LOWER CHURCHILL PROJECT DESIGN PROGRESSION

1998 TO 2011

Technical Note

Date: 29-July-2011
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nalcor energy
LOWER CHURCHILL PROJECT

Lower Churchill Project Design Progression
1998 – 2011
Date: 10-July-2011

1. Purpose

The purpose of this technical note is to explain the changes that have been made by Nalcor Energy (Nalcor) to the development plans for the Lower Churchill Project from 1998 to 2011.

This note addresses the following:

- Muskrat Falls Hydroelectric Development
- HVac Interconnecting Transmission Lines
- Labrador-Island Transmission Link

2. Muskrat Falls

In 1998, Newfoundland and Labrador Hydro (NL Hydro) conducted a Final Feasibility Study for the hydroelectric generation facility at Muskrat Falls. The Study concluded with a short list of three development scenarios known as Variant 7, Variant 10 and Variant 11. Following an analysis of comparative costs, schedule and risk; Variant 7 was selected as the layout of choice for further development. The conceptual development for Variant 7 was described in the Final Feasibility Report by SNC-AGRA in January 1999.

Variant 7 is an 824 MW hydroelectric development. It includes two tunnels through the rock knoll on the north side of the Churchill River for diversion of the river during construction, a four unit powerhouse with Kaplan/propeller turbines, a gated spillway constructed in the river channel, a north overflow dam with a partial fixed crest and an inflatable rubber dam, and a south closure dam. Permanent access to the powerhouse is from the north side of the river, around the rock knoll of the North Spur and across the top of the dams, spillway and intake structures.

As part of Phase III of the Trans Labrador Highway, the Government of Newfoundland and Labrador constructed a bridge across the Churchill River. The Blackrock Bridge, as it is known, is located approximately 18 km downstream of Muskrat Falls and provides the possibility of access to the Muskrat Falls site along the south side of the river, an alternative that did not exist in 1998. Consequently, Nalcor commissioned a new review of the potential development options for Muskrat Falls. This review was carried out by SNC in 2007 and is called Review of Variants (MF1010).

The study revisited Variants 7, 10 and 11 with the new knowledge that access to the south side of the Churchill River could be obtained. Following an analysis of comparative costs, schedule and risks, Variant 10 now proved to be the most attractive development layout. The study showed Variant 10 would achieve first power nine months ahead of Variant 11 and ten months ahead of Variant 7.

In addition, since 1998, Nalcor had begun conducting extensive consultation initiatives with a variety of groups, including the Innu Nation of Labrador. During these consultations, it became clear that the rock knoll that sits in the middle of the lower Churchill River has significant spiritual and cultural significance to the Labrador Innu. Variant 10, which eliminates the need for river diversion through the rock knoll and provides permanent access to the development along the south shore of the river, avoids interference with this sensitive location.

The avoidance of interference with a location sensitive to the Labrador Innu and the cost and schedule advantages make Variant 10 the preferred development alternative.

Further studies were initiated as part of Nalcor's phase III engineering work to evaluate spillway alternatives, river operation during diversion and impounding, construction flood studies, probable maximum flood studies (PMF), dam break studies and associated inundation mapping, ice studies, site access studies and to move forward with additional geotechnical field investigations based on the new scenario. The results of these studies were incorporated in the capital cost estimate for Muskrat Falls in the fall of 2010.

3. HVac Transmission System in Labrador

A number of transmission alternatives have been considered to interconnect the lower Churchill generation sites to the Labrador transmission grid.

Previous planning with Hydro-Quebec for integration of Gull Island had concluded that 735 kV transmission facilities between Gull Island and Churchill Falls, as well as 735 kV facilities between Gull Island and the Romaine project would be required to integrate Gull Island. Given the proximity of Muskrat Falls to Gull Island, a 230 kV interconnection was proposed between these sites.

With a focus on the Muskrat Falls site, lower voltage (and lower cost) options were evaluated in order to develop a transmission solution that satisfied reliability requirements. The results of this analysis indicated a requirement for two 345 kV transmission lines that link Muskrat Falls and Churchill Falls.

With Muskrat Falls moving to development first, the 345 kV transmission configuration represents the least cost transmission interconnection solution

4. Labrador – Island Transmission Link

The original configuration of the Labrador-Island HVdc Link (LIL) was based on a system proposed in 1998 with an 800 MW transmission system from Gull Island to Soldiers Pond having an overload capacity of 200% (800 MW) for 10-minutes and 150% (600 MW) continuously.

