1:500 000

0 5 10 15 20 25

KILOMETRES

| REV | Y | M | D | REVISION DESCRIPTION | DES | CHK | DRN | CHK |
|---|---|---|---|---|---|---|---|---|
| C | 24 | 01 | 03 | GENERAL UPDATES – PROJECT NAMES | GS | GS | AM | CPB |
| B | 23 | 04 | 06 | GENERAL UPDATES | GS | GS | AM | CPB |
| A | 23 | 03 | 02 | NEW DRAWING | JG | JG | AM | CPB |

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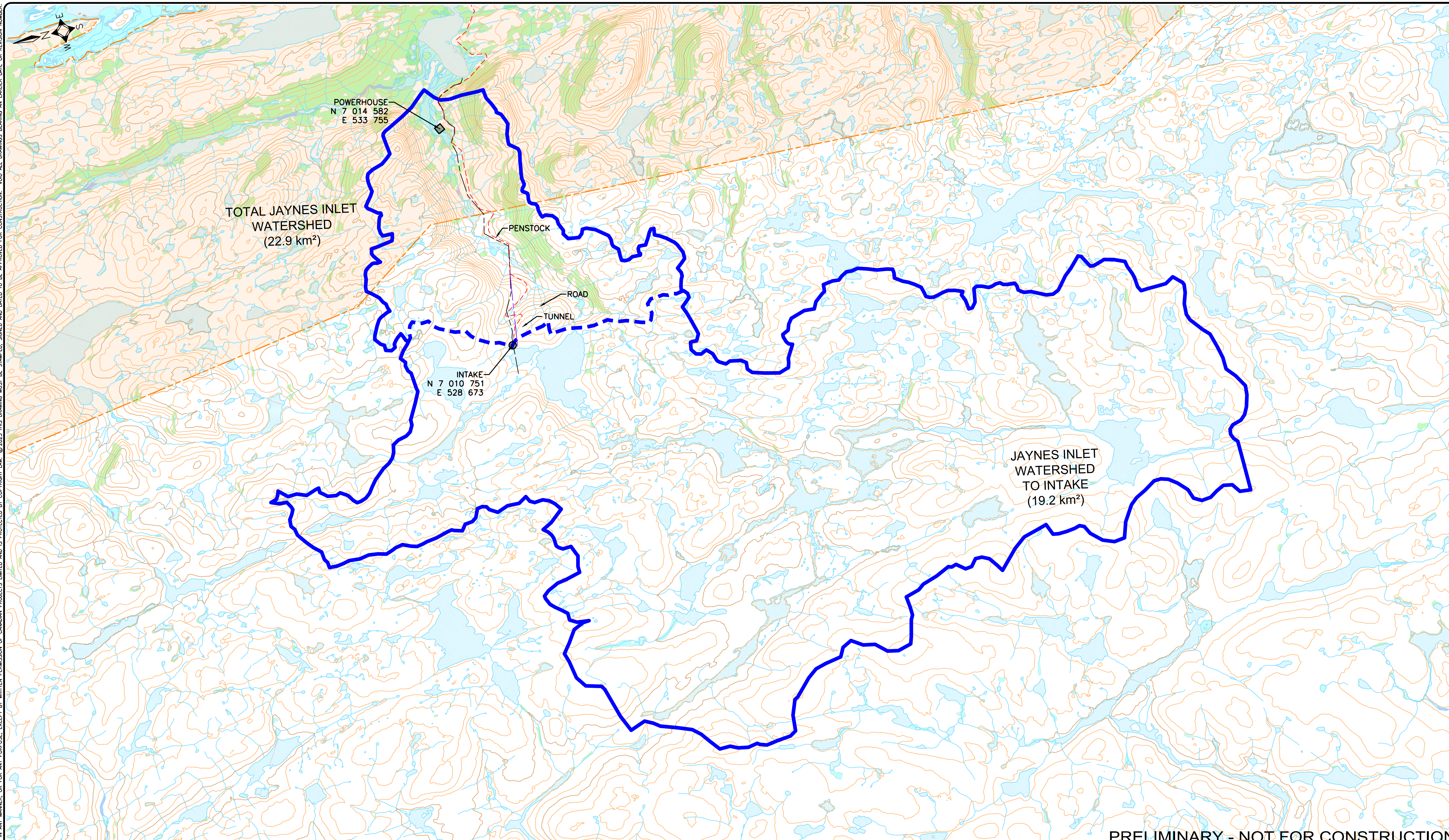
GROWLER ENERGY

IQALUIT RENEWABLE ENERGY PROJECT
GENERAL - PROJECT
ALTERNATIVES OVERVIEW
PLAN

PROJECT NUMBER
1096-006

CADD NUMBER
4.3.010

DRAWING NUMBER
112




PRELIMINARY - NOT FOR CONSTRUCTION

## NOTES

1. ALL DIMENSIONS AND ELEVATIONS ARE IN METRES, UNLESS NOTED OTHERWISE.
2. 40m INTERVAL CONTOURS GENERATED BY CPL FROM DEM DATA FROM THE ARCTICDEM POLAR GEOSPATIAL CENTER DATED APRIL 15 TO JUNE 17, 2017
3. BASE MAPPING IS CANVEC VECTOR MAPPING OBTAINED FROM THE GOVERNMENT OF CANADA IN FEBRUARY, 2023.
4. HORIZONTAL DATUM: NAD83 (CSRS) UTM ZONE 19.
5. VERTICAL DATUM: WGS84 ELLIPSOID.

Growler Energy

Landsvirkjun Power

SCALE 1:100 000

0 1 2 3 4 5

KILOMETRES

| REV | Y | M | D | REVISION DESCRIPTION | DES | CHK | DRN | CHK |
|---|---|---|---|---|---|---|---|---|
| B | 23 | 04 | 05 | GENERAL UPDATES | ADF | CJW | ADF | CPB |
| A | 23 | 03 | 21 | NEW DRAWING | ADF | CJW | ADF | CPB |

