Lower Churchill Project

1 - Introduction and Project Components

June 2018

Boundless Energy

nalcor energy
LOWER CHURCHILL PROJECT

Privileged and Confidential in Contemplation of Litigation

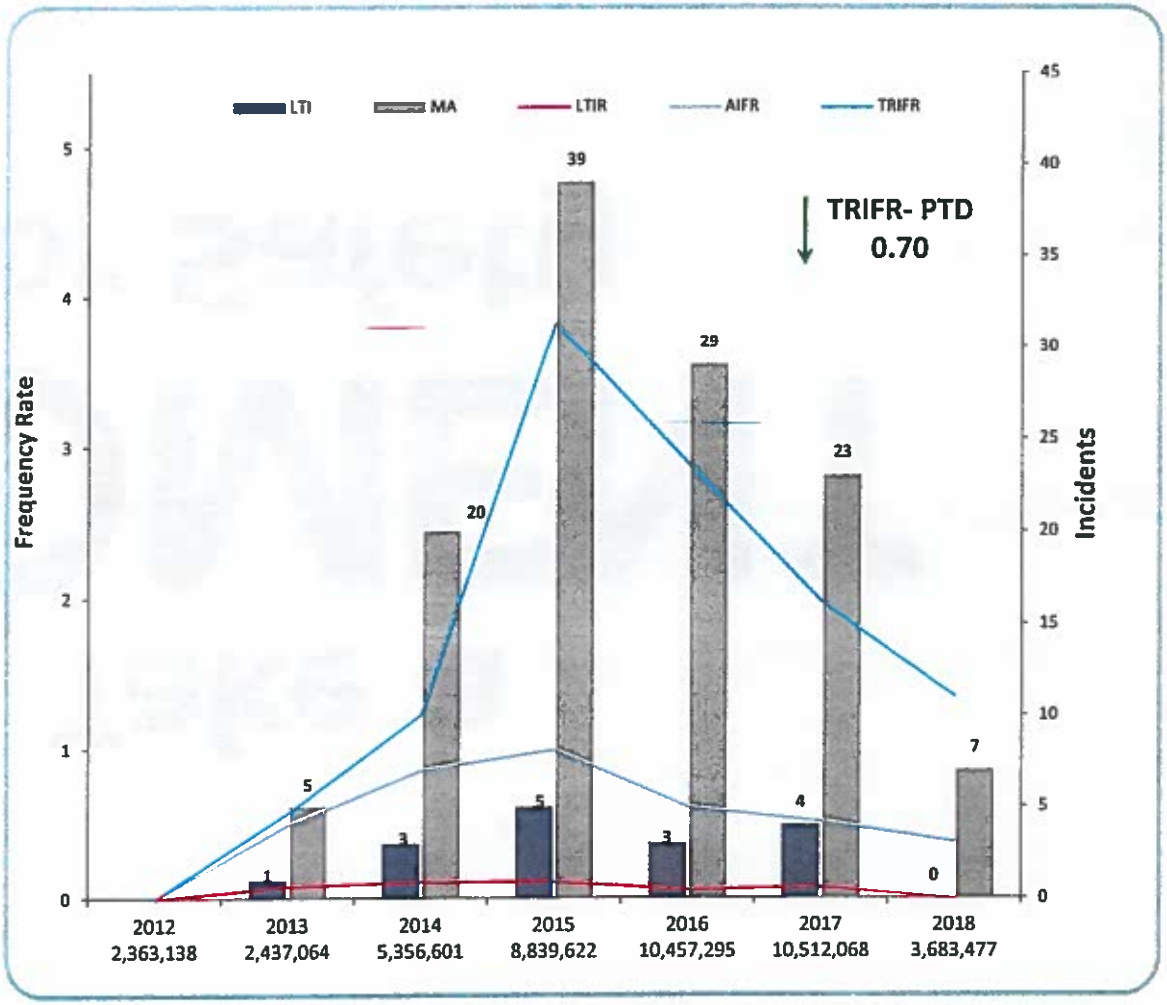
Disclaimer

- This presentation was developed by consultants to the Lower Churchill Project team
- Any expressed opinions or other statements of what occurred in the project that are documented in the presentation are the product of the consultants' recollection
- The consultants have prepared a more comprehensive document addressing the project phases
- Any reliance upon or decisions made from the information that is contained in this presentation or the more detailed documentation prepared by the consultants is the sole judgement/decision of the user of the information
- In the event of any discrepancies between this presentation and other documentation, please contact the presenters for clarification

Take a MOMENT for Safety

Safety Performance

- ~ 43.0M hours worked project wide (End June 2018)
- **Zero fatalities**
- Multiple work fronts
- Harsh working locations
- Multiple contractors with varied safety procedures/processes
- 16 lost-time injuries
- ~10.3M hours worked with no LTI



Total Recordable Incident Frequency Rate

Introduction

Introduction to the consultants

- Paul Harrington
- Ron Power
- Lance Clarke
- Scott O'Brien
- Pat Hussey
- Jason Kean

Objective

- Share accurate and relevant information and insights to assist Muskrat Falls Inquiry Counsel
- Present from a viewpoint and insight that few individuals hold (depth and breadth of knowledge of, and experience) with the Muskrat Falls Project ('MFP')
- Demonstrate a willingness to support the Commissioner's mandate and objectives related to the Muskrat Falls Inquiry

The scope of the presentation is from pre-sanction to date

1. Introduction and project components
2. Governance, oversight and assurance reviews
3. Project delivery model and organization
4. SNC-Lavalin contract
5. Contracting strategy and process
6. Astaldi contract
7. Pre-sanction
8. The sanction decision
9. Financial close / completion guarantees / COREA
10. Post-sanction
11. SNC risk report
12. Cost updates and forecasting

Key points of context

Inquiry context

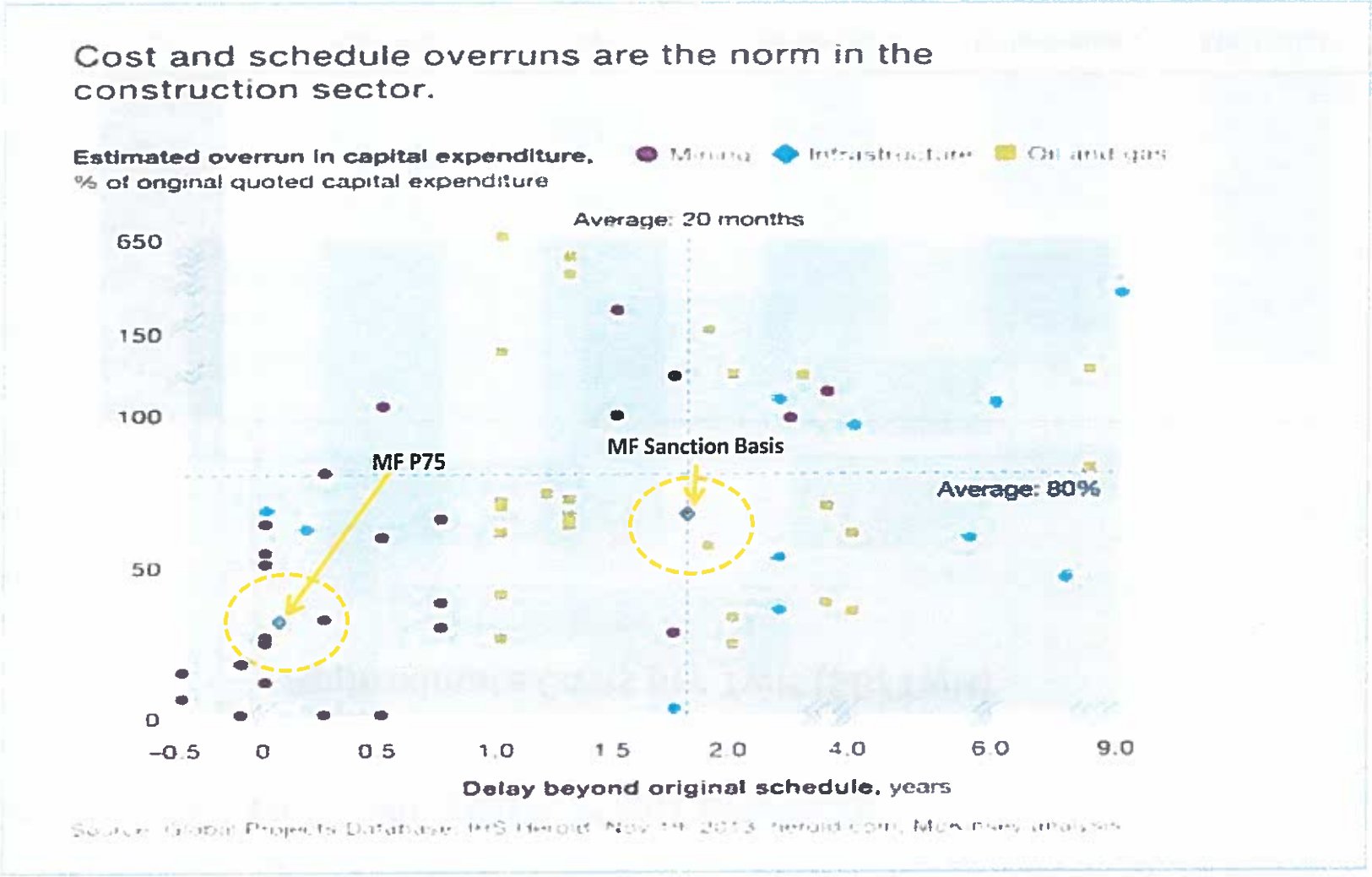
- Our understanding
  - Making the best decision with the information available at the time (reasonableness at the time - not the 20/20 perfection of hindsight)
  - Fact based, no conjecture or "what if's"
  - Materiality is critical
- Our perspective - the project is…
  - Extremely well documented – procedures and decisions
  - Heavily reviewed and scrutinized
  - Highly politicized and target of the media – led to a lot of misinformation, innuendo and false accusation
  - Expected ~95% complete at Sanction completion date (mid-2018)

Key points of context (cont.)

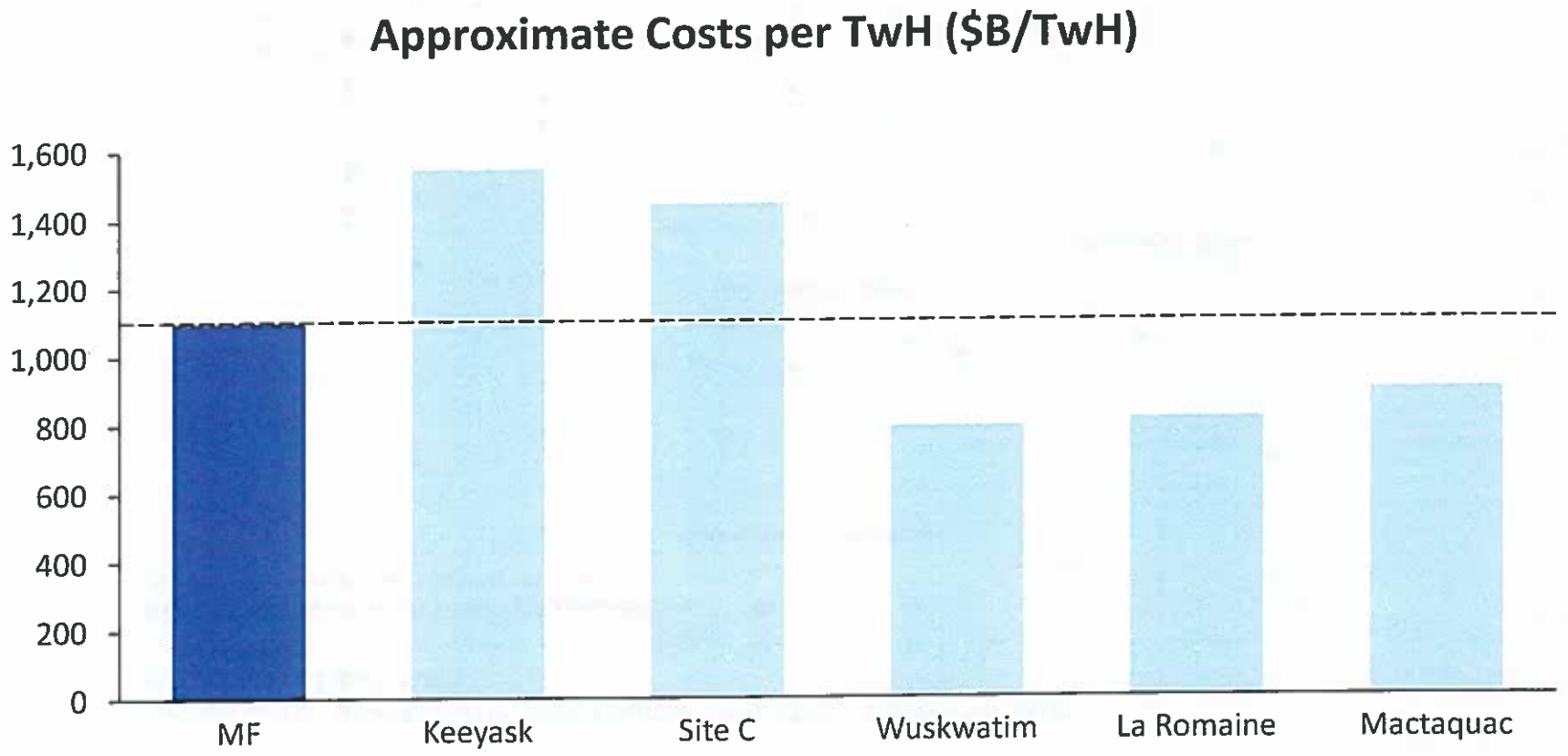
Industry Benchmarks

- Mega Projects experience a lot of challenges – many times due to strategic risk
- A 2016 McKinsey report highlighted:
  - Muskrat Falls is better than average on cost overruns (against P50)
  - Right on average for time overrun (much less than P50)
- For generation the capital $/TwH for Muskrat Falls puts us right in the middle of the pack for recent Canadian Utility Mega Projects, cheaper than both Site C and Keeyask which have a lot of risk remaining