One transmission option that was considered for Gull Island was the development of a 1600 MW multi-terminal HVdc system interconnecting Gull Island with Soldier's Pond, NL and Salisbury, NB. A number of integration studies were completed to evaluate the performance of this alternative. As part of the Voltage and Conductor Optimization Study (DC1010), voltages of ± 400, ± 450 and ± 500 kV dc were considered for the transmission system and Mass Impregnated (MI) cables were considered for the Strait of Belle Isle (SOBI) Crossing.

With the decision to advance Muskrat Falls, the proposed 1600 MW multi-terminal HVdc scheme was replaced with a smaller point-to-point system from Muskrat Falls to Soldiers Pond. It was determined that the HVdc link should be sized at 900 MW based on the size of the Muskrat Falls Development, obtaining up to 300 MW of recall from Churchill Falls and moving an estimated 4.9 TWh over the HVdc scheme.

Analysis carried out in June and July of 2010 confirmed that a 900 MW HVdc link between Labrador and the Island would require a minimum operating voltage of ±320 kV to ensure that transmission losses for the proposed HVdc system would be in the order of 10% over peak.

While this is a bi-pole HVdc system, it still requires a return path to operate under normal conditions and provide a return path during infrequent periods of mono-polar operation. Earlier studies, in particular a 1998 report by Teshmont, assumed that a sea electrode be installed in Lake Melville for the Labrador converter station and in Conception Bay South for the Soldiers Pond converter station.

In 2007/2008 Nalcor initiated an electrode review by Statnett of Norway. This report, Electrode Review (DC1110), recommended sea electrodes for both converter stations; however, Nalcor was concerned that the report did not consider other types of electrodes, such as land, shoreline or shoreline pond electrodes
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Accordingly, in 2009, Nalcor assembled a panel of five experts who provided input from their varying experience to complete a thorough electrode review. The panel, working closely with Hatch, completed their initial review in 2010 and issued the report Electrode Review, Types and Locations (DC1250). This report recommended the use of shoreline pond electrodes for the Soldiers Pond converter station and recommended further work to confirm type and location of electrodes for the Labrador converter station. This further work was completed in 2010 and culminated in the report Electrode Review, Confirmation of Type and Site Selection (DC1500). This report recommended shoreline pond electrodes for the Labrador converter station to be constructed on the Labrador shore of the Strait of Belle Isle and confirmed shoreline pond electrodes for the Soldiers Pond converter station to be constructed on the east shore of Conception Bay.

5. Strait of Belle Isle Cable Crossing

Part of the feasibility engineering performed over the last few years also involved the determination of the preferred solution for extending the HVdc transmission system across the Strait of Belle Isle (SOBI). Basically, two options were considered for detailed study. The first option was for construction of a full-length cable tunnel across SOBI with HVdc cables installed in the tunnel. The second option was to have HVdc cables installed on or near the seabed with appropriate protection features.

Studies were led by Nalcor and included an exhaustive review of existing information from many previous studies that existed in Nalcor archives along with extensive work carried out by external consultants including national/international experts. These studies included a field program in 2009 which culminated in a series of reports and workshops that led to a decision regarding the best way to move forward.

The risks associated with the two crossing alternatives were compared by the project team. Several risks associated with the tunnel crossing option were deemed to be unacceptable. These included geological risk, schedule risk, cost and schedule overrun exposure, safety during construction risk, and risk with respect to fall-back options. No unacceptable risks were identified for the seabed crossing option. Accordingly, this option was chosen as the method for installing HVdc cables across the Strait of Belle Isle, and this option has been carried forward into final optimization and detailed design.

6. Basis of Design

The following section describes the projects in additional detail to support the preceding general overview.

6.1. Definitions

Basis of Design	A compilation of the fundamental criteria, principles and/or assumptions upon which Design Philosophies and Engineering Design Briefs will be developed.
Bulkhead Gates	Steel gates used to isolate water passages for inspection or maintenance and are installed and removed under balanced pressures.
Cavitation Resistant Design	A design to prevent the formation of the vapour phase in a liquid flow when the hydrodynamic pressure falls below the vapour pressure of the liquid.
Change Control Board	A panel within the Project Management Team that is responsible for making the ultimate decision to approve, reject or elevate a Project Change Notice is to become a Project Change, as explained in LCP-PT-MD-0000-PM-PL-0002-01, Project Change Management Plan.
Cofferdam	A temporary barrier for excluding water from an area that could otherwise be submerged.
Construction Flood	The seasonal peak river flow that the diversion facilities are designed to pass during construction of the dam. Accepted practice is based on a 5% risk of exceedence for the duration of the operation of the diversion facilities.
Converter Station	A Converter Station consists of equipment that converts power from ac to dc (rectifier) and dc to ac (inverter).
Counterpoise	Steel wire installed along the length of the overhead line and bonded (connected) to each tower. Used to reduce resistivity between the overhead line structures and the ground for lightning protection.