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# GROWLER ENERGY

IQALUIT RENEWABLE ENERGY PROJECT

JAYNES INLET

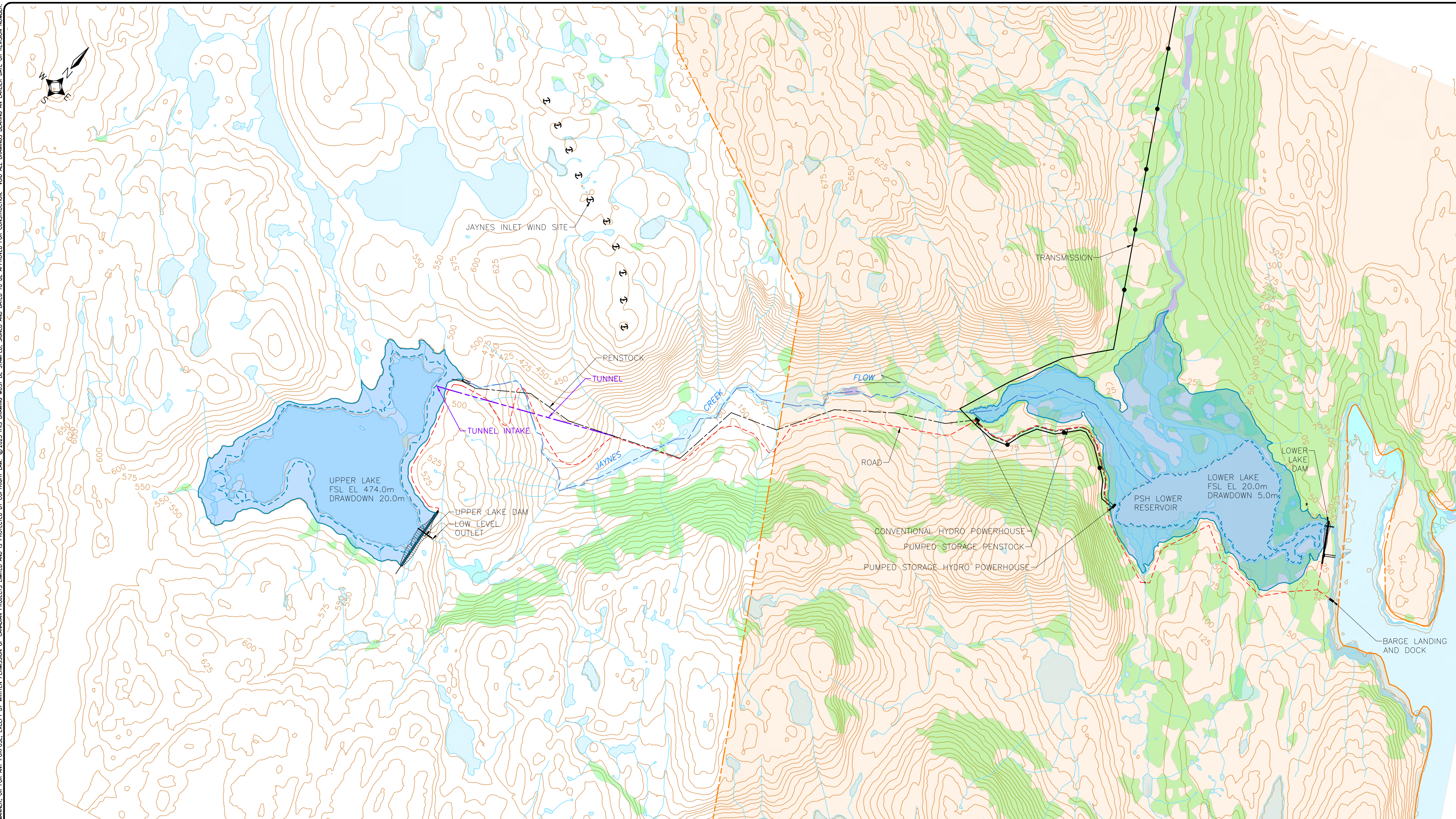
WATERSHEDS

PLAN

PROJECT NUMBER
1096-006

CADD NUMBER
4.3.012

DRAWING NUMBER
311




## NOTES

1. ALL DIMENSIONS AND ELEVATIONS ARE IN METRES, UNLESS NOTED OTHERWISE.
2. 5m INTERVAL CONTOURS GENERATED BY CPL FROM DEM DATA FROM THE ARCTICDEM POLAR GEOSPATIAL CENTER DATED APRIL 15 TO JUNE 17, 2017
3. BASE MAPPING IS CANVEC VECTOR MAPPING OBTAINED FROM THE GOVERNMENT OF CANADA IN FEBRUARY, 2023.
4. HORIZONTAL DATUM: NAD83 (CSRS) UTM ZONE 19.
5. VERTICAL DATUM: WGS84 ELLIPSOID.

## LEGEND

- PENSTOCK
- ROAD
- TUNNEL
- FSL
- LSL
- INUIT OWNED LANDS
- VEGETATED AREA
- NORMAL WATER
- PROPOSED RESERVOIR
- INTERMITTENT WATER
- TRANSMISSION LINE
- TURBINE

Growler Energy

Landsvirkjun Power

SCALE 1:40 000

0 400 800 1200 1600 2000

METRES

| REV | Y | M | D | REVISION DESCRIPTION | DES | CHK | DRN | CHK |
|---|---|---|---|---|---|---|---|---|
| C | 23 | 12 | 21 | GENERAL COMMENTS | GS | GS | MH | CPB |
| B | 23 | 04 | 17 | ADDED WIND SITE, UPDATED LAYOUT | JG | CJW | MH | CPB |
| A | 23 | 03 | 20 | NEW DRAWING | JG | CJW | MH | CPB |

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PRELIMINARY - NOT FOR CONSTRUCTION

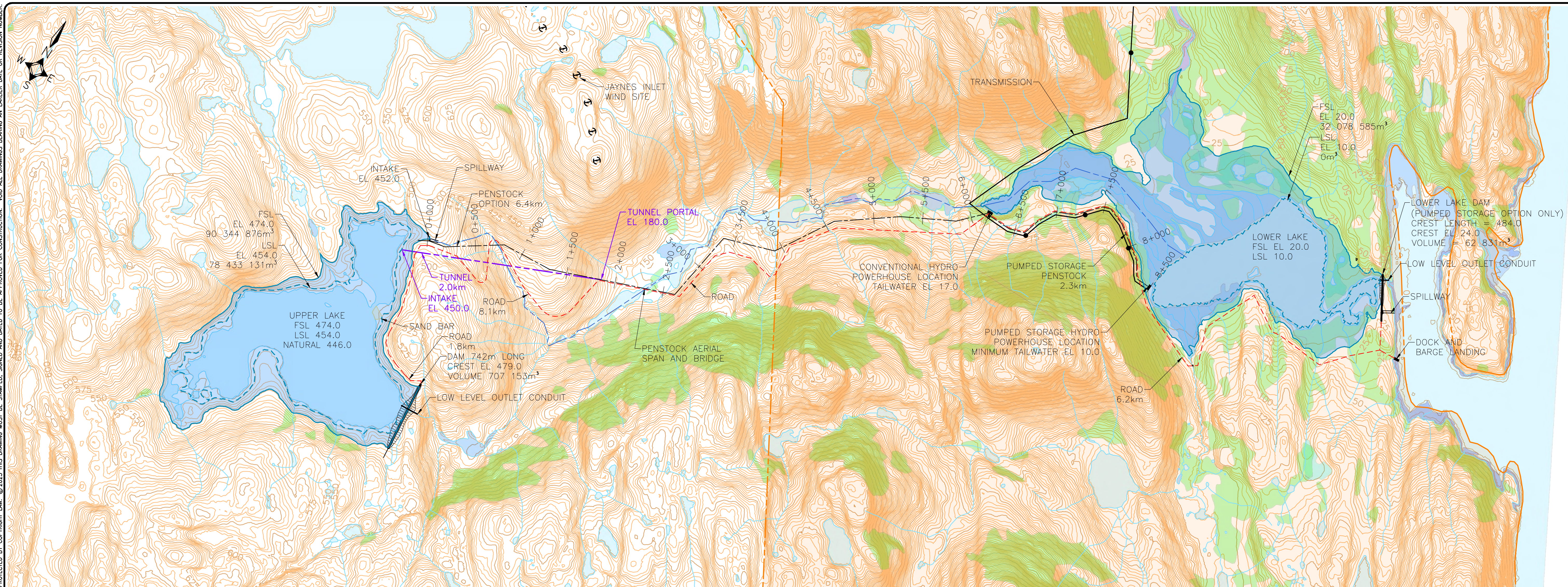
# GROWLER ENERGY

IQALUIT RENEWABLE ENERGY PROJECT
JAYNES INLET
HYDRO AND PSH OPTIONS
PLAN

PROJECT NUMBER 1096-006

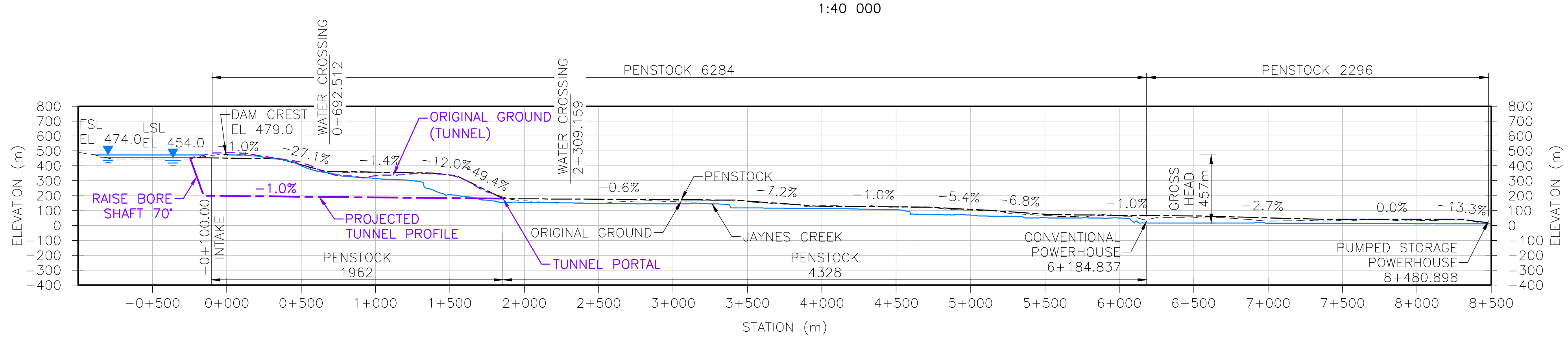
CADD NUMBER 4.3.002

DRAWING NUMBER 312




## PLAN

1:40 000




## PROFILE - PENSTOCK

1:40 000

## NOTES

1. ALL DIMENSIONS AND ELEVATIONS ARE IN METRES, UNLESS NOTED OTHERWISE.
2. 10m INTERVAL CONTOURS GENERATED BY CPL FROM DEM DATA FROM THE ARCTICDEM POLAR GEOSPATIAL CENTER DATED APRIL 15 TO JUNE 17, 2017
3. BASE MAPPING IS CANVEC VECTOR MAPPING OBTAINED FROM THE GOVERNMENT OF CANADA IN FEBRUARY, 2023.
4. HORIZONTAL DATUM: NAD83 (CSRS) UTM ZONE 19.
5. VERTICAL DATUM: WGS84 ELLIPSOID.