2016 McKinsey report: Cost and schedule overruns within construction industry



Comparison of capital efficiency (excl. IDC) for Muskrat Falls Generation to other generation projects



Note: TwH = TerawattHour

Overview of components

General

Historical context

- In 2006 the Government of NL announced that Newfoundland Hydro (now Nalcor) would lead the development of the Lower Churchill Project
- A Provincial Energy Plan was developed in 2007 / 2008 which set the policy for all energy development in NL
- Nalcor was formed in 2008 to lead the implementation of this Plan

Nalcor's vision: *"to build a strong economic future for successive generations of Newfoundlanders and Labradorians"*

nalcor energy

- NL Hydro
- Churchill Falls
- Oil & Gas
- Lower Churchill
- Bull Arm Fabrication
- Energy Marketing



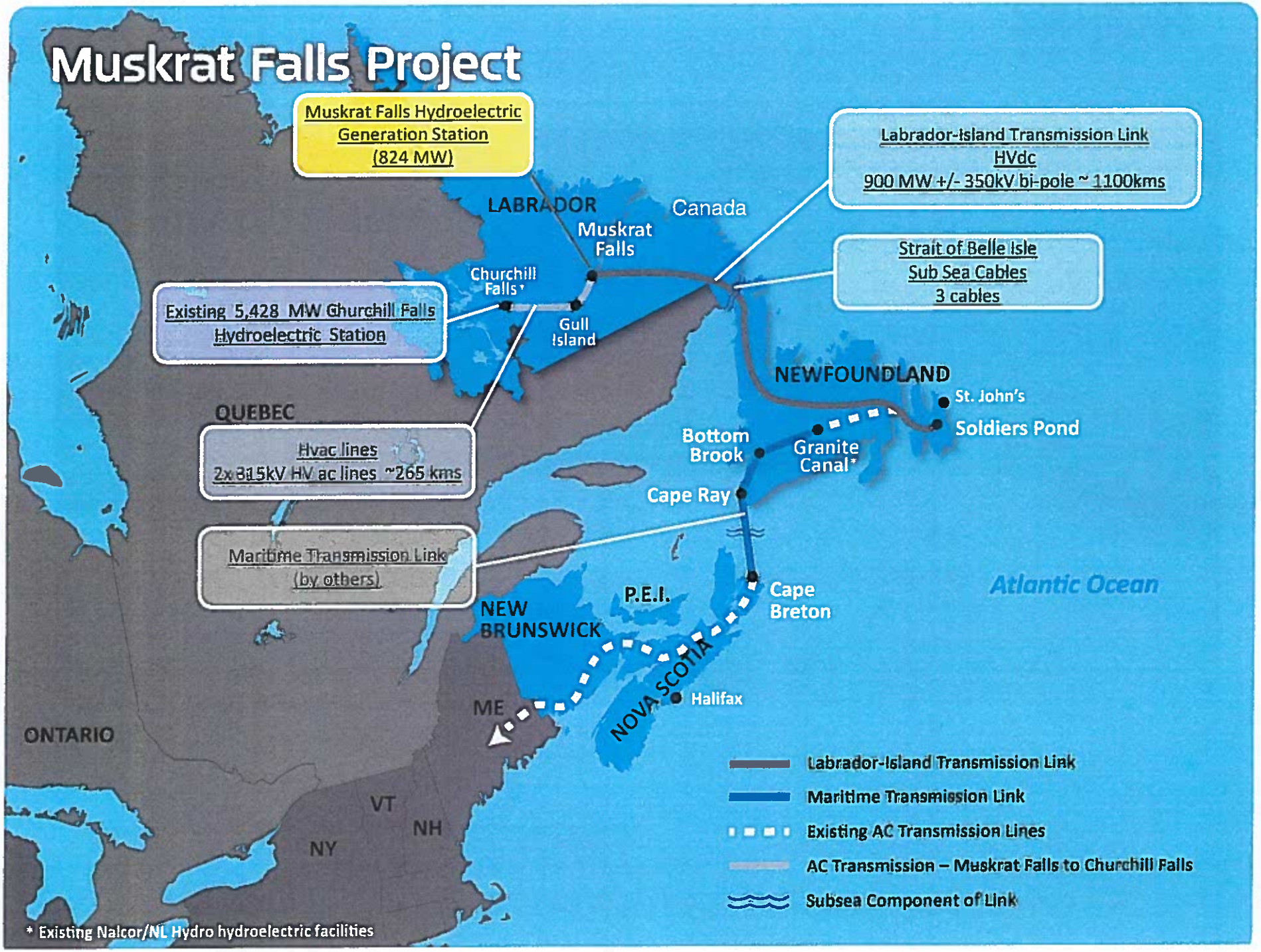



Phase 1 – Muskrat Falls

Phase 2 – Gull Island

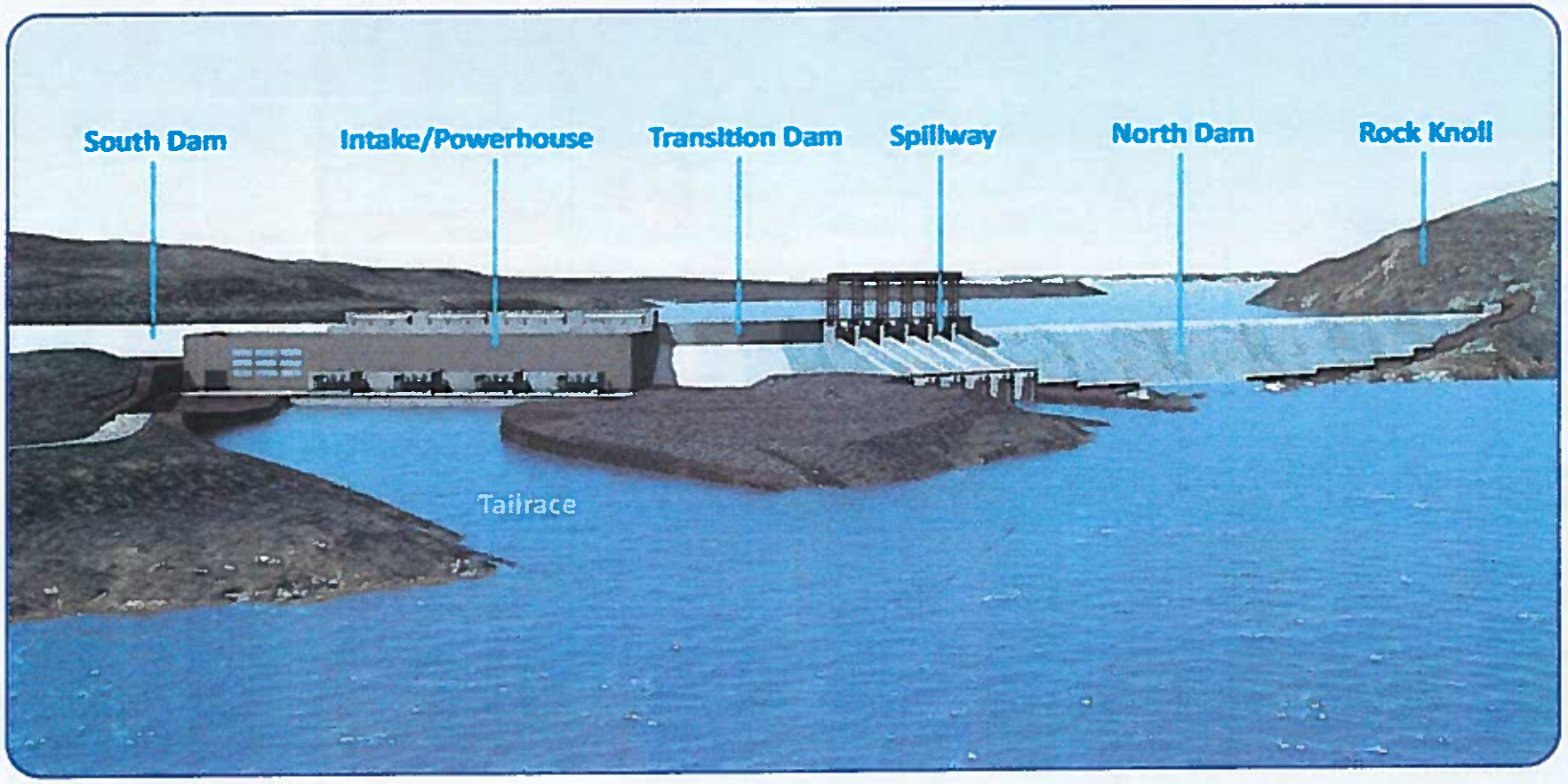
Overview of components

Generating Site

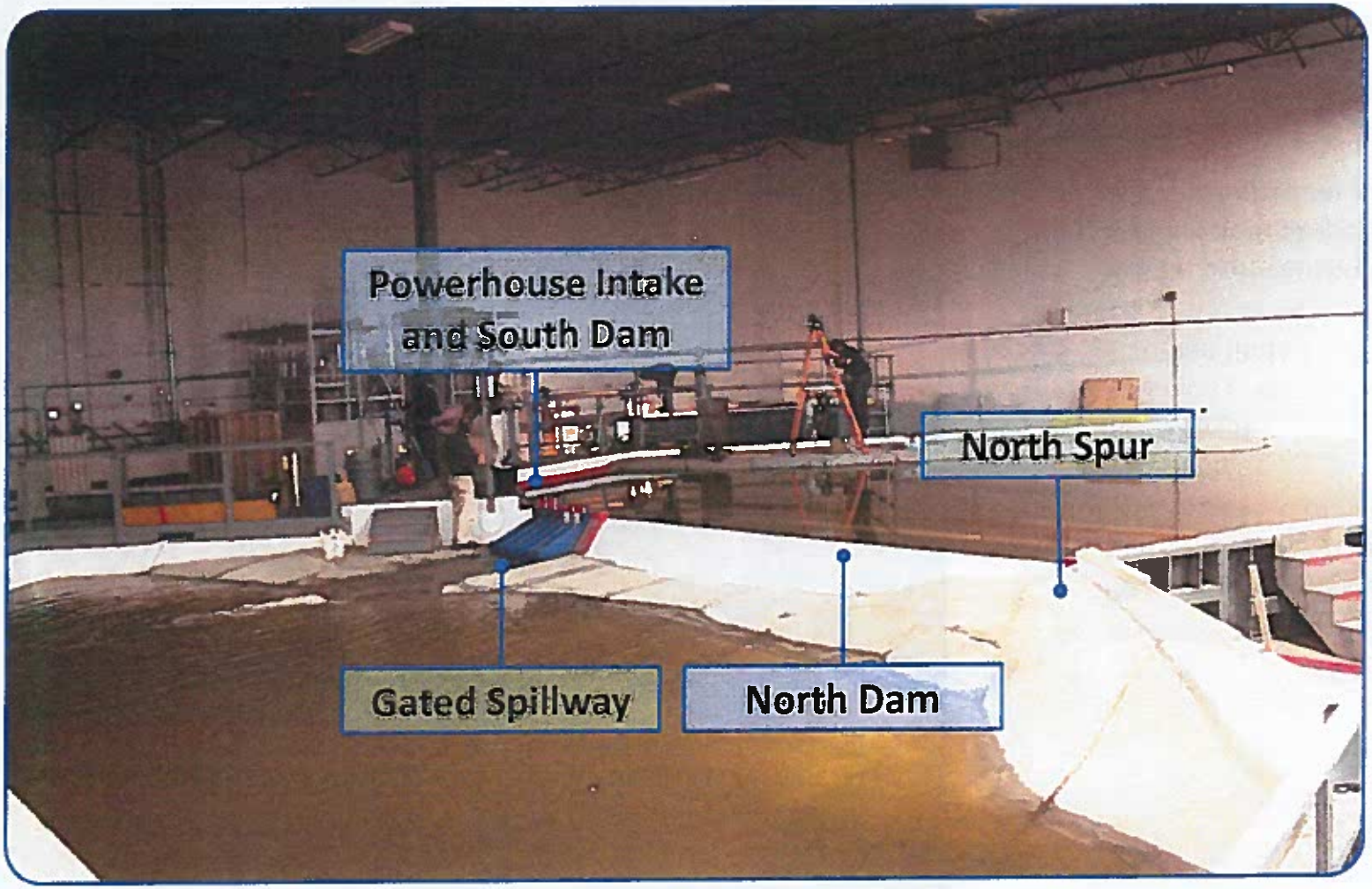

Muskrat Falls Project
Muskrat Falls Hydroelectric Generation Station (824 MW)
Labrador-Island Transmission Link HVdc 900 MW +/- 350kV bi-pole ~ 1100kms
Strait of Belle Isle Sub Sea Cables 3 cables
Existing 5,428 MW Churchill Falls Hydroelectric Station
Hvac lines 2x 315kV HV ac lines ~265 kms
Maritime Transmission Link (by others)
LABRADOR
Canada
Muskrat Falls
Churchill Falls*
Gull Island
QUEBEC
NEWFOUNDLAND
St. John's
Soldiers Pond
Bottom Brook
Granite Canal*
Cape Ray
Cape Breton
P.E.I.
NEW BRUNSWICK
NOVA SCOTIA
Halifax
Atlantic Ocean
ME
ONTARIO
VT
NH
NY
Labrador-Island Transmission Link
Maritime Transmission Link
Existing AC Transmission Lines
AC Transmission – Muskrat Falls to Churchill Falls
Subsea Component of Link
* Existing Nalcor/NL Hydro hydroelectric facilities