Electrode	A grounded means to provide a return path for unbalanced dc current for HVdc transmission system, enabling it to operate in mono-polar mode.
Electrode Line	A transmission line connecting the Electrode site to the converter station.
Fail Safe Design	A design that in the event of the failure of equipment, processes or systems, the event will produce minimum propagation beyond the immediate environment of the failing entity. In addition, the failure will be economically acceptable, and those devices in the system will perform their intended function and eliminate danger upon the loss of actuating power.
Fish Compensation Flow	Minimum flow required downstream of the dam sites during reservoir impoundment which will be required to maintain fish habitat and reduce the effects of salt water intrusion into the Churchill River.
Flip Bucket	A formed geometrical shape at the downstream end of a spillway discharge for the purpose of throwing the water clear of the hydraulic structure and into a Plunge Pool for energy dissipation.
Francis Turbine	A mixed flow reaction turbine with fixed runner vanes that converts hydraulic energy to mechanical energy where the water flow is controlled by the setting of the adjustable wicket gates.
Generator	An assembly of stationary and rotating components coupled to the turbine, converting mechanical energy to electrical energy.

Good Utility Practice	The practices, methods and acts engaged in, or approved by, a significant portion of the electrical utility industry in North America, or any of the practices, methods and acts which, in the exercise of reasonable judgment in light of the facts known at the time the decision was made, are expected to accomplish the desired result at a reasonable cost consistent with good business practices, reliability, safety and expedition. Good Utility Practice is not intended to be limited to optimum practice, method or act to the exclusion of all others, but rather to include all practices, methods or acts generally accepted in North America.
Kaplan Turbine	A reaction type, axial flow, adjustable blade turbine that converts hydraulic energy to mechanical energy.
Life Cycle Cost Analysis	The process of selecting the most cost effective approach from a series of alternatives so that the least long-term cost of ownership is achieved where life cycle costs are total costs estimated to be incurred in the design, development, production, operation, maintenance, support, and final disposition of an asset over its anticipated useful life from inception to disposal.
Mass Impregnated (MI)	An electrical insulation method used for power cables. The conductor is tightly wrapped with porous paper and saturated with oil, installed under pressure, to provide electrical insulation.
Mitigation	Measures implemented during the design, construction and operations phases of the project which are intended to avoid or reduce known or predicted impacts to the existing environment.
Overhead Ground Wire (OHGW)	Provides lightning protection for the power conductors. When used, direct lightning strikes are minimized, and potential disturbances due to lightning are reduced.
Optical Ground Wire (OPGW)	Performs the same function as Overhead Ground Wire; however, it also carries a fibre optic communication system within the wire strands.

Penstock	A conduit that conveys water from the intake to the turbine.
Plunge Pool	A deep depression downstream of a spillway into which spilled water “plunges” to dissipate energy.
Probable Maximum Flood (PMF)	Canadian Dam Association terminology for “an estimate of hypothetical flood (peak flow, volume and hydrograph shape) that is considered to be the most severe ‘reasonably possible’ at a particular location and time of year, based on relatively comprehensive hydro meteorological analysis of critical runoff-producing precipitation (snowmelt if pertinent) and hydrologic factors favourable for maximum flood runoff”.
Proven Technology	This is the state of technology used in the design, construction and operation of any system including each piece of equipment, component or structure that has a proven record of performance. (First technology applications will only be considered after review by the LCP Design Integrity group and then only after approval by Executive Management).
Rehabilitation	Measures taken to remedy environmental damage to the environment.
Reliability Level Return Period	A statistical measurement denoting the average recurrence interval over an extended period of time. Used to estimate loads to design transmission lines.
Rotor	The multi-poled rotating component of the generator.
Split Yard	Switchyard divided physically into two independent sections with an electrical connection so as to limit the loss of generation in order to meet reliability criteria.
Stoplog	Steel sections used to isolate water passages for inspection or maintenance and are installed and removed under balanced pressures.
Tailrace	A watercourse that carries water away from a turbine or powerhouse.

Trash Boom	An anchored, floating barrier spanning the approach channel of the intake. It is used to limit floating objects from reaching the intake and blocking the Trash Racks.
Trash Racks	Equally spaced rectangular bars installed at the entrance to the intake to protect the turbine from impinging objects.
Waste Management	The management of waste generation in order to reduce the volume of solid waste deposited in landfills through recycling and the reuse of materials where practical.
Wicket Gates	Adjustable guide vanes used to regulate the flow of water into a turbine.