## LEGEND

- PENSTOCK
- ROAD
- TUNNEL
- FSL
- LSL
- INUIT OWNED LANDS
- VEGETATED AREA
- NORMAL WATER
- PROPOSED RESERVOIR
- INTERMITTENT WATER
- TRANSMISSION LINE

Growler Energy

Landsvirkjun Power

SCALE 1:40 000

0 400 800 1200 1600 2000

METRES

| REV | Y | M | D | REVISION DESCRIPTION | DES | CHK | DRN | CHK |
|---|---|---|---|---|---|---|---|---|
| C | 23 | 12 | 19 | GENERAL COMMENTS | GS | GS | MH | CPB |
| B | 23 | 04 | 06 | REVISED PENSTOCK, ROAD, PH, ADD DAM | GS | GS | MH | CB |
| A | 23 | 02 | 22 | NEW DRAWING | GS | GS | AM | CB |

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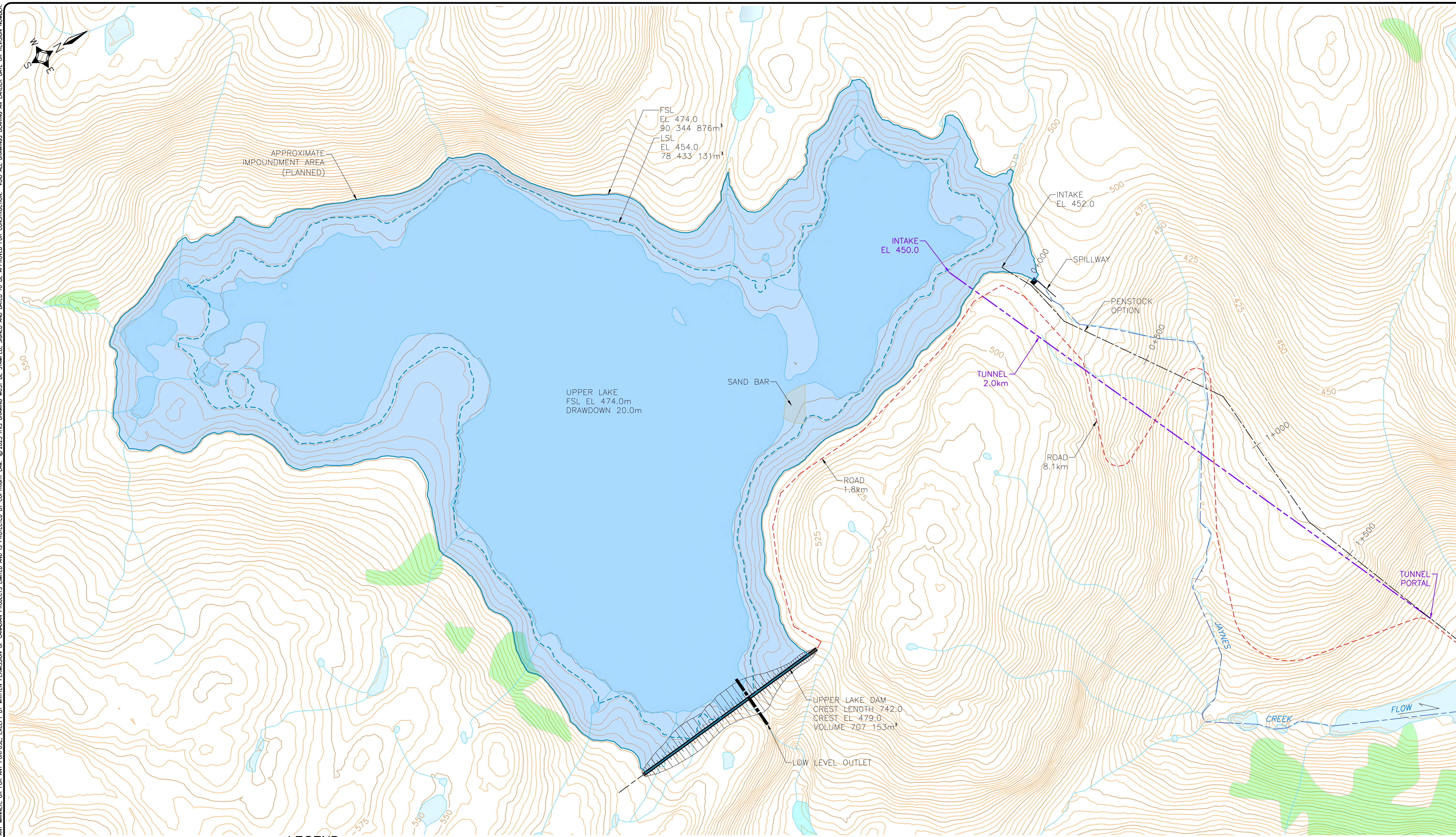
GROWLER ENERGY

IQALUIT RENEWABLE ENERGY PROJECT
JAYNES INLET
PROJECT LAYOUT
PLAN AND PROFILE

PROJECT NUMBER
1096-006

CADD NUMBER
4.3.002

DRAWING NUMBER
321




PRELIMINARY - NOT FOR CONSTRUCTION

## NOTES

1. ALL DIMENSIONS AND ELEVATIONS ARE IN METRES, UNLESS NOTED OTHERWISE.
2. 5m INTERVAL CONTOURS GENERATED BY CPL FROM DEM DATA FROM THE ARCTICDEM POLAR GEOSPATIAL CENTER DATED APRIL 15 TO JUNE 17, 2017
3. BASE MAPPING IS CANVEC VECTOR MAPPING OBTAINED FROM THE GOVERNMENT OF CANADA IN FEBRUARY, 2023.
4. HORIZONTAL DATUM: NAD83 (CSRS) UTM ZONE 19.
5. VERTICAL DATUM: WGS84 ELLIPSOID.