Muskrat Falls Generating Facility

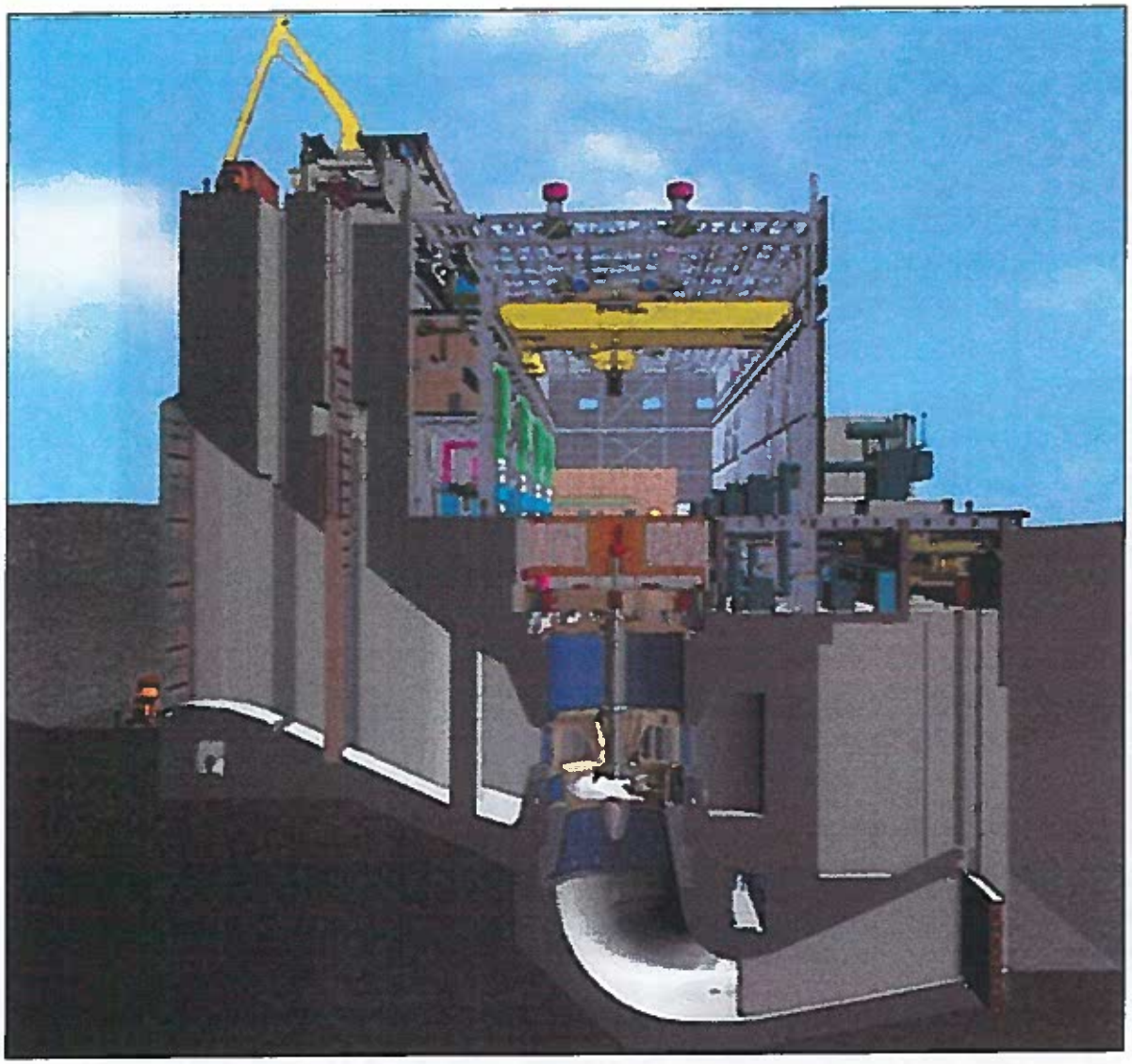
Muskrat Falls Generating Facility



Layout verified by scaled operational model



Powerhouse overview



- Powerhouse will house the four turbines and generate up to 824 MW of power
- ~85 m high
- 4 Kaplan units
- The units at Muskrat Falls will be some of the largest and most efficient Kaplans in the world

The powerhouse

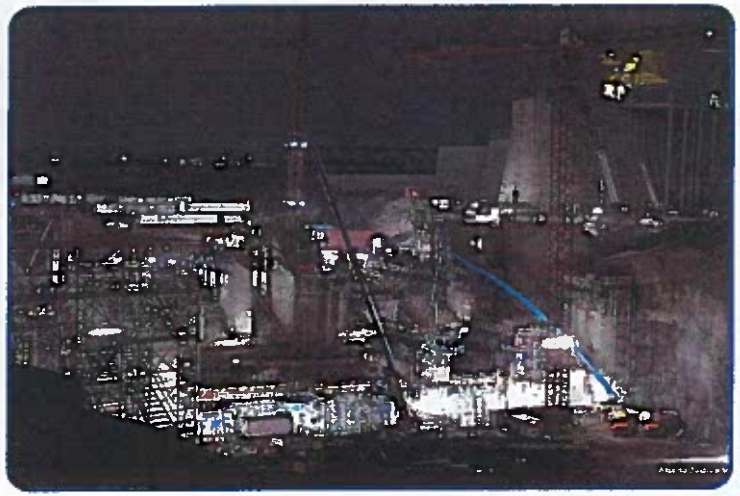
Construction takes place in harsh environments

Ice buildup

Ice buildup

Winter Construction

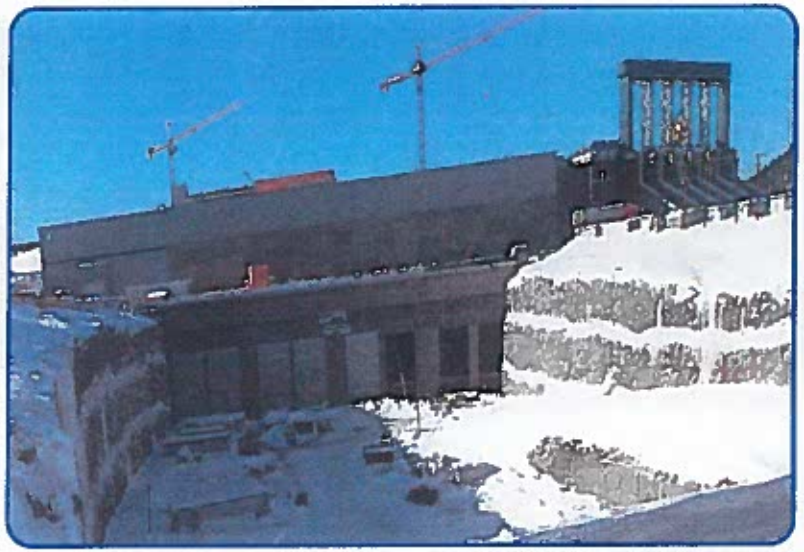
Night Shift



Intake and tailrace

Intake

Tailrace



Overview of components

Turbines and generators and Hydro-Mechanical Equipment (Gates and Hoists)

Heavy steel is manufactured in China

Forgings

Forgings

Turbine Stayring Fabrication

Machining

The heavy steel fabrication work was executed in China while the electrical and some specialized components are manufactured in other parts of the world

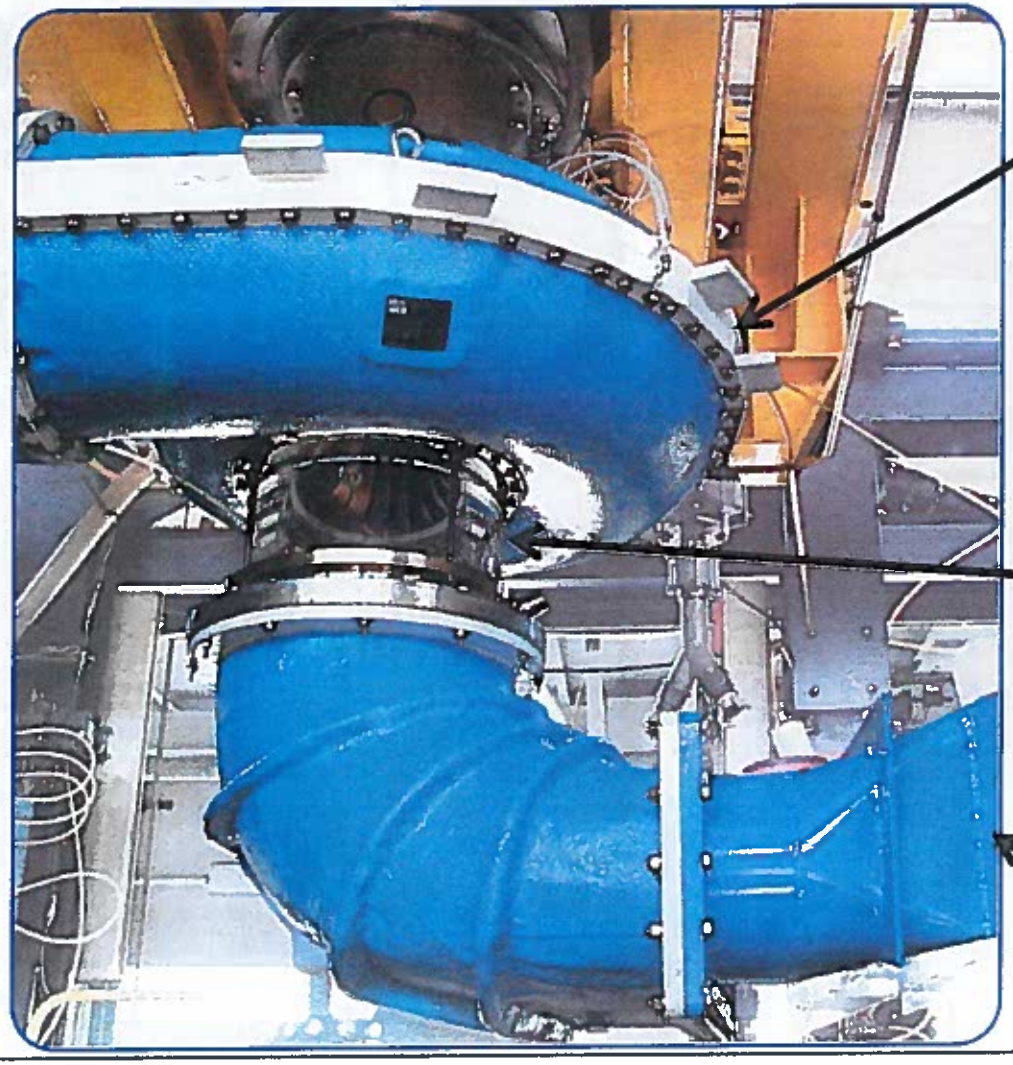
Some manufacturing was also done in India

Witnessing of rotor pole testing

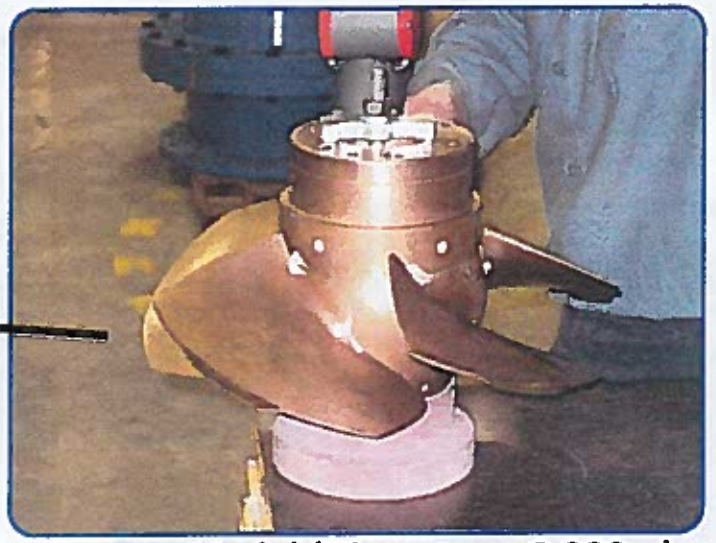
Witnessing of rotor pole testing

Operational and schedule risk reduction

Turbine Model Testing



Scroll Case



Runner Model (Diameter = 0.380m)