6.2. Abbreviations and Acronyms

ac	alternating current
BOD	Basis of Design
CF	Churchill Falls Hydroelectric Facility
CFRD	Concrete Faced Rockfill Dam
CPU	Central Processing Unit
dc	direct current
DFO	Department of Fisheries and Oceans
EPP	Environmental Protection Plan
FSL	Full Supply Level (Reservoir)
GI	Gull Island Hydroelectric Development
HADD	Harmful Alteration Damage or Disruption (Fish Habitat)
HVac	High Voltage alternating current
HVAC	Heating, Ventilation and Air Conditioning
HVdc	High Voltage direct current
HVGB	Happy Valley – Goose Bay
kV	kilovolts (Thousand Volts)

LCC	Line Commutated Converter
LEED	Leadership in Energy and Environmental Design
LCP	Lower Churchill Project
LSL	Low Supply Level (Reservoir)
MF	Muskrat Falls Hydroelectric Development
MFL	Maximum Flood Level (Reservoir)
MI	Mass Impregnated
MVAR	Mega Volt Ampere Reactive (Million VARs)
MW	MegaWatt (Million Watts)
OHGW	Over-Head Ground Wire
OPGW	Optical Ground Wire
pf	power factor
PMF	Probable Maximum Flood
RCC	Roller Compacted Concrete
ROW	Right of Way
SCADA	Supervisory Control and Data Acquisition
SLD	Single Line Diagram
SOBI	Strait of Belle Isle
TBD	To Be Determined
TL	Transmission Line
TLH	Trans Labrador Highway
VSC	Voltage Source Converter

6.3. General Overview of Design Assumptions

All design assumptions respect the following overarching principles:

- Only proven technologies will be considered, unless it can be clearly demonstrated to the satisfaction of the Engineering Manager, Project Director and VP of the LCP that emerging technologies can be as reliable and provide significant cost and/or schedule savings.

- Local climatic/service conditions such as ambient temperature, elevation, humidity, sea temperature, sea currents and wind will be respected throughout the Project.
- All hydroelectric plants and transmission systems will be remotely operated and monitored from NL Hydro's Energy Control Centre.
- Environmental mitigation and rehabilitation will be designed by LCP prior to issuing construction contracts for tender.
- The designs will assume the use of existing transportation infrastructure to the maximum extent possible. In particular, existing roads, bridges, railways and wharfs.
- Good Utility Practice will be observed.
- Fail Safe Design principles will be employed.
- Principles of Life Cycle Cost Analysis will be employed.
- The designs will be consistent with the Nalcor Safety and Health Program.
- The designs will be consistent with Nalcor Environmental Policy and Guiding Principles.
- The designs will be consistent with Nalcor asset management philosophy and approach.
- The designs will be consistent with all applicable governing Standards, Codes, Acts and Regulations.
- All assets and systems will be designed to ensure safety, reliability, efficiency and minimal impact to the environment.

6.4. Gull Island Hydroelectric Development

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6.5. Muskrat Falls Hydroelectric Development

Access - General

- Site roads to be gravel surfaced unless conditions dictate otherwise e.g. to limit dust and flying stones in areas such as accommodations complex and other site facilities.
- Permanent site access from south, along south side of river via TLH.
- Temporary site access to north side from TLH.

Permanent Accommodations

- No permanent accommodations required.

Construction Power

- Construction power will be from NL Hydro whenever practicable.

Construction Telecommunications – General

- Construction communication system required.

Temporary Site Facilities and Accommodations Complexes

- Staged, modular construction to accommodate up to 1,500 persons with appropriate offices, cooking, dining, sleeping, washing, medical, fire fighting, entertainment, recreational, power, water, sewage, and other life support facilities both at site , within the project area and at other locations, yet to be determined
- Main site facilities to be located on south side of river.
- Includes substation and distribution system for construction power supplied from NL Hydro and backup diesel generation at the site.
- Voice and data communication systems.
- Designed for removal following construction.

Reservoir

- FSL = 39 m; LSL = 38.5 m; MFL = 44 m.
- Remove all trees that grow in, or extend into the area between 3 m above FSL and 3 m below LSL, except where determined otherwise by the reservoir preparation strategy.
- Trash management system required for the reservoir.
- Fish habitat will be based on compensation strategy agreed with DFO.

Diversion

- Through spillway structure.
- Capacity = 5,930 m^3/s.
- Fish Compensation Flow will be approximately 30% of mean annual flow.
- Fish Compensation Flow will be through spillway structure.

Dams & Cofferdams

- Main dams are to be RCC.
- Development flood capacity is based on PMF.
- South RCC Dam crest elevation to be elevation 45.5 m.
- North RCC Dam to be an overflow dam with a crest elevation of elevation 39.5 m.
- All dams are to be founded directly on bedrock.
- Cofferdams are to be earth/rockfill dams.