## LEGEND

- PENSTOCK
- ROAD
- TUNNEL
- FSL
- LSL
- INUIT OWNED LANDS
- VEGETATED AREA
- NORMAL WATER
- PROPOSED RESERVOIR
- INTERMITTENT WATER
- TRANSMISSION LINE

SCALE 1:12 500

0 125 250 375 500 625

METRES

| REV | Y | M | D | REVISION DESCRIPTION | DES | CHK | DRN | CHK |
|---|---|---|---|---|---|---|---|---|
| C | 23 | 12 | 21 | GENERAL COMMENTS | GS | GS | MH | CPB |
| B | 23 | 04 | 06 | REVISED ALIGNMENT, TUNNEL, ROAD | JG | CJW | MH | CPB |
| A | 23 | 02 | 22 | NEW DRAWING | JG | CJW | AM | CPB |

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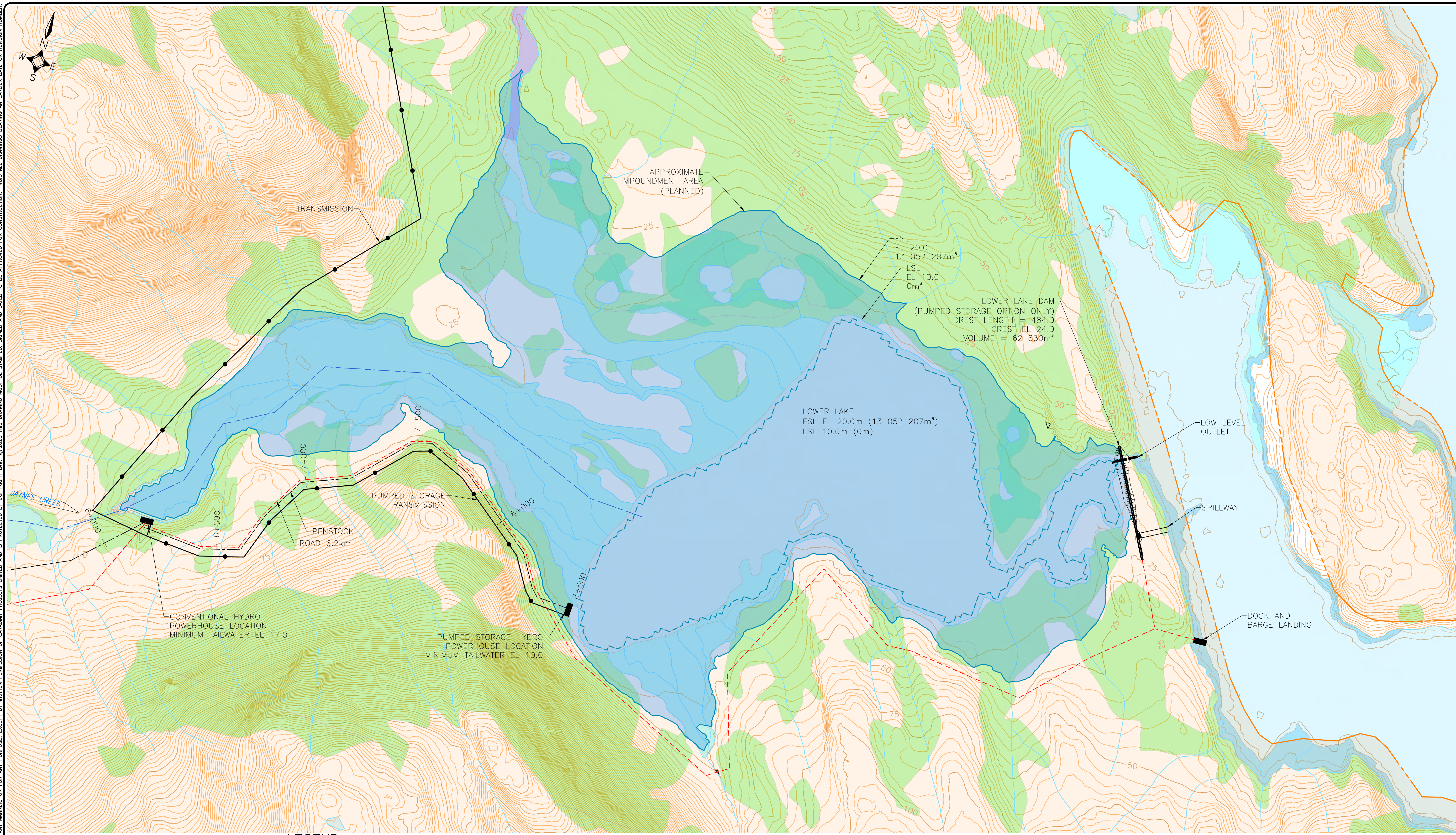
GROWLER ENERGY

IQALUIT RENEWABLE ENERGY PROJECT
JAYNES INLET
UPPER LAKE
PLAN

PROJECT NUMBER 1096-006
CADD NUMBER 4.3.002
DRAWING NUMBER 341




PRELIMINARY - NOT FOR CONSTRUCTION

## NOTES

1. ALL DIMENSIONS AND ELEVATIONS ARE IN METRES, UNLESS NOTED OTHERWISE.
2. 5m INTERVAL CONTOURS GENERATED BY CPL FROM DEM DATA FROM THE ARCTICDEM POLAR GEOSPATIAL CENTER DATED APRIL 15 TO JUNE 17, 2017
3. BASE MAPPING IS CANVEC VECTOR MAPPING OBTAINED FROM THE GOVERNMENT OF CANADA IN FEBRUARY, 2023.
4. HORIZONTAL DATUM: NAD83 (CSRS) UTM ZONE 19.
5. VERTICAL DATUM: WGS84 ELLIPSOID.

## LEGEND

- PENSTOCK
- ROAD
- TUNNEL
- FSL
- LSL
- INUIT OWNED LANDS
- VEGETATED AREA
- NORMAL WATER
- PROPOSED RESERVOIR
- INTERMITTENT WATER
- TRANSMISSION LINE

SCALE 1:15 000

0 150 300 450 600 750

METRES

| REV | Y | M | D | REVISION DESCRIPTION | DES | CHK | DRN | CHK |
|---|---|---|---|---|---|---|---|---|
| C | 23 | 12 | 21 | GENERAL COMMENTS | GS | GS | MH | CPB |
| B | 23 | 04 | 06 | REVISED ROAD, PENSTOCK, PH, ADD DAM | JG | CJW | MH | CPB |
| A | 23 | 02 | 22 | NEW DRAWING | JG | CJW | AM | CPB |

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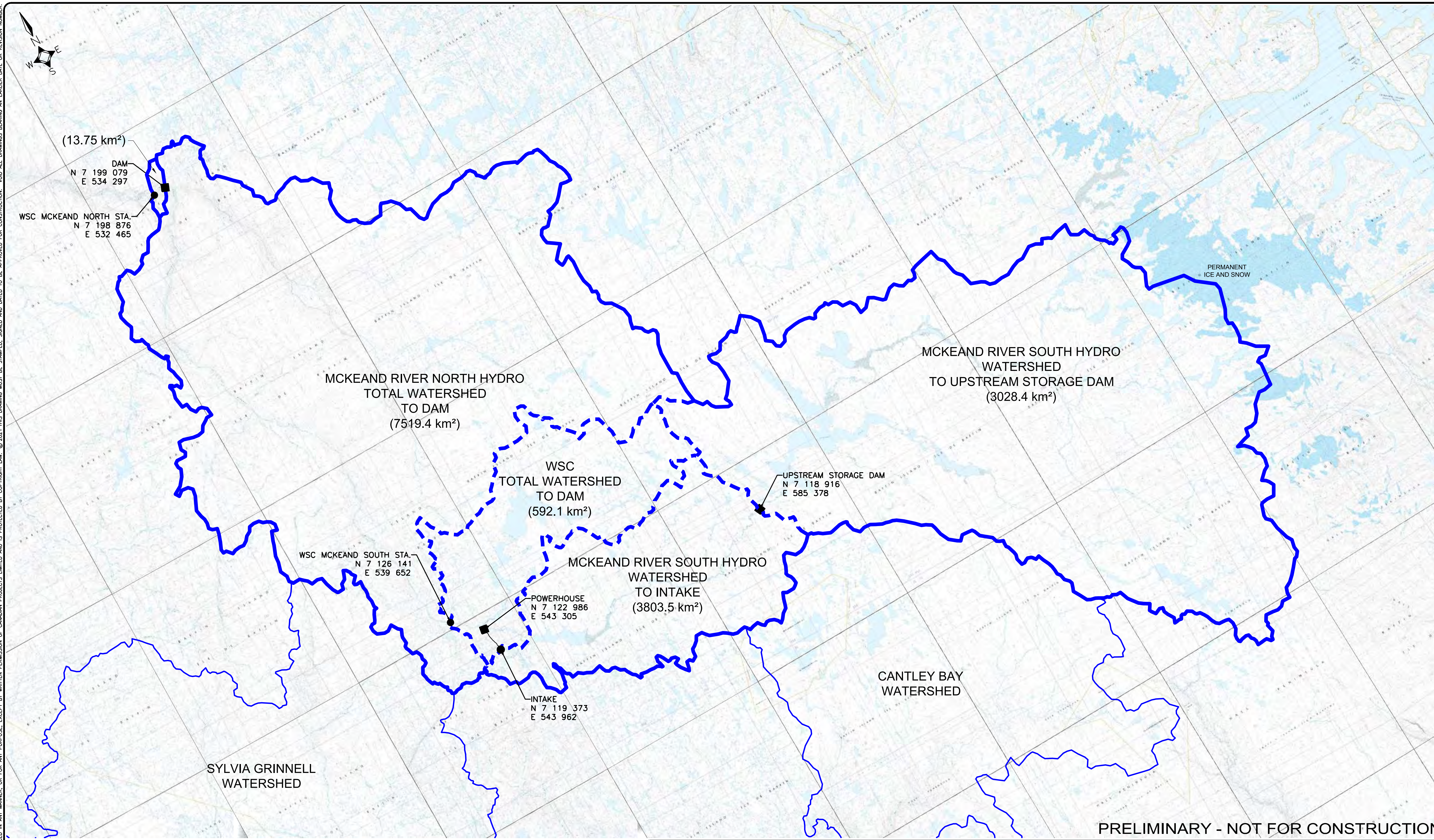
GROWLER ENERGY