Draft Tube

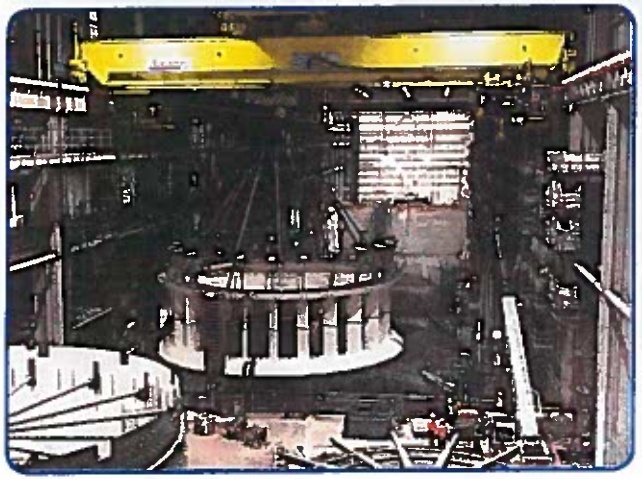
Turbine equipment

Turbines equipment

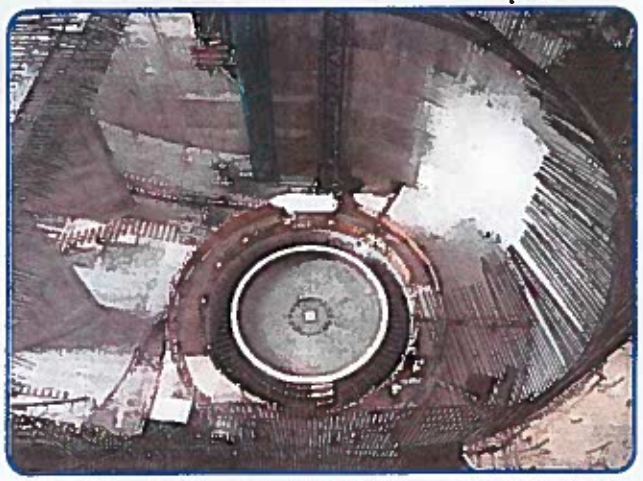
Draft tube liner

Draft tube liner

Unit 1 – Stayring Installation



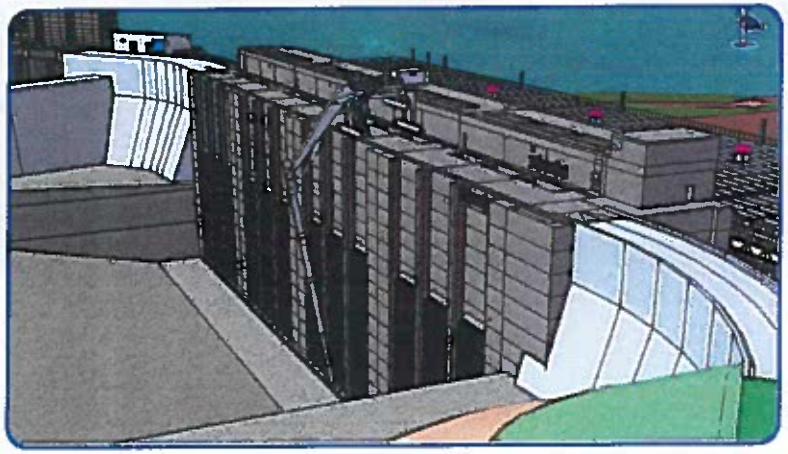
Unit 1 - Draft Tube Liner Inplace



Some hydro-mechanical equipment was manufactured in different international locations