Spillway (Gated Section)

- Concrete structure in rock excavation.
- Capacity = PMF in conjunction with North RCC Dam at MFL elevation of 44 m.
- Spillway sill at El. 5.0 m.
- Gates with heating and hoisting mechanisms designed for severe cold climate operation.
- 1 set (upstream and downstream) interchangeable steel Stoplogs with a permanent hoist system.

Tailrace

- Draft tubes discharge directly into river in rock excavation.

Intakes

- Approach channel in open cut earth/rock excavation and designed to eliminate frazil ice.
- Concrete structure in rock excavation.
- 4 intakes (one per unit).
- 4 sets of vertical lift operating gates with individual wire rope hoists in heated enclosures.
- 1 set of Bulkhead Gates with a permanent hoist system.
- 4 sets of removable steel Trash Racks.
- 1 permanent trash management system.

Penstocks

- No penstocks; 4 individual water passages in concrete (close-coupled intake/powerhouse).

Powerhouse Civil Works

- Concrete structure in rock excavation.
- Structural steel super-structure with metal cladding.
- Energy Star qualified building systems (Nalcor's LEED program).
- 4 unit powerhouse with maintenance bay large enough to assemble 1 complete turbine/Generator unit, plus assembly and transfer of 1 extra rotor. Provision for an unloading area.
- Area for offices, maintenance shops and warehouse. After completion of turbine/generator installation, the maintenance bay may be reduced in size to accommodate the dismantling of 1 entire turbine/generator unit only. Offices, maintenance shops, and warehouse may occupy the remaining area of the maintenance bay.
- 2 sets of draft tube Stoplogs with a permanent hoist system in a heated enclosure.

Turbines and Generators

- 4 – 206 MW, approximately, @ 0.90 pf vertical axis Generators.
- 4 Kaplan turbines with Cavitation Resistant Design.
- Unitized approach from intake to Generator step-up transformer.
- Failure of any equipment/system of one unit not to affect the operation of the remaining units.

Electrical Ancillary Equipment

- Dual dc battery system.
- A minimum of 2 sources of station service.
- Dual digital protection systems.
- A distributed digital control and monitoring system.
- Dual CPU for control system functions.
- 2 standby emergency diesel Generators, in separate locations, complete with fuel storage systems.

Mechanical Ancillary Equipment

- Separate high & low pressure compressed air systems.
- Separate service, domestic, and fire water systems.
- HVAC systems. Generators are to be a source of powerhouse heating.
- 2 overhead powerhouse cranes, with the capability to operate in tandem having a combined design capacity, when operated in tandem, to lift a fully assembled Rotor.
- Elevator access to all levels of powerhouse.
- Dewatering and drainage systems c/w oil interception system.
- Permanent waste hydraulic & lubricating oil storage and handling system complete with a permanent centrifuge filtration system.
- Permanent hoist system required for each turbine pit.

Generator Transformers & Switching

- 4 - step up transformers (unit voltage to 345 kV) located on powerhouse draft tube deck.
- Each unit will have a Generator breaker.

Churchill Falls Extension - General

- To accommodate 2 X 345 kV HVac transmission lines from Muskrat Falls.
- To be an extension within the existing CF Switchyard.
- Construction and operation not to adversely impact the existing CF operation.
- Concrete foundations and galvanized steel structures to support the electrical equipment and switchgear.

Muskrat Falls Switchyard - General

- Situated on the south side of the river on a level, fenced site.
- Concrete foundations and galvanized steel structures to support the electrical equipment and switchgear.
- Electrical layout of the switchyard is to be in accordance with the proposed SLD. (See Drawings).

Operations Telecommunication Systems

- All permanent control, teleprotection, SCADA and voice circuits to have communication redundancy.

6.6. HVac Transmission Systems

Soldiers Pond Switchyard

- Situated on the north-east side of Soldiers Pond on a level, fenced site.
- Concrete foundations and galvanized steel structures to support the electrical equipment and switchgear.
- Electrical layout of the switchyard is to be in accordance with the proposed SLD. (See Drawings).

- Muskrat Falls Switchyard to HVdc Converter Station
- 2 - 345 kV HVac transmission lines to connect the Muskrat Falls switchyard to the ±320 kV HVdc Converter Station.
- Each of the 345 kV HVac lines to have a designed power capacity of 900 MW.

HVac Overland Transmission - Muskrat Falls to Churchill Falls

- 2 - 345 kV HVac overhead transmission lines to connect the Muskrat Falls switchyard to Gull Island and the Churchill Falls switchyard extension.
- Lines are to be carried on galvanized lattice steel towers, with self supported angles and deadends, and guyed suspension towers.
- Line power capacity is to be 900 MW for each line, allowing for all load to be carried on a single circuit.
- Line corridor as per Key Plan. (See Drawings).
- 50 year Reliability Level Return Period of loads.
- All lines to have overhead lightning protection (OHGW) with one being OPGW for the Operations Telecommunications System.
- Counterpoise installed from station to station.