IQALUIT RENEWABLE ENERGY PROJECT
JAYNES INLET
LOWER LAKE
PLAN

| | |
|---|---|
| PROJECT NUMBER | 1096-006 |
| CADD NUMBER | 4.3.002 |
| DRAWING NUMBER | 342 |




PRELIMINARY - NOT FOR CONSTRUCTION

## NOTES

1. ALL DIMENSIONS AND ELEVATIONS ARE IN METRES, UNLESS NOTED OTHERWISE.
2. BASE MAPPING IS NRCAN 1:50 000 TOPO MAPS.
3. HORIZONTAL DATUM: NAD83 (CSRS) UTM ZONE 19.
4. VERTICAL DATUM: WGS84 ELLIPSOID.

Growler Energy

Landsvirkjun Power

SCALE 1:500 000

0 5 10 15 20 25

KILOMETRES

| REV | Y | M | D | REVISION DESCRIPTION | DES | CHK | DRN | CHK |
|---|---|---|---|---|---|---|---|---|
| B | 23 | 12 | 19 | REMOVED DRAWING REFERENCES | ADF | AT | ADF | CPB |
| A | 23 | 05 | 02 | NEW DRAWING | ADF | CJW | ADF | CPB |

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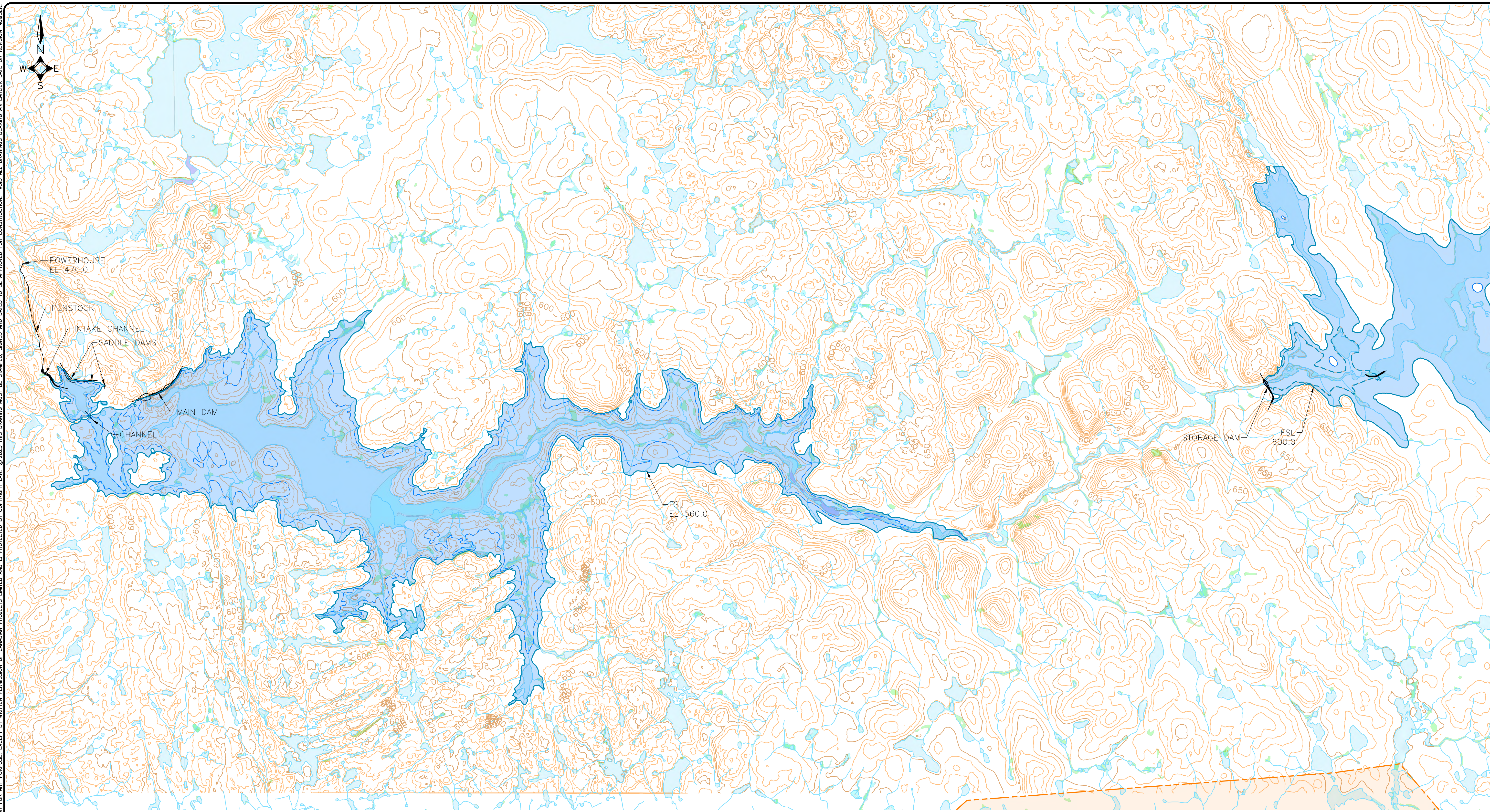
# GROWLER ENERGY

IQALUIT RENEWABLE ENERGY PROJECT
MCKEAND RIVER
WATERSHED
PLAN

PROJECT NUMBER
1096-006

CADD NUMBER
4.3.024

DRAWING NUMBER
511




## NOTES

1. ALL DIMENSIONS AND ELEVATIONS ARE IN METRES, UNLESS NOTED OTHERWISE.
2. 5m INTERVAL CONTOURS GENERATED BY CPL FROM DEM DATA FROM THE ARCTICDEM POLAR GEOSPATIAL CENTER DATED APRIL 15 TO JUNE 17, 2017
3. BASE MAPPING IS CANVEC VECTOR MAPPING OBTAINED FROM THE GOVERNMENT OF CANADA IN FEBRUARY, 2023.
4. HORIZONTAL DATUM: NAD83 (CSRS) UTM ZONE 19.
5. VERTICAL DATUM: WGS84 ELLIPSOID.