Manufactured in China

Trash Rack Cleaner



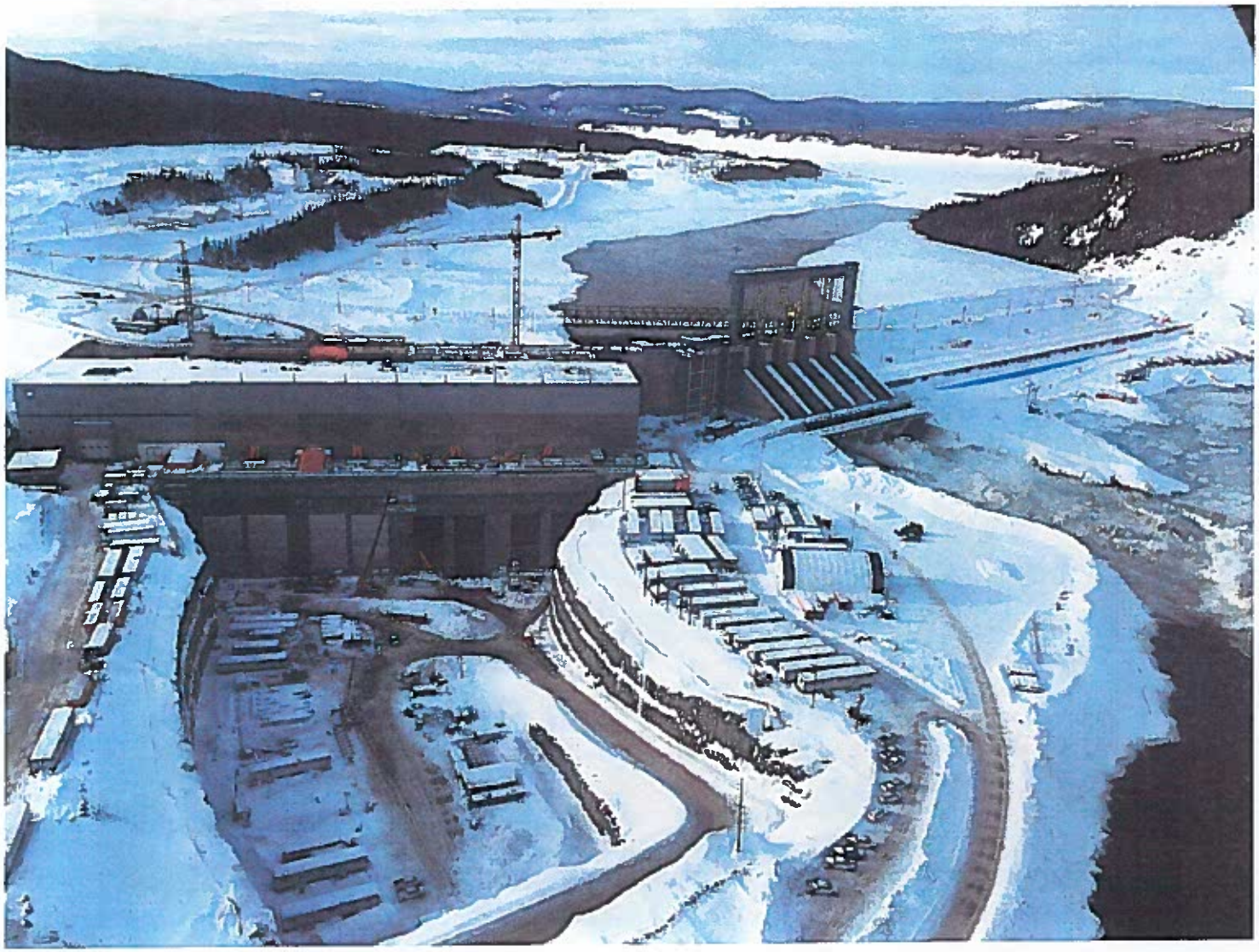
Manufactured in Germany

Overview of components

Spillway

Spillway

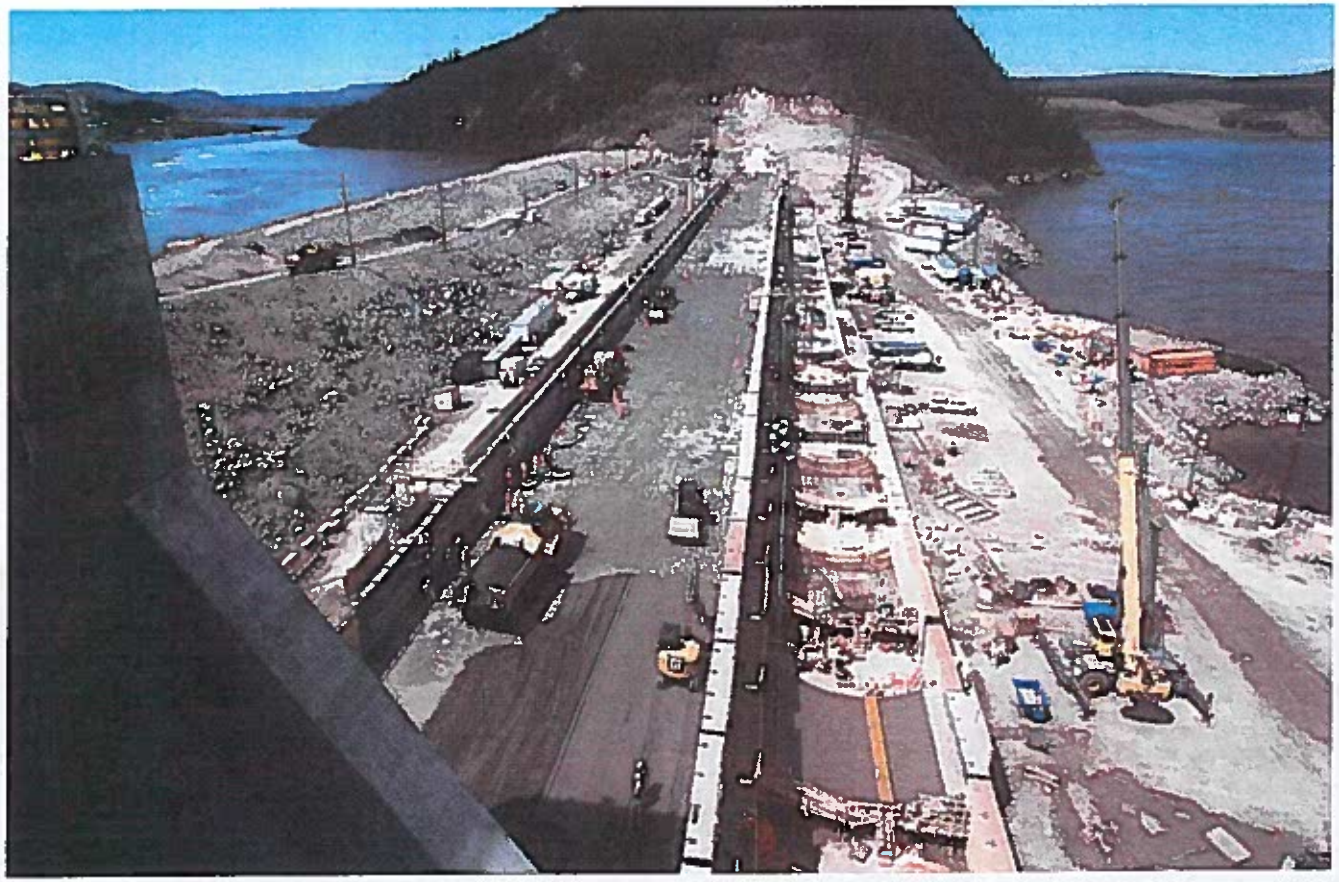
Aerial View



Overview of components

North Dam

North Dam – largest Roller Compacted Concrete (RCC) Dam in Canada



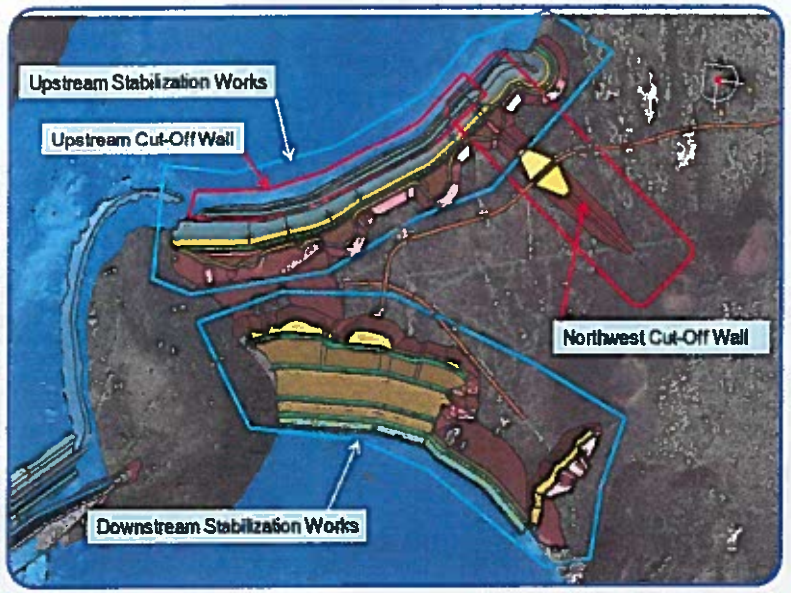
Overview of components

North Spur

North spur

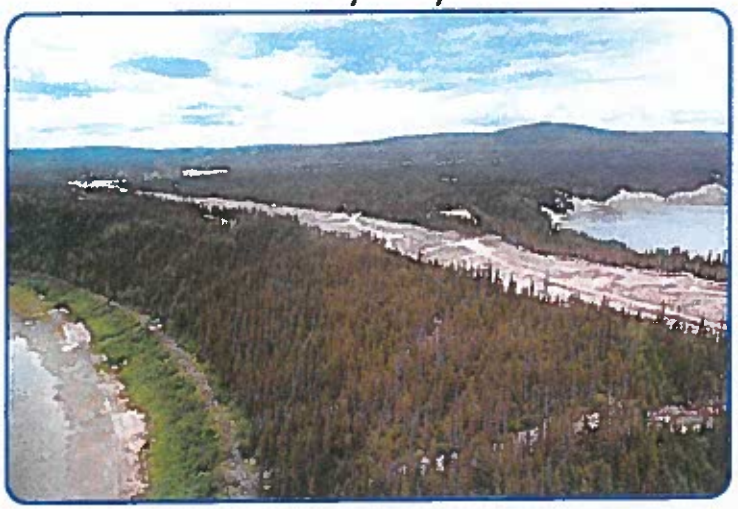
North Spur aerial view

North Spur design



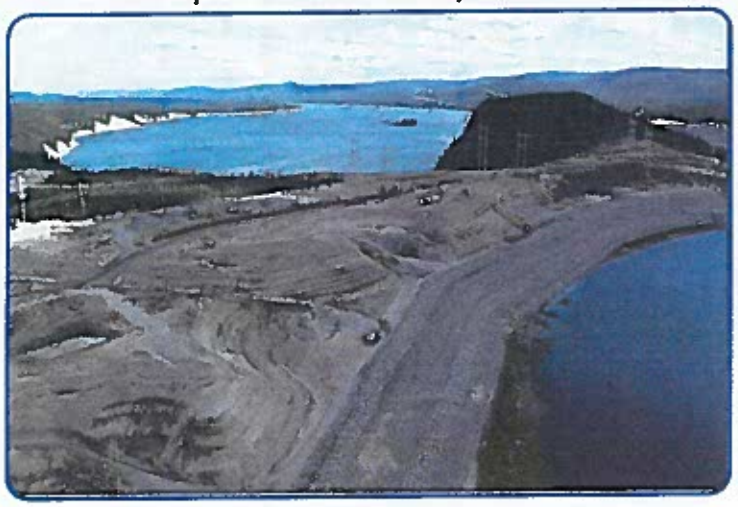
North spur construction

Early Days



Mid - Construction

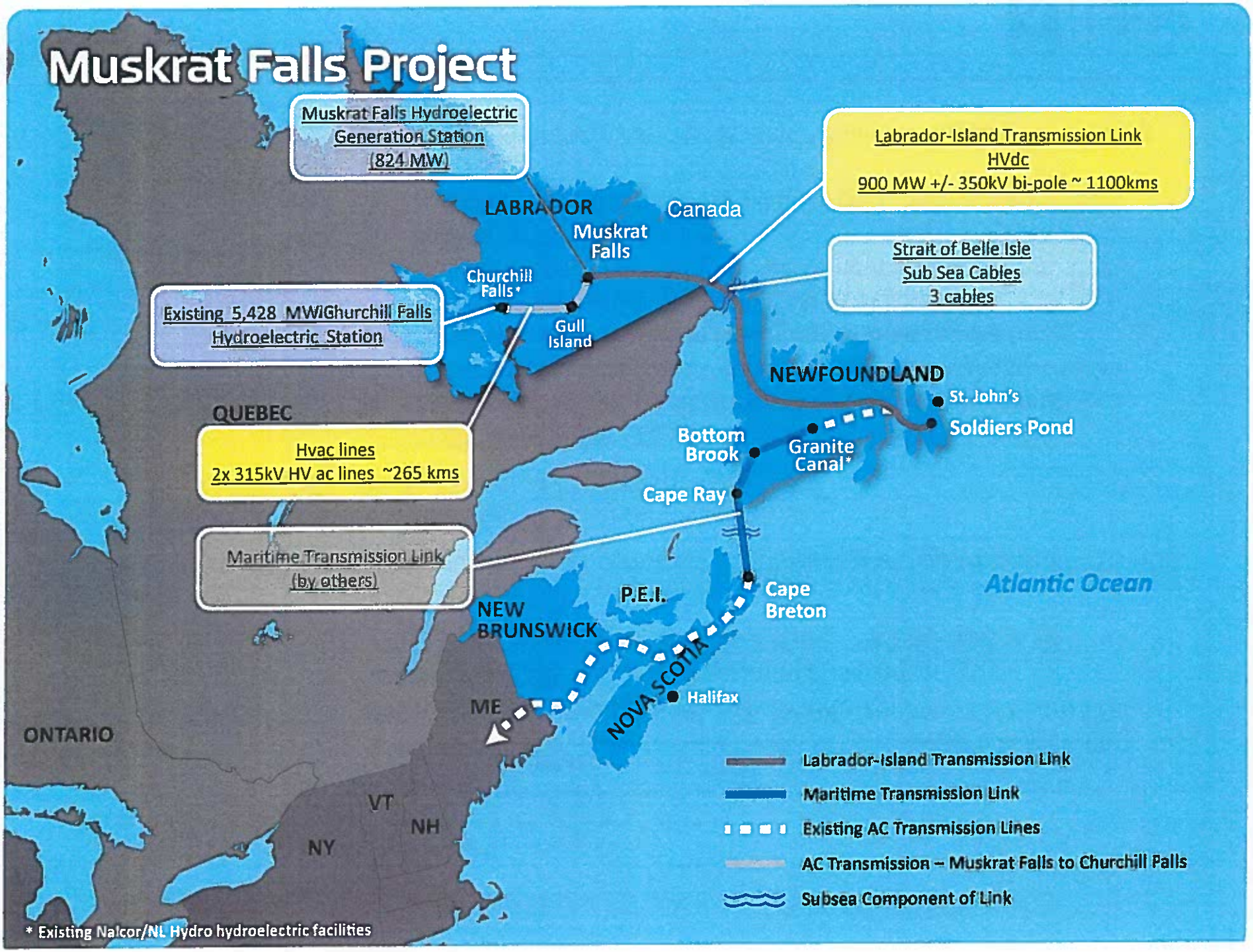
Upstream Completed



Downstream Completed

Overview of components

Transmission Lines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Subsea Component of Link
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The transmission project scope

Scope summary

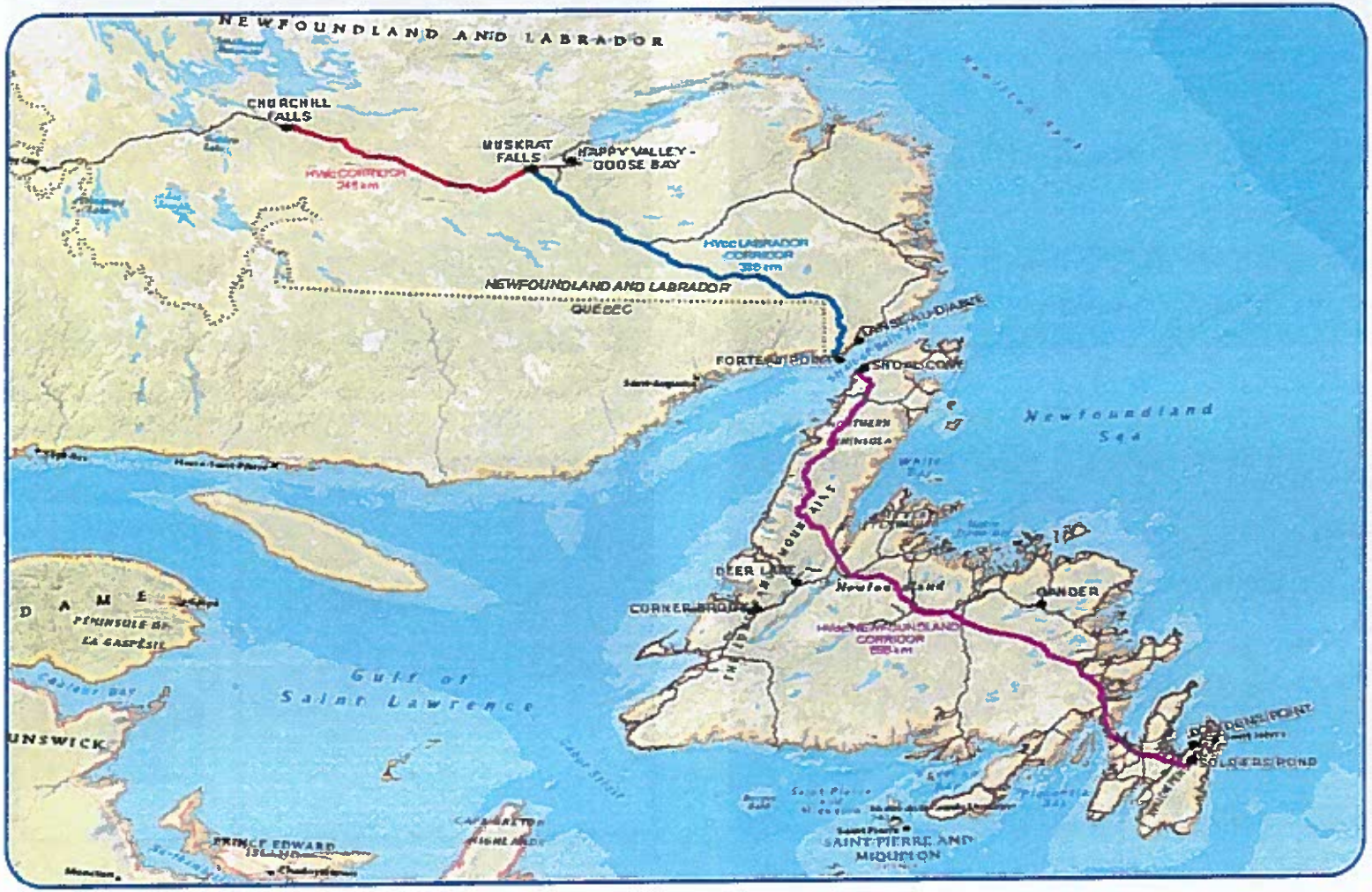
AC Transmission (Muskrat to Churchill Falls)

- ~ 265 km of two parallel 315 kV AC Transmission Line (TL), Muskrat Falls (MF) to Churchill Falls (CF)
- 1,262 towers, ~100,000 insulators, ~3,000,000 m of conductor
- Weight of steel required for towers and foundations ~ 15,000 tonnes
- Hvac line: 371 stream crossings

DC Transmission (Labrador-Island Link)

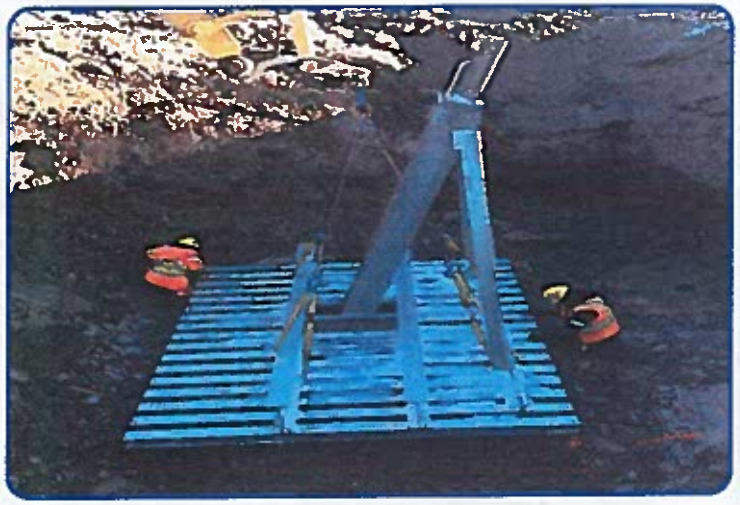
- ~ 1100 km of 350 kV DC TL (Muskrat Falls to Soldier's Pond)
- Engineered to withstand the harsh environmental and weather conditions experienced in Newfoundland and Labrador
- 3230 towers, ~330,000, ~2,184,000 m of conductor
- Weight of steel required for towers and foundations ~ 45,000 tonnes
- HVdc line: ~ 373 bridges (small to large) / ~900 culvert stream crossings
- ~ 1100 km new access roads, and ~ 800 kms upgrades to existing roads