HVac Overland Transmission - Collector Lines

- Muskrat Falls
  - o 4 – 345 kV HVac cable sets to connect the high side of the step up transformers to the switchyard.

6.7. HVdc Transmission Systems

Overall HVdc system consists of a 900 MW HVdc Island Link between Labrador and Newfoundland.

<u>Muskrat Falls Converter Station</u>

- 900 MW, ±320 kV bi-pole, LCC Converter Station capable of operating in mono-polar mode.
- Each pole rated at 450 MW with 100% overload protection for 10 minutes and 50% overload protection for continuous operation.
- Situated on the south side of the Churchill River on a level fenced site.
- Concrete foundations and galvanized steel structures to support the electrical equipment and switchgear.
- Mono-polar operation shall be supported by an Electrode.

<u>Electrode Line - Muskrat Falls to SOBI</u>

- An Electrode Line carrying 2 conductors – route to be selected within the same ROW of the HVdc transmission line.
- Wood pole construction.
- 50 year Reliability Level Return Period of loads.
- Electrode line will have provision for lightning protection.

<u>Electrode - Labrador</u>

- A shoreline pond electrode to be located on the Labrador side of the SOBI.
- Nominal rating of 450 MW with 100% overload protection for 10 minutes and 50% overload protection for continuous operation.

<u>HVdc Overland Transmission - Muskrat Falls to Strait of Belle Isle</u>

- An HVdc overhead transmission line, ±320 kV bi-pole, to connect the Muskrat Falls Converter Station to the Labrador Transition Compound at the Strait of Belle Isle.
- Line to carry both poles (single conductor per pole), and one OPGW.
- Line corridor as per Key Plan. (See Drawings).
- This segment of the HVdc line is to have a designed nominal power capacity of 900 MW; however, given the mono-polar operation criteria, each pole is to have a nominal rating of 450 MW with 100% overload capacity for 10 minutes and 50% overload capacity for continuous operation.
- Counterpoise installed from station to station.
- Towers are to be galvanized lattice steel, with self supported angles and deadends, and guyed suspension towers.
- 50 year Reliability Level Return Period of loads.

Transition Compound - Labrador

- Situated on a level fenced site.
- Provision for cables and associated switching requirements.
- Concrete pads and steel structures to support the electrical equipment and switchgear.
- Overhead line to cable transition equipment.
- Switching, control, protection, monitoring and communication equipment.

Marine Crossing - SOBI

- 3 - ±320 kV MI sub-sea cables transmit power across the SOBI. One of these cables will be a spare.
- Cable(s) for each pole to have a nominal rating of 450 MW with 100% overload capacity for 10 minutes and 50% overload capacity for continuous operation.
- The route for the sub-sea cable(s) crossing shall be designed to meet the transmission, protection, reliability, and design life requirements, and give consideration to technical and economic optimization.
- Cable corridor as per Key Plan. (See Drawings).
- Cables shall be adequately protected along the entire length of the crossing as required. However, installation methodologies may be employed to mitigate damage from external environmental and man-made risks.
- Where discrete protection application is required, protection measures shall be designed to meet the transmission and reliability requirements.
- Cable protection methodology will employ proven technologies only, and may include tunnelling, rock placement, trenching, horizontal directional drilling (HDD) and concrete mattresses.

Transition Compound – Northern Peninsula

- Situated on a level fenced site.
- Provision for cables and associated switching requirements.
- Concrete pads and steel structures to support the electrical equipment and switchgear.
- Cable to overhead line transition equipment.
- Switching, control, protection, monitoring and communication equipment.

HVdc Overland Transmission - Strait of Belle Isle to Soldiers Pond

- An HVdc overhead transmission line, ±320 kV bi-pole, to connect the Northern Peninsula Transition Compound at the Strait of Belle Isle to the Soldiers Pond Converter Station.
- Line to carry both poles (single conductor per pole) and one OPGW.
- Line corridor as per Key Plan. (See Drawings).

- This segment of the HVdc line is to have a designed nominal power capacity of 900 MW; however, given the mono-polar operation criteria, each pole is to have a nominal rating of 450 MW with 100% overload capacity for 10 minutes and 50% overload capacity for continuous operation.
- Counterpoise installed from station to station.
- Towers are to be galvanized lattice steel, with self supported angles and deadends, and guyed suspension towers.
- 50 year Reliability Level Return Period of loads.