## LEGEND

- PENSTOCK
- ROAD
- TUNNEL
- FSL
- LSL
- INUIT OWNED LANDS
- WOODED AREA
- NORMAL WATER
- PROPOSED RESERVOIR
- INTERMITTENT WATER
- TRANSMISSION LINE

Growler Energy

Landsvirkjun Power

SCALE 1:125 000

0 1250 2500 3750 5000 6250

METRES

| REV | Y | M | D | REVISION DESCRIPTION | DES | CHK | DRN | CHK |
|---|---|---|---|---|---|---|---|---|
| A | 23 | 04 | 19 | NEW DRAWING | ADF | CJW | AM | CPB |

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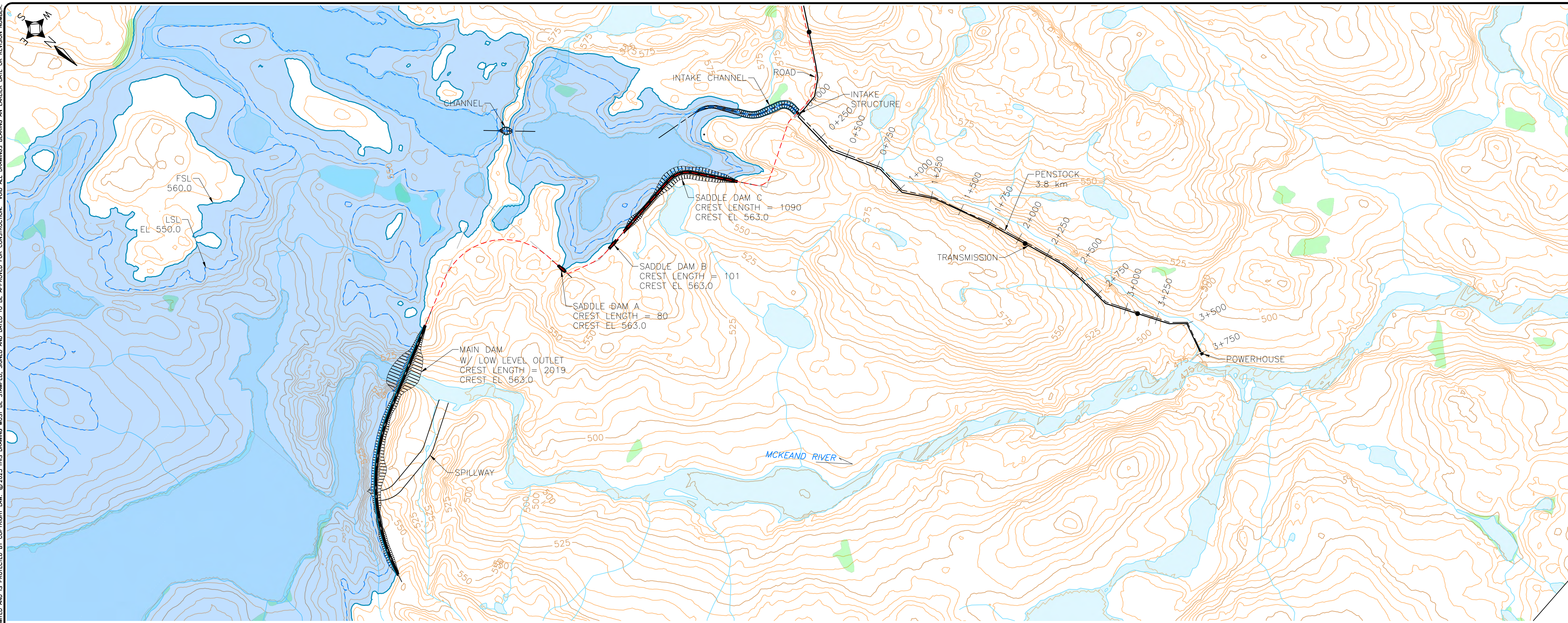
GROWLER ENERGY

IQALUIT RENEWABLE ENERGY PROJECT
MCKEAND RIVER SOUTH
OVERALL AREA
PLAN

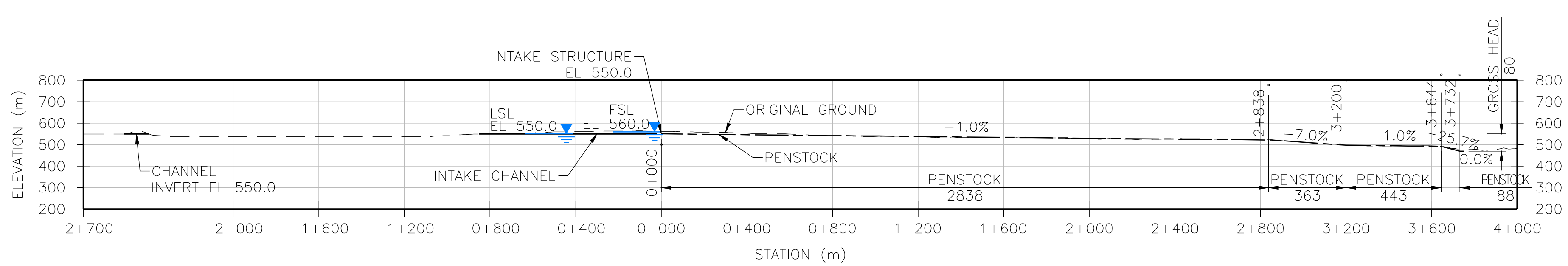
PROJECT NUMBER 1096-006

CADD NUMBER 4.3.023

DRAWING NUMBER 531




PLAN
1:30 000




PROFILE - PENSTOCK
1:30 000

## NOTES

1. ALL DIMENSIONS AND ELEVATIONS ARE IN METRES, UNLESS NOTED OTHERWISE.
2. 5m INTERVAL CONTOURS GENERATED BY CPL FROM DEM DATA FROM THE ARCTICDEM POLAR GEOSPATIAL CENTER DATED APRIL 15 TO JUNE 17, 2017
3. BASE MAPPING IS CANVEC VECTOR MAPPING OBTAINED FROM THE GOVERNMENT OF CANADA IN FEBRUARY, 2023.
4. HORIZONTAL DATUM: NAD83 (CSRS) UTM ZONE 19.
5. VERTICAL DATUM: WGS84 ELLIPSOID.

## LEGEND

- PENSTOCK
- ROAD
- TUNNEL
- FSL
- LSL
- INUIT OWNED LANDS
- VEGETATED AREA
- NORMAL WATER
- PROPOSED RESERVOIR
- INTERMITTENT WATER
- TRANSMISSION LINE

Growler Energy

Landsvirkjun Power

SCALE 1:30 000

0 300 600 900 1200 1500

METRES

| REV | Y | M | D | REVISION DESCRIPTION | DES | CHK | DRN | CHK |
|---|---|---|---|---|---|---|---|---|
| B | 23 | 12 | 19 | REVISED LEGEND | | | | |
| A | 23 | 04 | 19 | NEW DRAWING | | | | |

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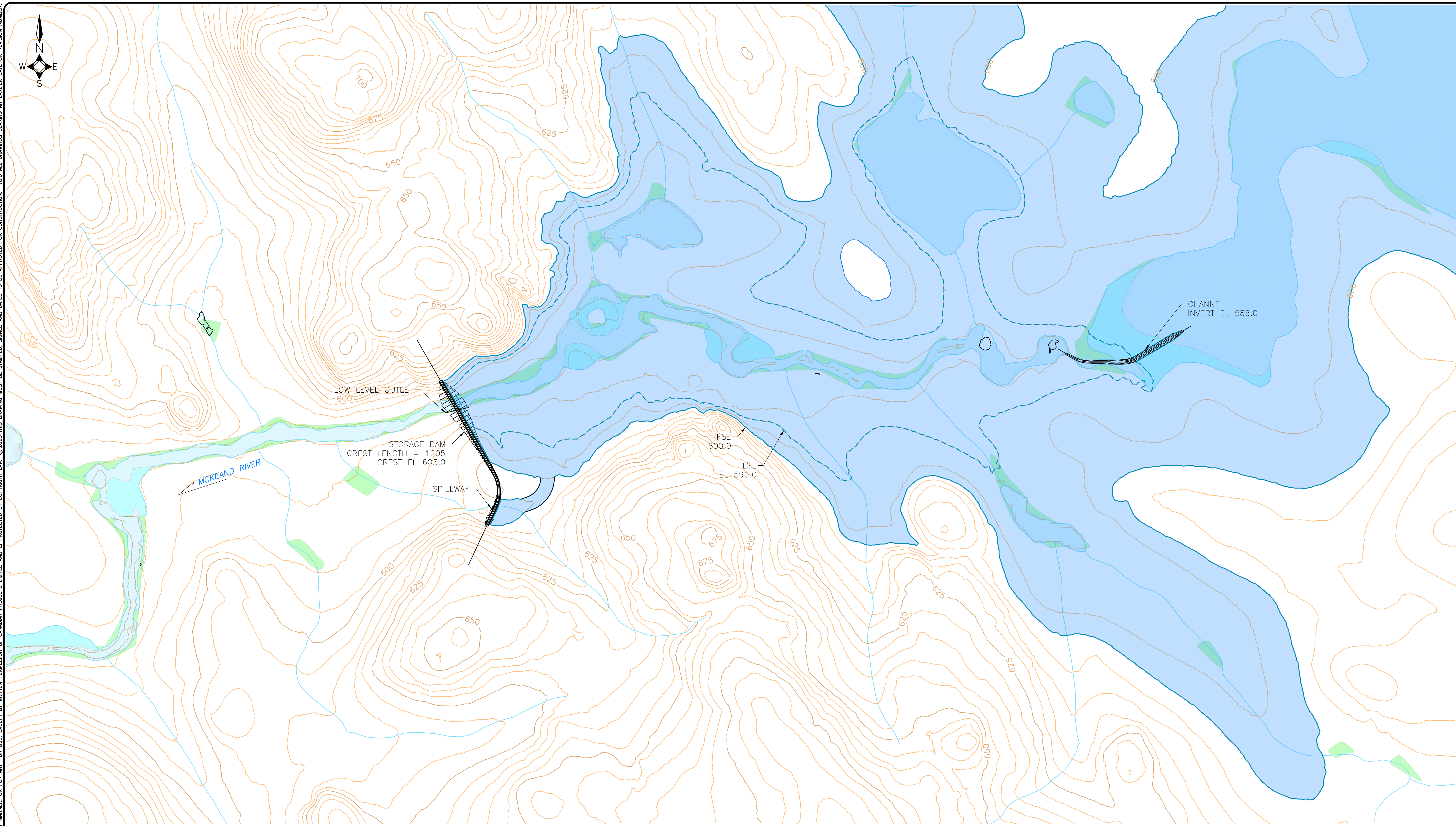
GROWLER ENERGY