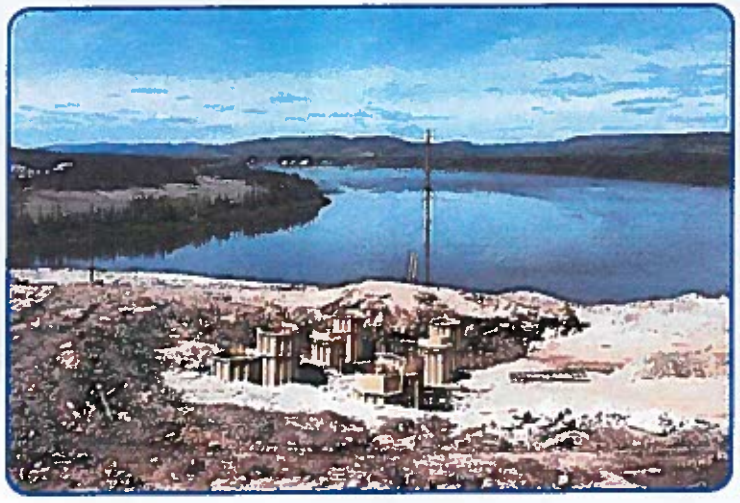
Line routing



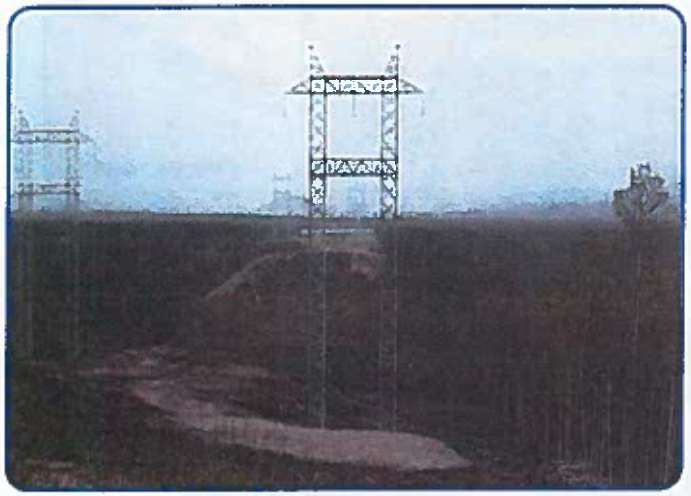
Long range mountains

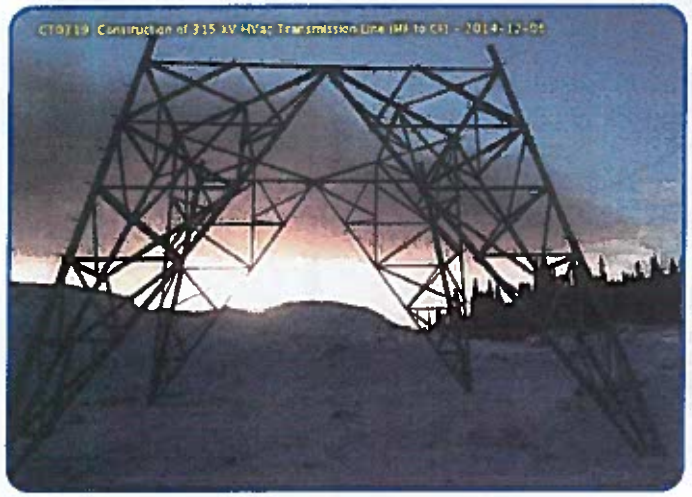
Foundation installation

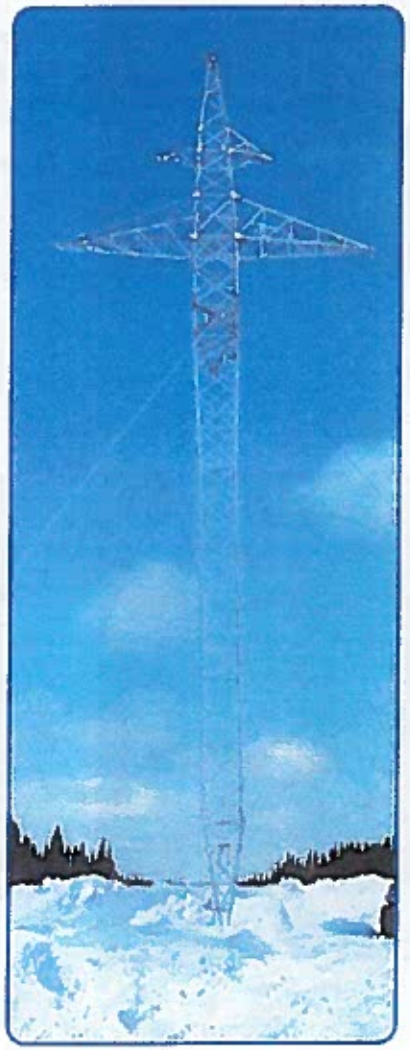




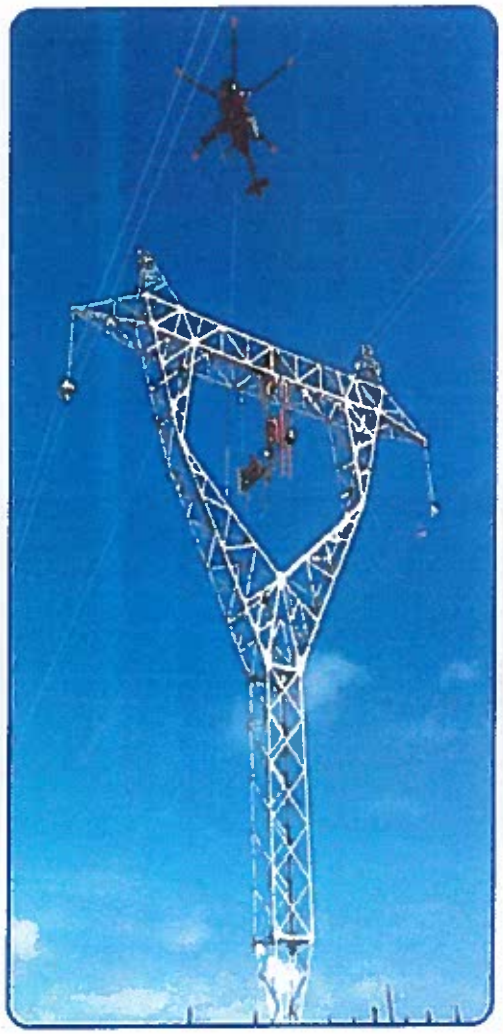
Tower erection







Stringing

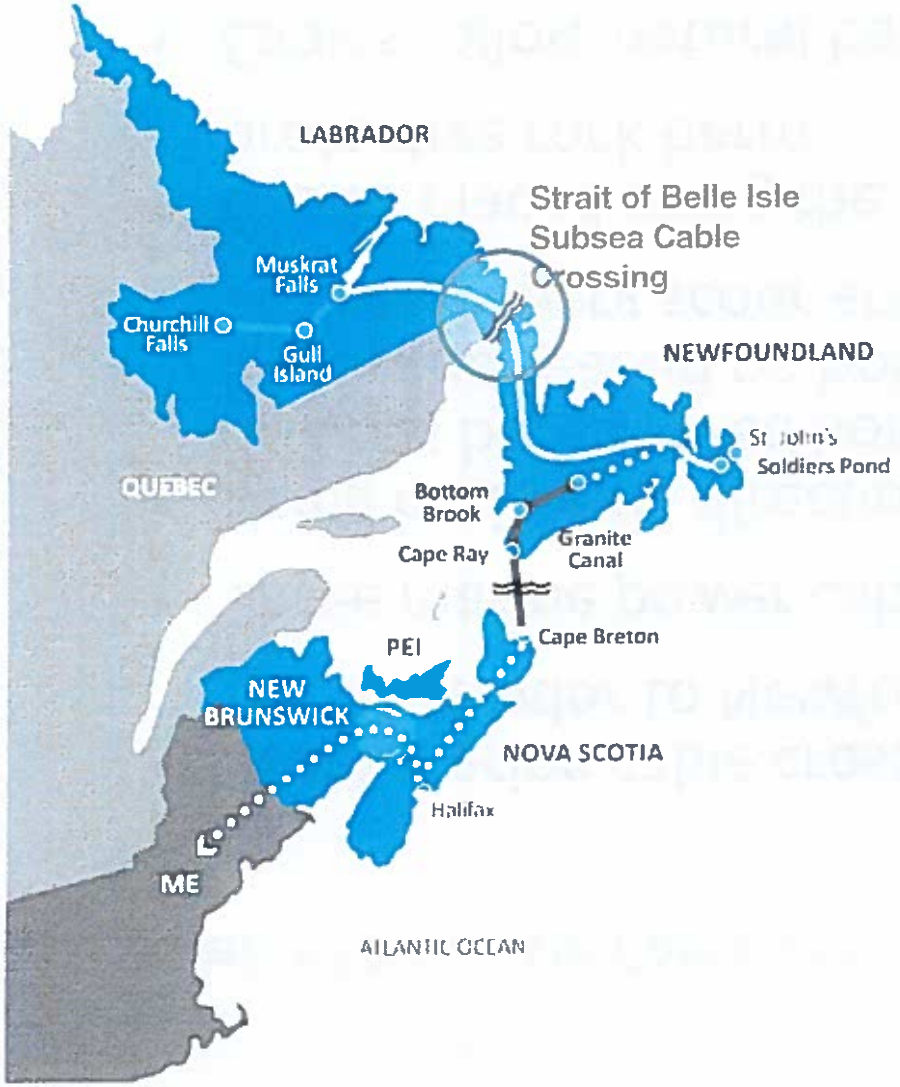


Overview of components

Strait of Belle Isle Marine Crossing

Strait of Belle Isle Crossing

The Background

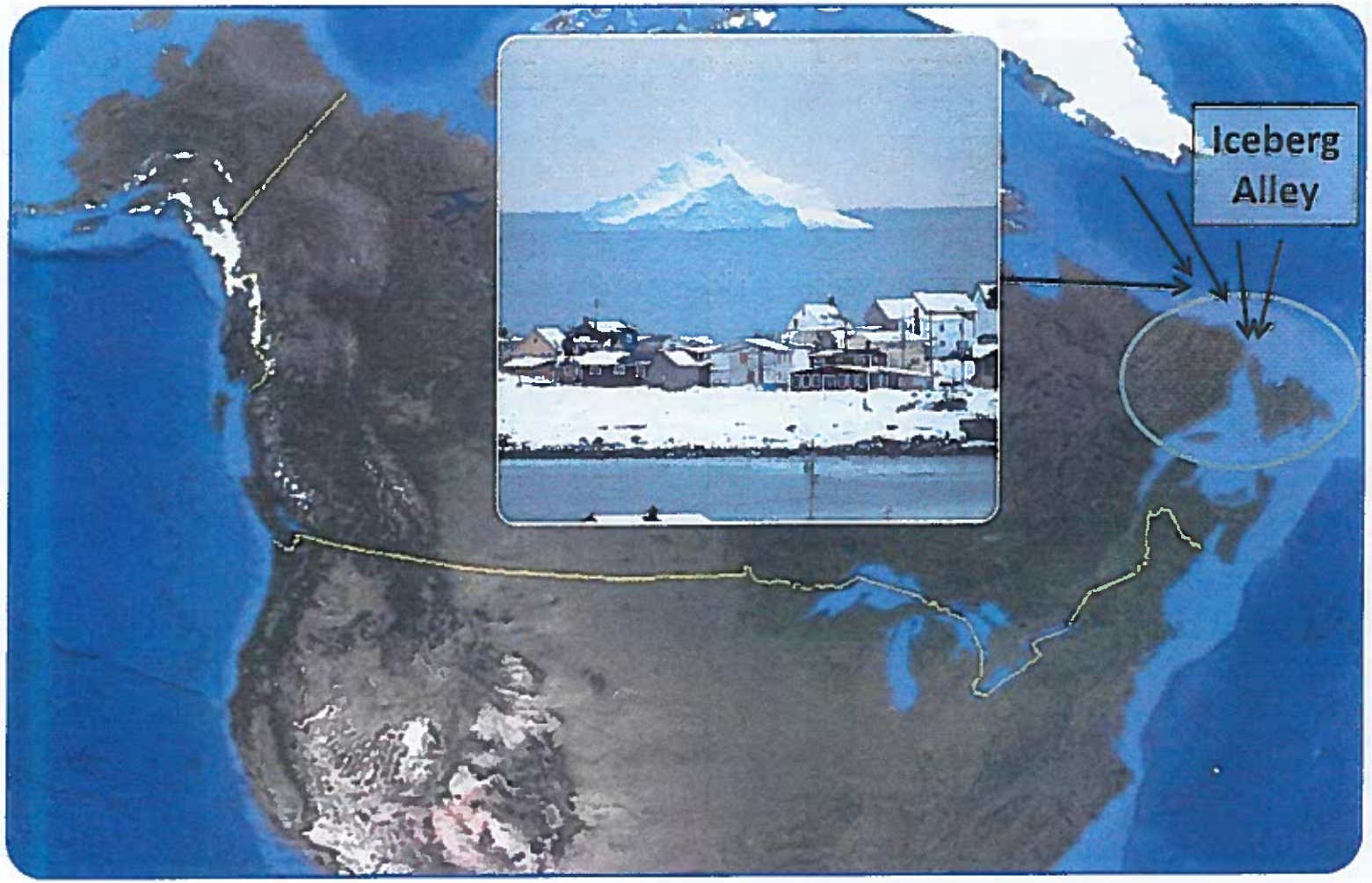


- The Strait of Belle Isle (SOBI) subsea cable crossing is the transmission component that connects Labrador to Newfoundland.
- High quality and reliability is an absolute requirement.
- In the early project phases, the SOBI crossing was *one of the key project risks*.

Strait of Belle Isle Cable Crossing

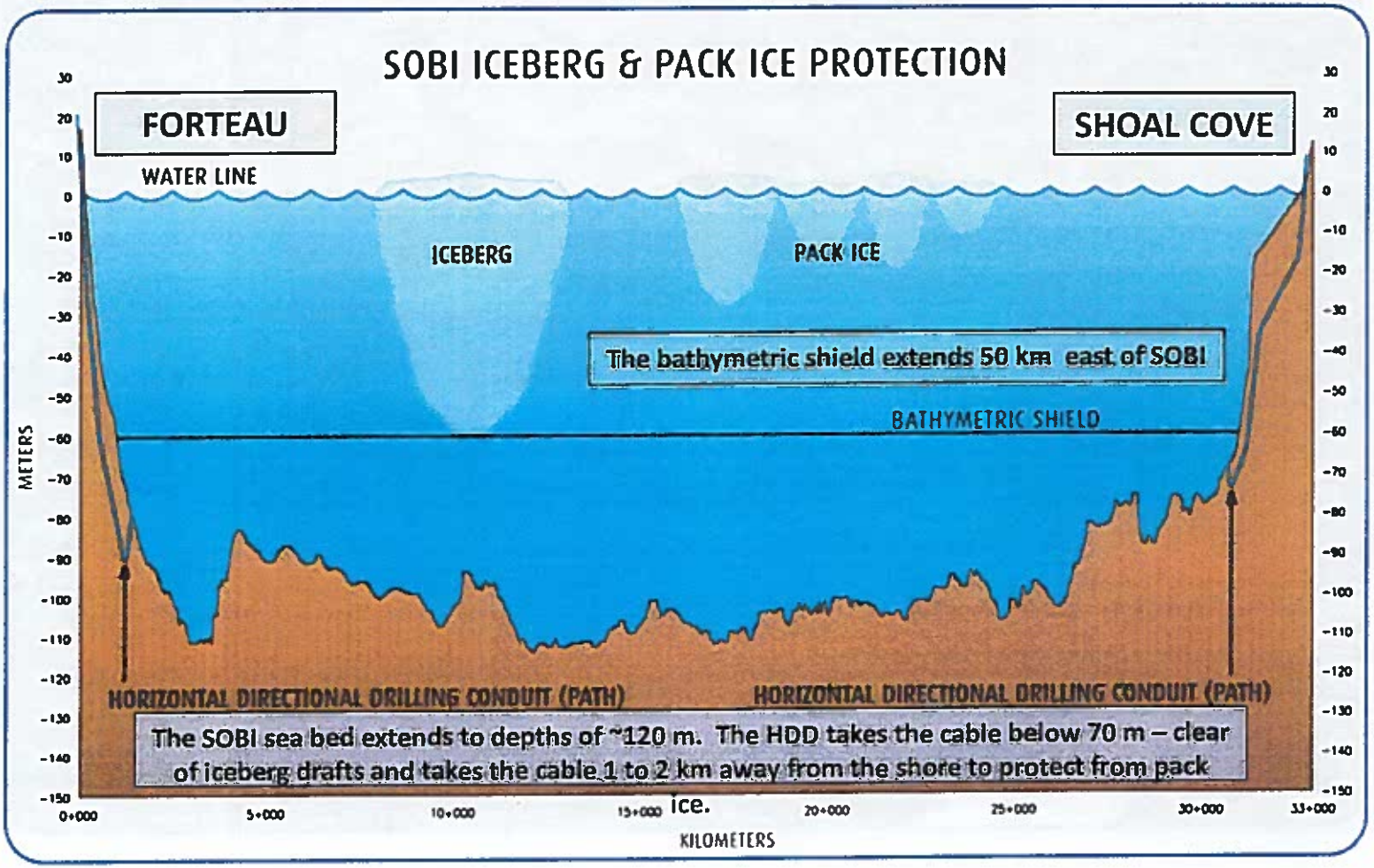
- 30km marine cable crossing connecting transmission line from Labrador to Newfoundland
- Three marine power cables along the seabed
- Using horizontal directional drilling (HDD) technology, drill rigs bored three holes from the shoreline and out under the seabed on both sides of the Straits to protect against iceberg scour and pack ice
- Cables placed along the sea floor and covered by protective rock berm
- Cables follow natural bathymetric lines, below depth of icebergs in the area