<u>Soldiers Pond Converter Station</u>

- 900 MW, ±320 kV bi-pole, LCC Converter Station capable of operating in mono-polar mode.
- Each pole rated at 450 MW with 100% overload protection for 10 minutes and 50% overload protection for continuous operation.
- Situated on the north side of the Soldiers Pond Tap on the Avalon Peninsula on a level fenced site.
- Concrete foundations and galvanized steel structures to support the electrical equipment and switchgear.
- Mono-polar operation shall be supported by an Electrode.

<u>Electrode Line – Soldiers Pond to Conception Bay</u>

- An Electrode Line carrying 2 conductors generally follows the existing transmission ROW from Soldiers Pond to Conception Bay.
- Wood pole construction.
- 50 year Reliability Level Return Period of loads.
- Electrode line will have provision for lightning protection.

<u>Electrode - Soldiers Pond</u>

- A shoreline pond electrode to be located on the east side of Conception Bay.
- Nominal rating of 450 MW with 100% overload protection for 10 minutes and 50% overload protection for continuous operation.

System Upgrades for Island Link

- Conversion of existing Holyrood Units 1 & 2 to synchronous condensers.
- 230 kV and 138 kV circuit breaker replacements.
- 3 - 300 MVAR high inertia synchronous condensers at Soldiers Pond to maintain system performance.

Operations Telecommunication Systems – Island Link

- All permanent control, teleprotection, SCADA and voice circuits to have communication redundancy.

6.8. Drawings

1. Key Plan
2. Muskrat Falls General Arrangement
3. Proposed Single Line Diagram – Muskrat Falls

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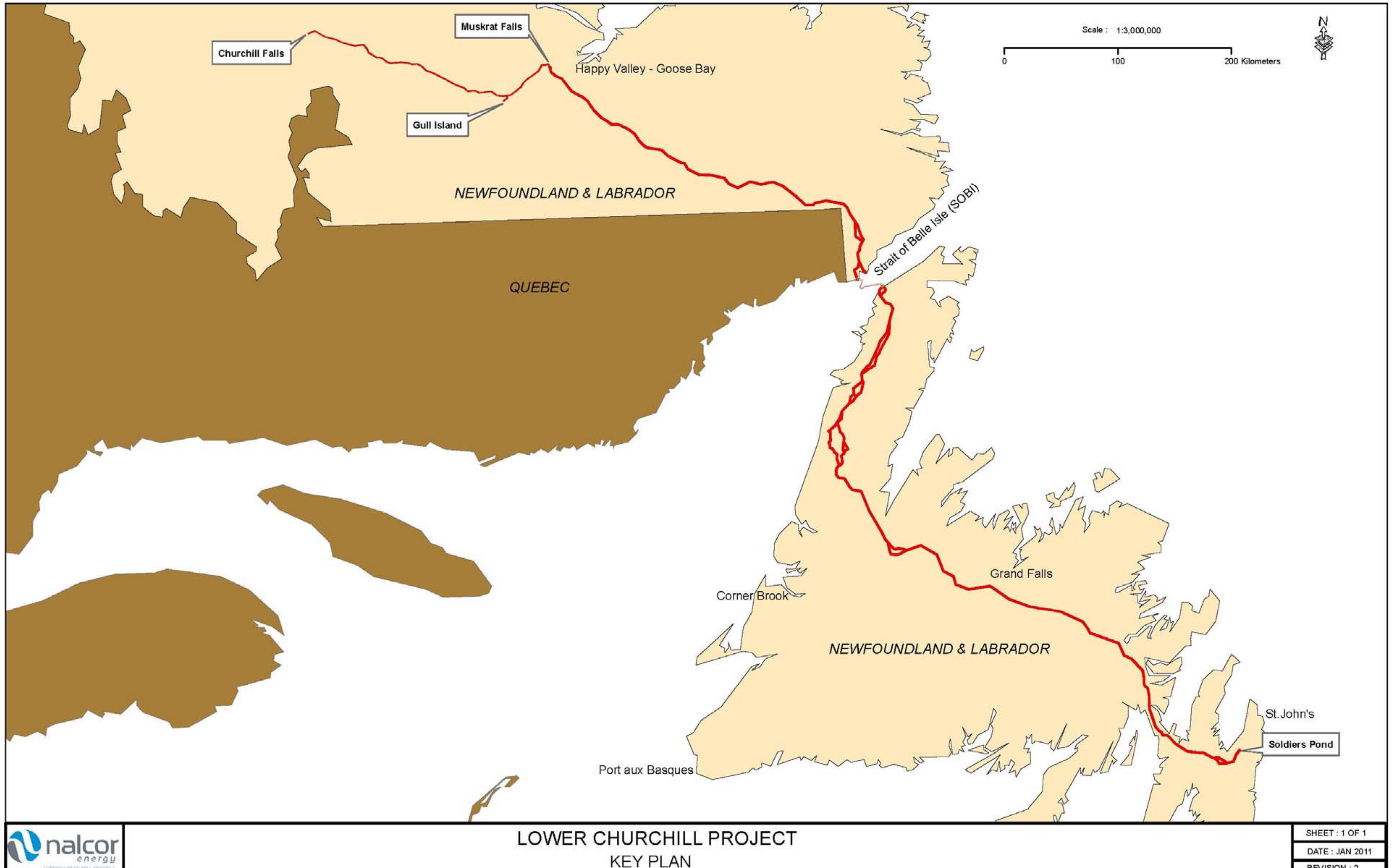