IQALUIT RENEWABLE ENERGY PROJECT
MCKEAND RIVER SOUTH HYDRO
PROJECT LAYOUT
PLAN AND PROFILE

PROJECT NUMBER 1096-006

CADD NUMBER 4.3.020

DRAWING NUMBER 532




## NOTES

1. ALL DIMENSIONS AND ELEVATIONS ARE IN METRES, UNLESS NOTED OTHERWISE.
2. 5m INTERVAL CONTOURS GENERATED BY CPL FROM DEM DATA FROM THE ARCTICDEM POLAR GEOSPATIAL CENTER DATED APRIL 15 TO JUNE 17, 2017
3. BASE MAPPING IS CANVEC VECTOR MAPPING OBTAINED FROM THE GOVERNMENT OF CANADA IN FEBRUARY, 2023.
4. HORIZONTAL DATUM: NAD83 (CSRS) UTM ZONE 19.
5. VERTICAL DATUM: WGS84 ELLIPSOID.

## LEGEND

- PENSTOCK
- ROAD
- TUNNEL
- FSL
- LSL
- INUIT OWNED LANDS
- VEGETATED AREA
- NORMAL WATER
- PROPOSED RESERVOIR
- INTERMITTENT WATER
- TRANSMISSION LINE

Growler Energy

Landsvirkjun Power

SCALE 1:20 000

0 200 400 600 800 1000

METRES

| REV | Y | M | D | REVISION DESCRIPTION | DES | CHK | DRN | CHK |
|---|---|---|---|---|---|---|---|---|
| B | 23 | 12 | 19 | REVISED LEGEND | ADF | AT | ADF | CPB |
| A | 23 | 04 | 19 | NEW DRAWING | ADF | CJW | ADF | CPB |

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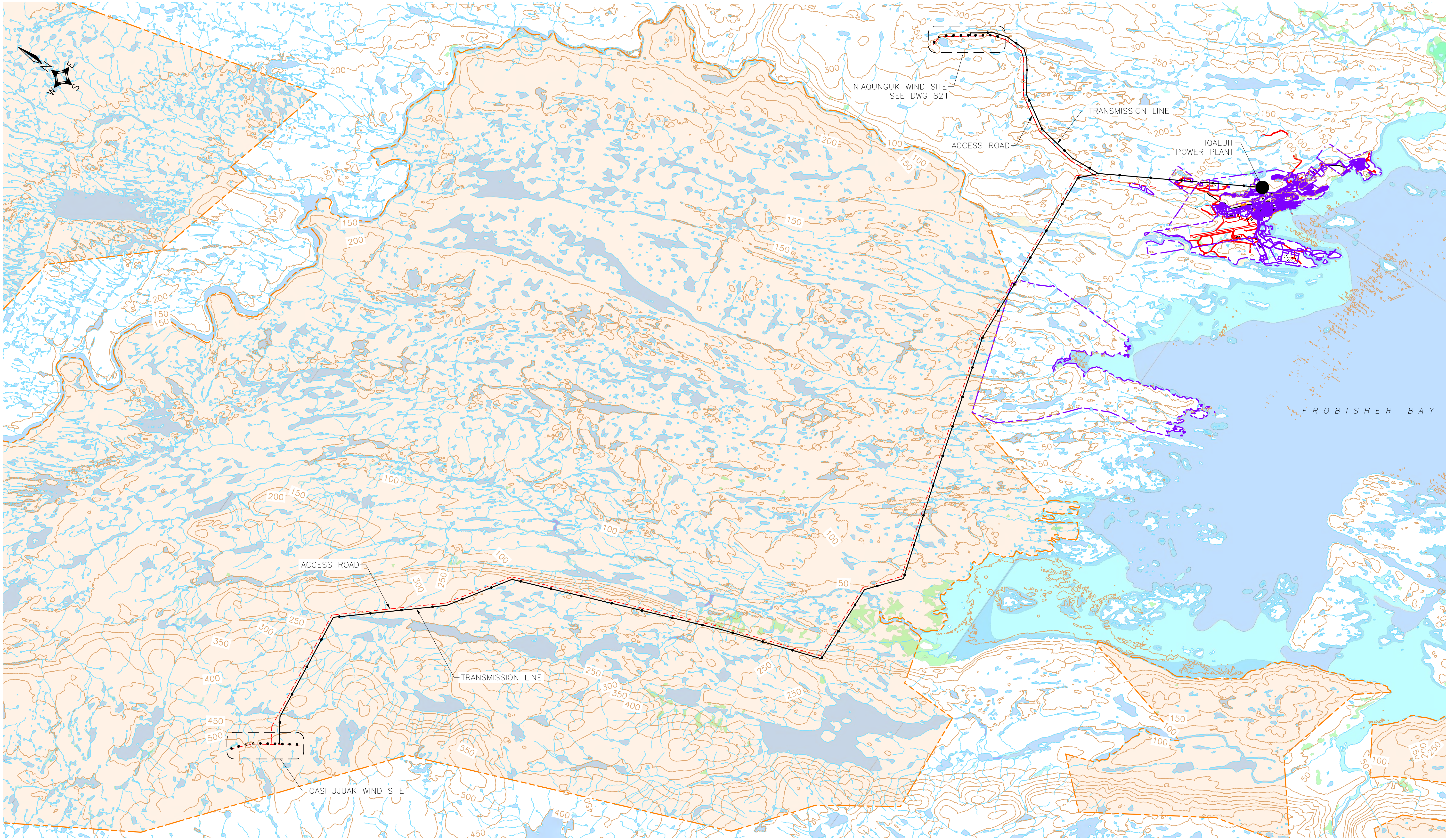
GROWLER ENERGY

IQALUIT RENEWABLE ENERGY PROJECT
MCKEAND RIVER SOUTH HYDRO
STORAGE DAM
PLAN

PROJECT NUMBER
1096-006

CADD NUMBER
4.3.021

DRAWING NUMBER
533




## NOTES

1. ALL DIMENSIONS AND ELEVATIONS ARE IN METRES, UNLESS NOTED OTHERWISE.
2. 5m INTERVAL CONTOURS GENERATED BY CPL FROM DEM DATA FROM THE ARCTICDEM POLAR GEOSPATIAL CENTER DATED APRIL 15 TO JUNE 17, 2017
3. BASE MAPPING IS CANVEC VECTOR MAPPING OBTAINED FROM THE GOVERNMENT OF CANADA IN FEBRUARY, 2023.
4. HORIZONTAL DATUM: NAD83 (CSRS) UTM ZONE 19.
5. VERTICAL DATUM: WGS84 ELLIPSOID.