Risk of Iceberg Scour



Strait of Belle Isle Crossing

The 'Bathymetric Shield'



Strait of Belle Isle

SOBI Route Selection

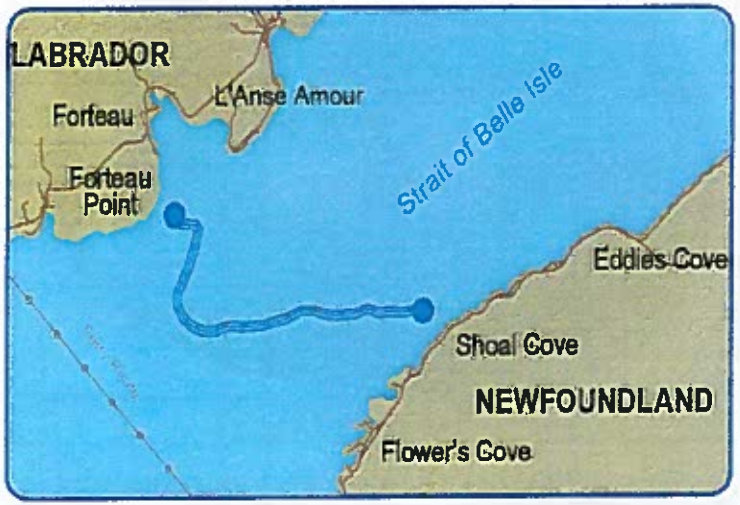
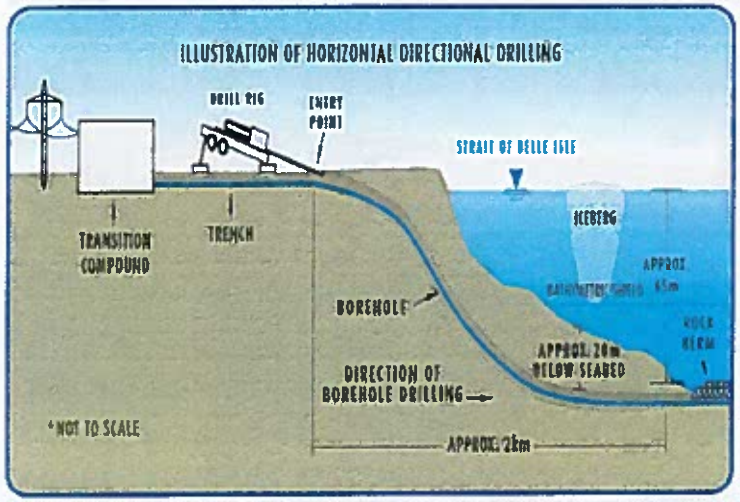


Illustration of horizontal directional drilling



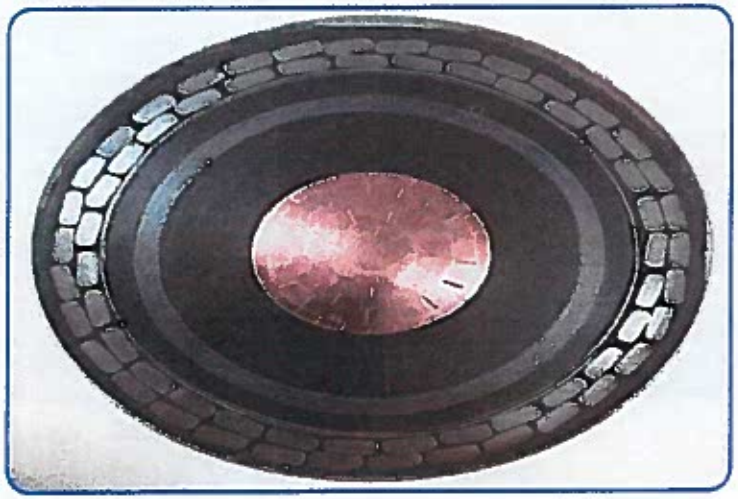
HDD Drilling at Forteau Point

Strait of Belle Isle Crossing – cable details

Cable Manufacturing

Batch 3 completeion

+/-350 kV, 1300 mm^2 Cable

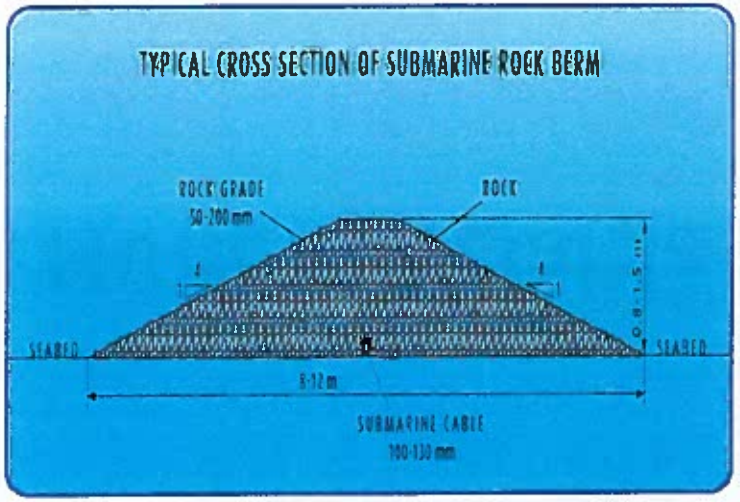


First cable on sea floor

Strait of Belle Isle – rock protection

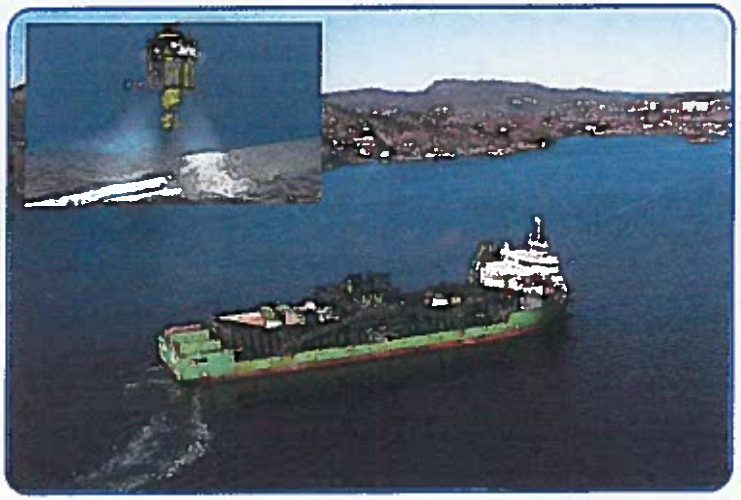
Work during winters

Subsea rock protection



Rock protection loadout

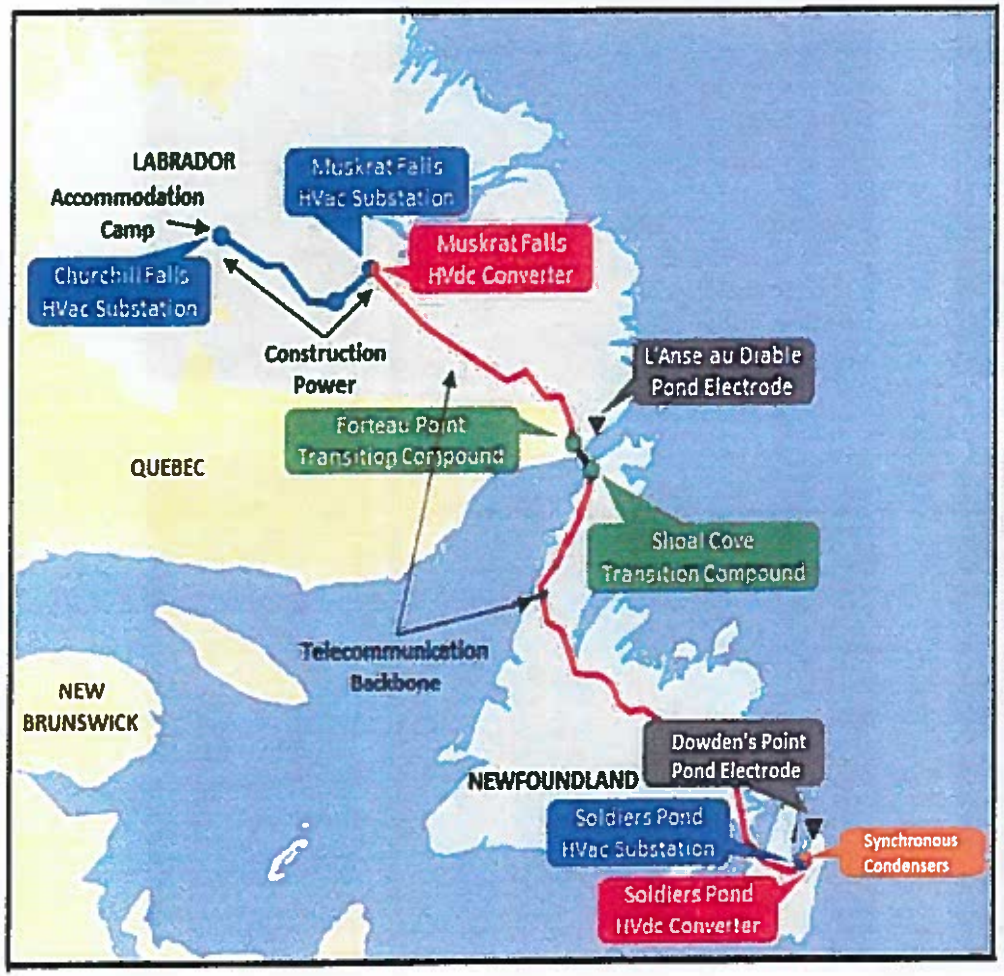
Tideway Flintstone



Overview of components

HVdc specialties

HVdc specialties - scope

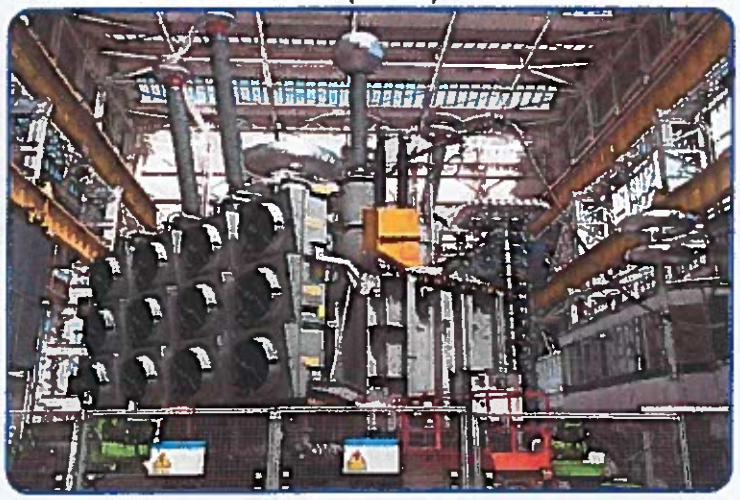


- **Three (3) HVac substations**
  - 735-315 kV Churchill Falls
  - 315 kV Muskrat Falls
  - 230 kV Soldiers Pond
- **Two (2) HVdc converter stations**
  - ±350 kV Muskrat Falls
  - ±350 kV Soldiers Pond
- **Two (2) HVdc transition compounds**
  - ±350 kV Forteau Point
  - ±350 kV Shoal Cove
- **Two (2) shore line grounding sites**
  - L'Anse au Diable
  - Dowden's Point
- **One (1) synchronous condenser facility**
  - 3 x 175 MVar Soldiers Pond
- **Other systems**
  - Telecommunications & system integration
  - Construction power