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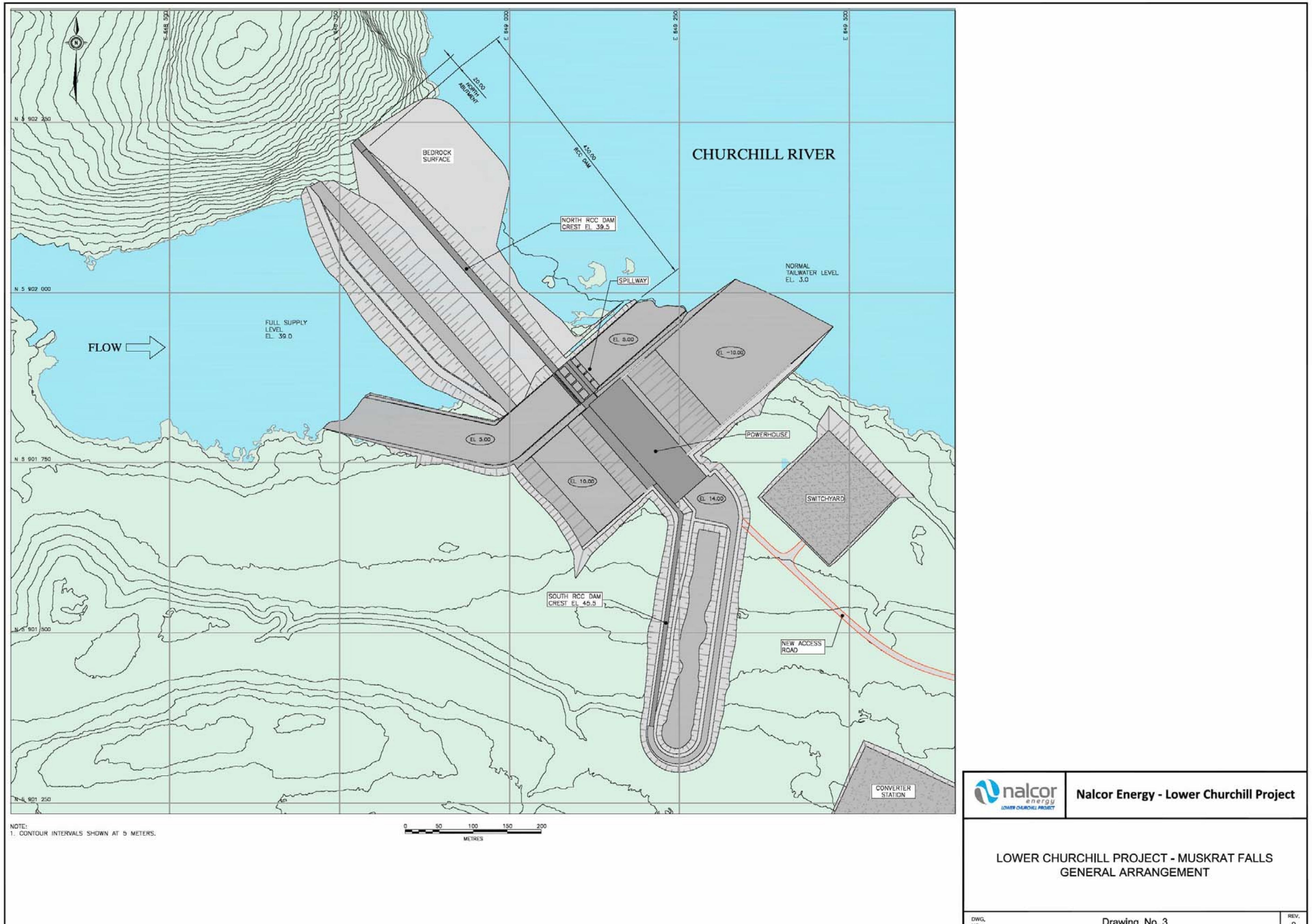

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