## LEGEND

- TRANSMISSION LINE
- ROAD
- WATER
- CONTOUR 50m
- INUIT OWNED LANDS
- VEGETATED AREA
- GOVT. PARCELS
- PROPOSED WIND TURBINE

Growler Energy

Landsvirkjun Power

SCALE 1:150 000

0 1500 3000 4500 6000 7500

METRES

| REV | Y | M | D | REVISION DESCRIPTION | DES | CHK | DRN | CHK |
|---|---|---|---|---|---|---|---|---|
| C | 23 | 12 | 19 | REVISED LEGEND | AT | PK | ADF | CPB |
| B | 23 | 04 | 17 | UPDATED ROAD AND TURBINE LAYOUTS | JG | CJW | MH | CPB |
| A | 23 | 03 | 21 | NEW DRAWING | JG | CJW | MH | CPB |

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PRELIMINARY - NOT FOR CONSTRUCTION

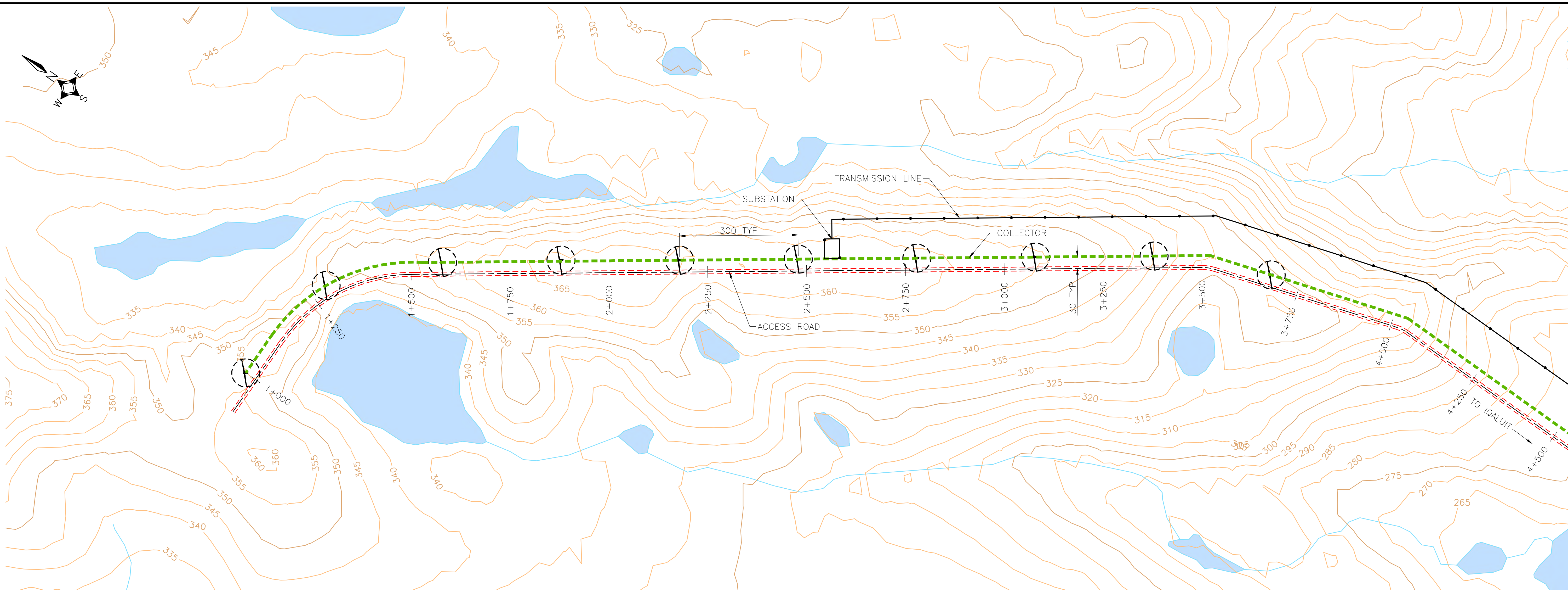
GROWLER ENERGY

IQALUIT RENEWABLE ENERGY PROJECT
NIAQUNGUK AND QASITUJUAK WIND PROJECT LAYOUTS
PLAN

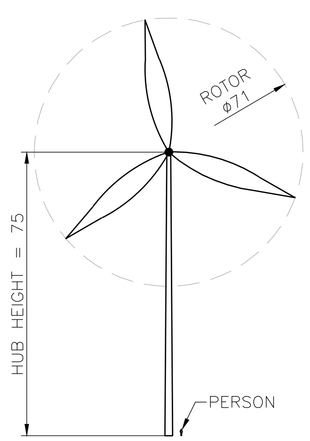
PROJECT NUMBER 1096-006

CADD NUMBER 4.3.015

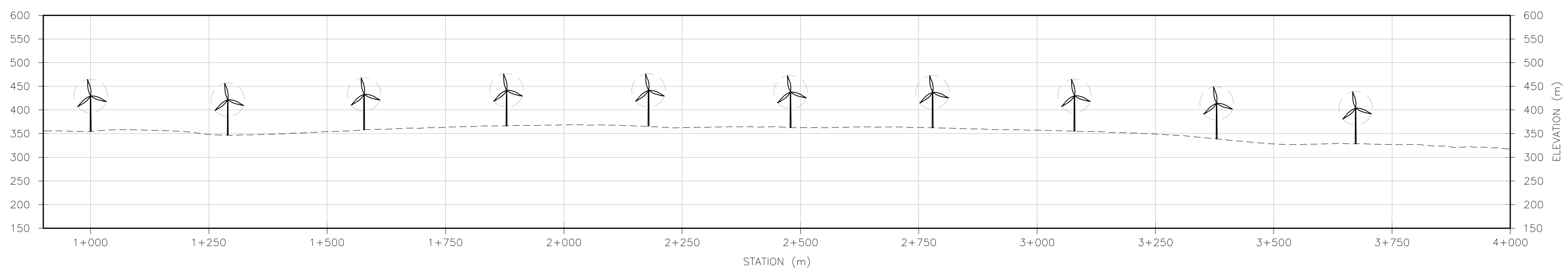
DRAWING NUMBER 811




PLAN
1:10 000




TURBINE ELEVATION
ENERCON E70 – 2.3MW
1:2000




PROFILE - ROAD
1:10 000

## NOTES

1. ALL DIMENSIONS AND ELEVATIONS ARE IN METRES, UNLESS NOTED OTHERWISE.
2. 5m INTERVAL CONTOURS GENERATED BY CPL FROM DEM DATA FROM THE ARCTICDEM POLAR GEOSPATIAL CENTER DATED APRIL 15 TO JUNE 17, 2017
3. BASE MAPPING IS CANVEC VECTOR MAPPING OBTAINED FROM THE GOVERNMENT OF CANADA IN FEBRUARY, 2023.
4. HORIZONTAL DATUM: NAD83 (CSRS) UTM ZONE 19.
5. VERTICAL DATUM: WGS84 ELLIPSOID.

## LEGEND

- COLLECTOR
- TRANSMISSION LINE
- ROAD
- WATER
- CONTOUR 25m
- CONTOUR 5m
- TURBINE (ENERCON E70)

Growler Energy

Landsvirkjun Power

| 0 | 100 | 200 | 300 | 400 | 1:10000 |
|---|---|---|---|---|---|
| 0 | 20 | 40 | 60 | 80 | 1:2000 |

METRES

| REV | Y | M | D | REVISION DESCRIPTION | DES | CHK | DRN | CHK |
|---|---|---|---|---|---|---|---|---|
| B | 23 | 04 | 17 | REVISE WTG LAYOUT, ADD TURBINE DETAIL | | | | |
| A | 23 | 03 | 21 | NEW DRAWING | | | | |

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GROWLER ENERGY

IQALUIT RENEWABLE ENERGY PROJECT
NIAQUNGUK WIND
PROJECT LAYOUT
PLAN AND PROFILE

PROJECT NUMBER 1096-006

CADD NUMBER 4.3.015

DRAWING NUMBER 821