Muskrat Falls – switchyard & converter station

MF Switchyard & Converter Station

Converter Transformer (MF#3) – Converter Station



Gas insulated switchgear

Switchyard, Converter, & Synchronous Condenser

Muskrat Falls – synchronous condenser

Synchronous Condenser

Rotor Assembly

Stator Frame

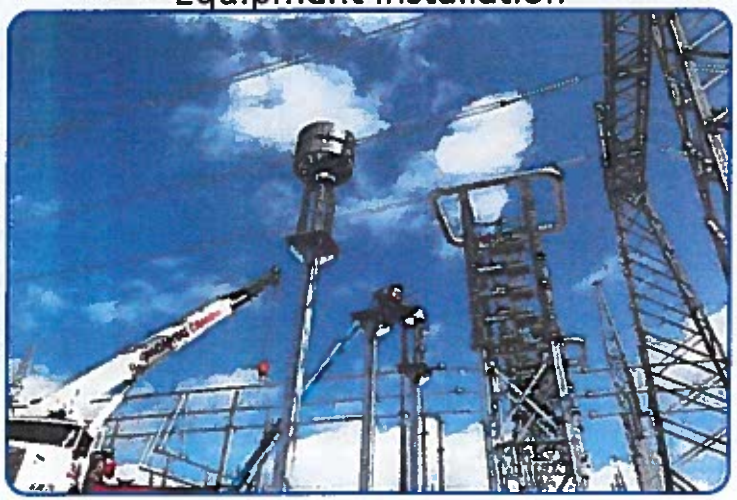
Synchronous Condenser

Soldiers pond

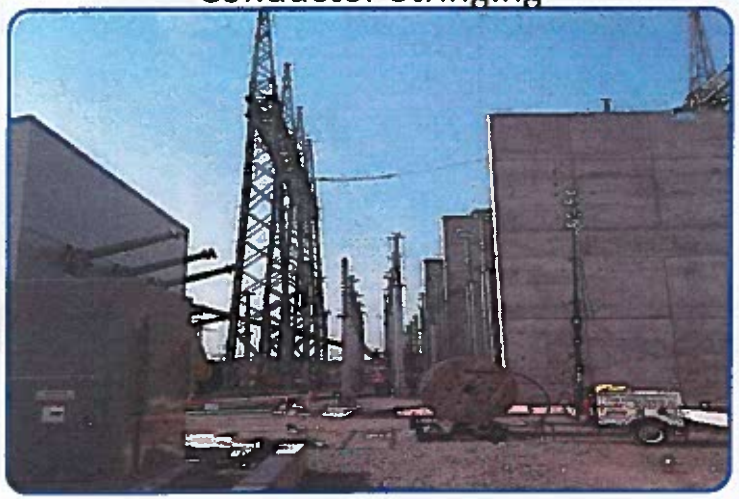
Valve Installation Pole 1

DC Yard Gantry Erection

Equipment Installation

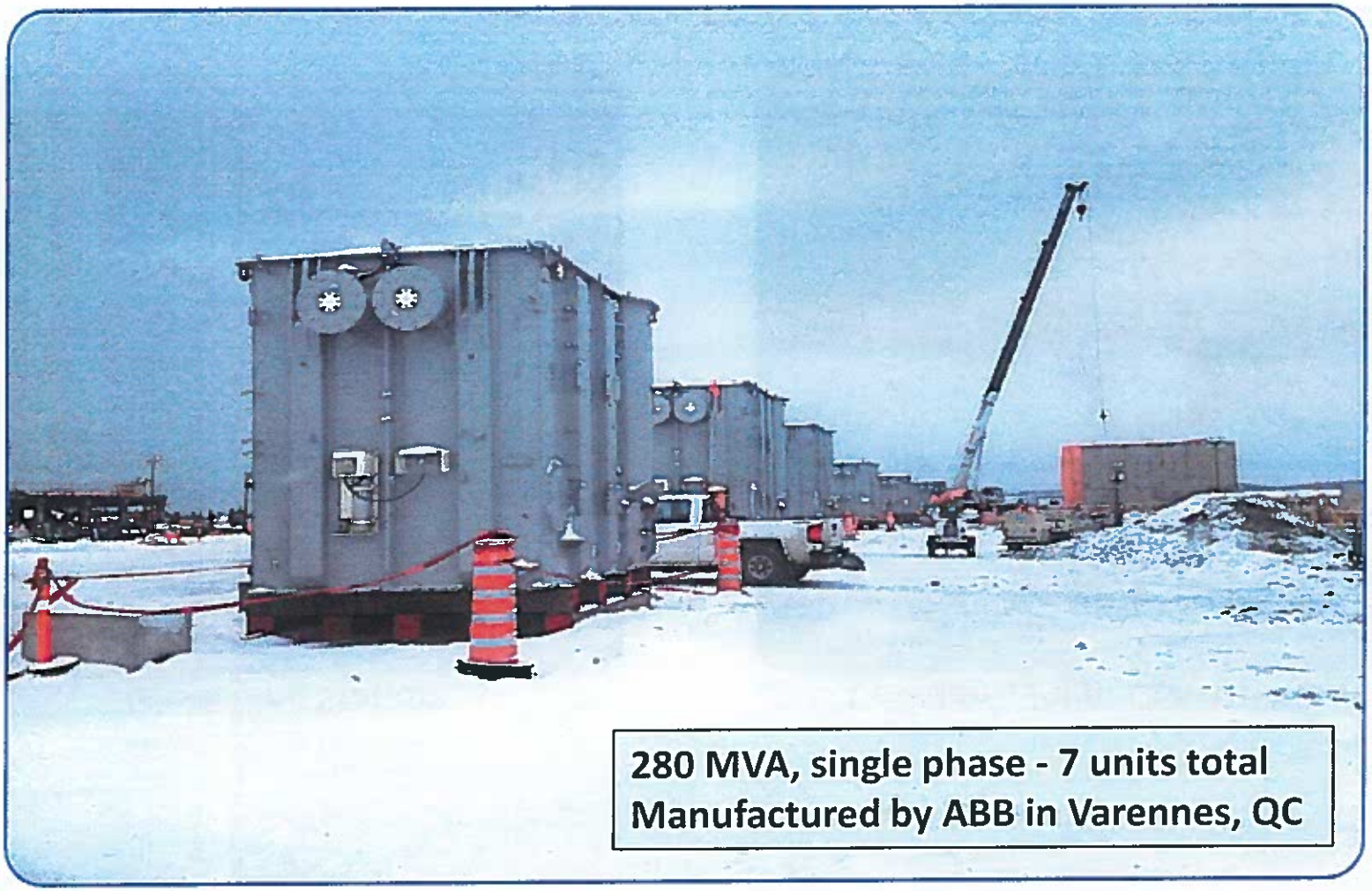


Conductor Stringing



735/315/13.8kV Power Transformers

10-Dec-2015



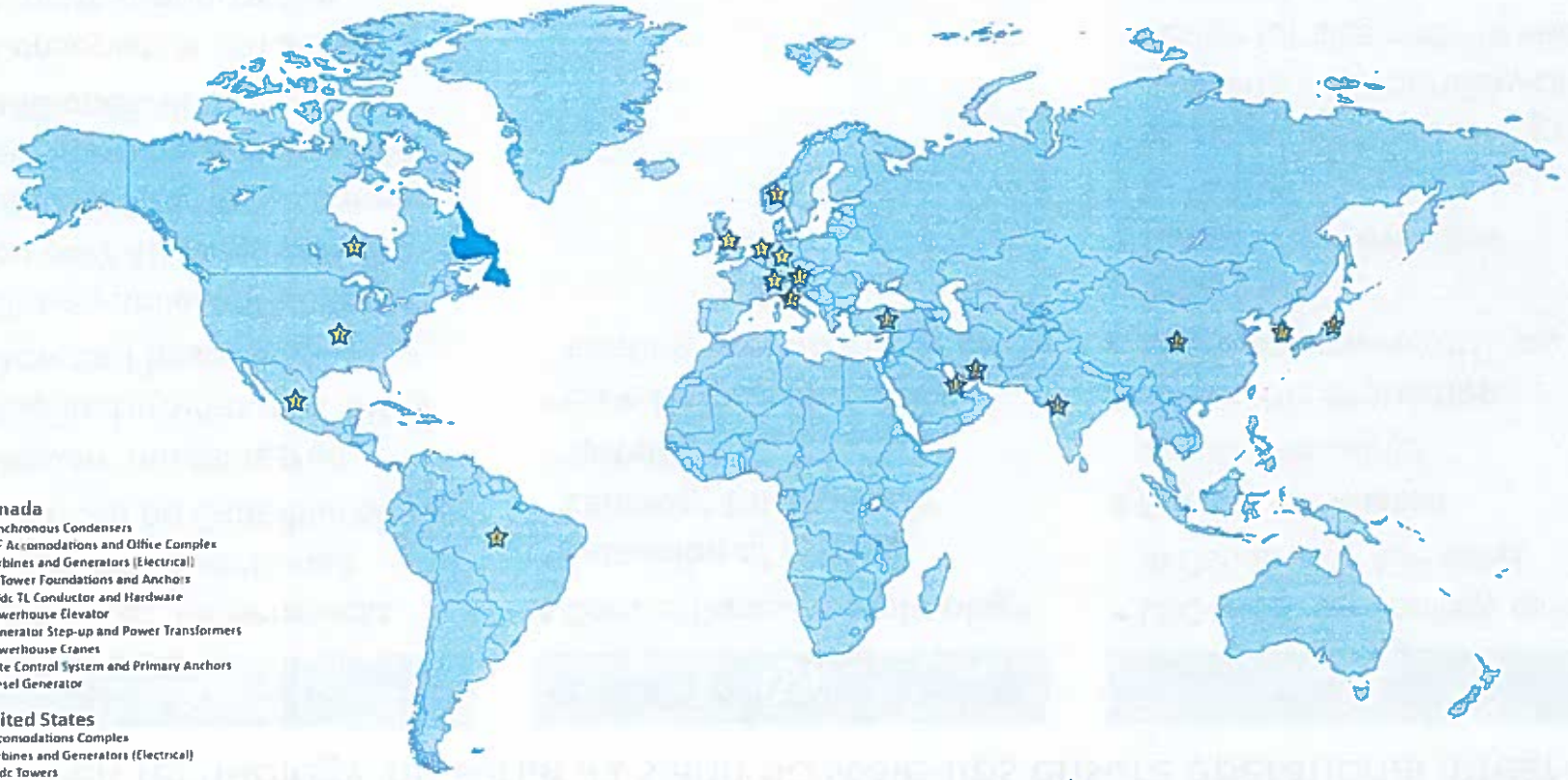
Dowden's Point

Grounding Station

Dowden's Point Construction

Lower Churchill Project Global Reach

Locations around the world where components for the Muskrat Falls Project are being manufactured and fabricated



Canada
- Synchronous Condensers
- MF Accomodations and Office Complex
- Turbines and Generators (Electrical)
- TL Tower Foundations and Anchors
- HVdc TL Conductor and Hardware
- Powerhouse Elevator
- Generator Step-up and Power Transformers
- Powerhouse Cranes
- Gate Control System and Primary Anchors
- Diesel Generator

United States
- Accomodations Complex
- Turbines and Generators (Electrical)
- HVdc Towers
- Power Transformers

Mexico
- Construction Transformers

Brazil
- HDD Casing
- HVdc Converter Transformers

England
- Gas Insulated Switchgear
- HVdc Converter Transformers
- HVdc Thyristor Valves

Netherlands
- Rock Installation

Switzerland
- Generator Circuit Breakers

Norway
- Fibre Optics
- Cable Engineering

Germany
- Trash Rack Cleaning Machine

Italy
- TL Insulators
- Isolated Phase Bus

Austria
- HVac Tower Hardware
- Govern High Pressure Unit

Turkey
- HVac Towers

Bahrain
- HVac Conductors
- HVdc Electrode Conductors

United Arab Emirates (Dubai)
- HVdc Towers

India
- HVdc Towers
- Generator Rotor Poles

China
- Turbines and Generators (Mechanical)
- Optical Ground Wires
- Gates (major structural components)

Korea
- Synchronous Condenser (Flywheel/Shaft) Forging and Machining

Japan
- Marine Cables

nalcor energy
LOWER CHURCHILL PROJECT

Proven technology

Proven technology, no serial #1's and no scale-ups ensure operational integrity

MF	LTA	LIL
• Low-head, no penstocks concrete powerhouse founded on Canadian Shield • Proven, model tested Kaplan turbines well within flow and head range • Design philosophies based on over 40 years of hydro-electric and transmission engineering, construction and operations • Conservative efficiency targets supported by equipment redundancy • Core Nalcor technology	• Conventional AC technology • Extension of existing Labrador transmission system • Core Nalcor capability – existing lines up to 735 kv	• LCC HVDC technology used in Canada for 40+ years • Mass impregnated submarine cables • SOBI cable protection methods proven offshore east coast • Typical HVdc overland transmission • Standard HDD technology well with the boundary of design for size and distance

Current project status

The overall project progress is ~90% as of April 2018

Project progress

	Name	Approximate % Complete	Scope
LTA (100%)	Valard	100%	T-line construction AC
	Grid Solutions	100%	CF/MF switchyards
LITL (99%)	Valard	100%	T-line construction DC
	Grid Solns/ Alstom Ren. Power	97%	Switchyards, converter stn., synchronous condensers
	Multiple	100%	Clearing and access
	Nexans	100%	Subsea cable
MFG (81%)	Astaldi	90%	Powerhouse, intake, and spillway, transition dams
	Andritz	75%	Turbines, generators, gates
	Barnard Pennecon	60%	Dams
	Cahill-Ganotec	20%	Balance of plant
	Gilbert	100%	North Spur stabilization
	Johnsons	100%	Reservoir clearing

1 Approximate Forecast Value (April 2018)