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The Proposed Strait of Belle Isle Cable Crossing

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ABSTRACT

The Muskrat Falls Hydroelectric Project will allow Newfoundland and Labrador to reduce greenhouse gas emissions created by oil-fired, electricity generation by more than one million tonnes annually [1]. In order for the hydroelectricity created at Muskrat Falls to be consumed by people on the island of Newfoundland it must be transmitted across the Strait of Belle Isle.

The Strait of Belle Isle is approximately 14.5km wide at its narrowest point and poses many engineering challenges for installing a subsea transmission cable. Tides, currents, bathymetry, icebergs and sea ice are just some of the ocean related environmental factors which create problems while planning for a subsea cable crossing in the Strait of Belle Isle. Investigations have been conducted to study each of these factors and engineers have devised a plan to install three subsea cables across the Strait.

Three horizontal directional drill paths will be drilled from each shoreline between. The boreholes will extend between 1.5 and 2.5km into the Strait. At about 65m below the water's surface the drill paths will pierce the seabed. A transmission cable will be placed in each of the drill paths. Between the two sets of drill paths, the cable will be laid directly on the seafloor. The cable will follow the natural occurring bathymetry and be laid in the deepest areas. Once the cables are in place a rock berm will be placed around each cable [2].

Although installing a subsea transmission cable is not a new task, there are currently no subsea transmission cables in the world that had to be designed around such unpredictable ice conditions. Based on this fact and based on the evidence outlined in this paper, the proposed plan for the for the Strait of Belle Isle cable crossing seems to leave the transmission cables at unnecessary risk of damage.

1 INTRODUCTION

The proposed plan for the Muskrat Falls Hydroelectric project is to create electricity at Muskrat Falls on the mainland of Labrador and transmit that power by way of transmission lines to a converter station at Soldier's Pond on the Avalon Peninsula of the island of Newfoundland. The most challenging aspect of transmitting this electricity from Muskrat Falls to Soldier's Pond is the 14.5km of ocean which separates the island of Newfoundland from mainland Labrador known as the Strait of Belle Isle.

The proposed plan for the Strait of Belle Isle cable crossing has transmission cables extending from Forteau Point on the Southern Labrador coast underwater across the Strait of Belle Isle and making landfall at Shoal Cove on the Northwest coast of the Northern Peninsula. There are many challenges that affect the planning of this project. This paper includes: descriptions of the findings from studies of the physical ocean environment in the region, an explanation of the proposed project description, along with a project evaluation based on knowledge of the physical environment, project description and other subsea cables.

2 PHYSICAL OCEAN ENVIRONMENT

2.1 Geology and Bathymetry

The seafloor within the proposed cable corridor is made up of a variety of different substrate classes. The seafloor substrate is dominated by over 60% coarse to small material, ranging in size from 2 to 140mm. Over 15% of the sea floor is covered by rubble and boulders which range in size from 140 to 1000mm. This substrate class occurs mostly at depths between 97 and 110m, at the centre of the Strait and are typically in berms resulting from relic iceberg scour. The other 3 recognized substrates each make up approximately 8% of the seafloor cover. The first is exposed bedrock and is found mostly in the valley located 8 – 13km from the Labrador coast. The other two substrate types are classified as shells and small shells [3].

The depth of the Strait of Belle Isle varies greatly, with a maximum depth greater than 125m deep. Four distinct regions make up the bathymetry of the Strait. The first being the Labrador coastal zone which is approximately 1 to 2km wide and has depths up to 115m. The slopes in this region are uniform and between 6 – 12%. The second zone is known as the Centre Bank South and the Centre Bank North. As the name implies they are regions of shallower depths between 1 and 6km from the Labrador shoreline. In this area the water depth ranges from 15 – 85m. The North and South Banks are separated by a narrow trough which is about 85m deep. The Newfoundland Trough is the third bathymetric zone and is located generally in the centre of the Strait. It has a width of 5 -12km and is the deepest section in the Strait with depths between 70 and 125m. The final bathymetric zone is the Newfoundland Coastal Zone. This zone has a relatively linear slope from the Newfoundland Trough to the coastline [3]. A bathymetric map of the cable crossing region can be seen in Fig. 1

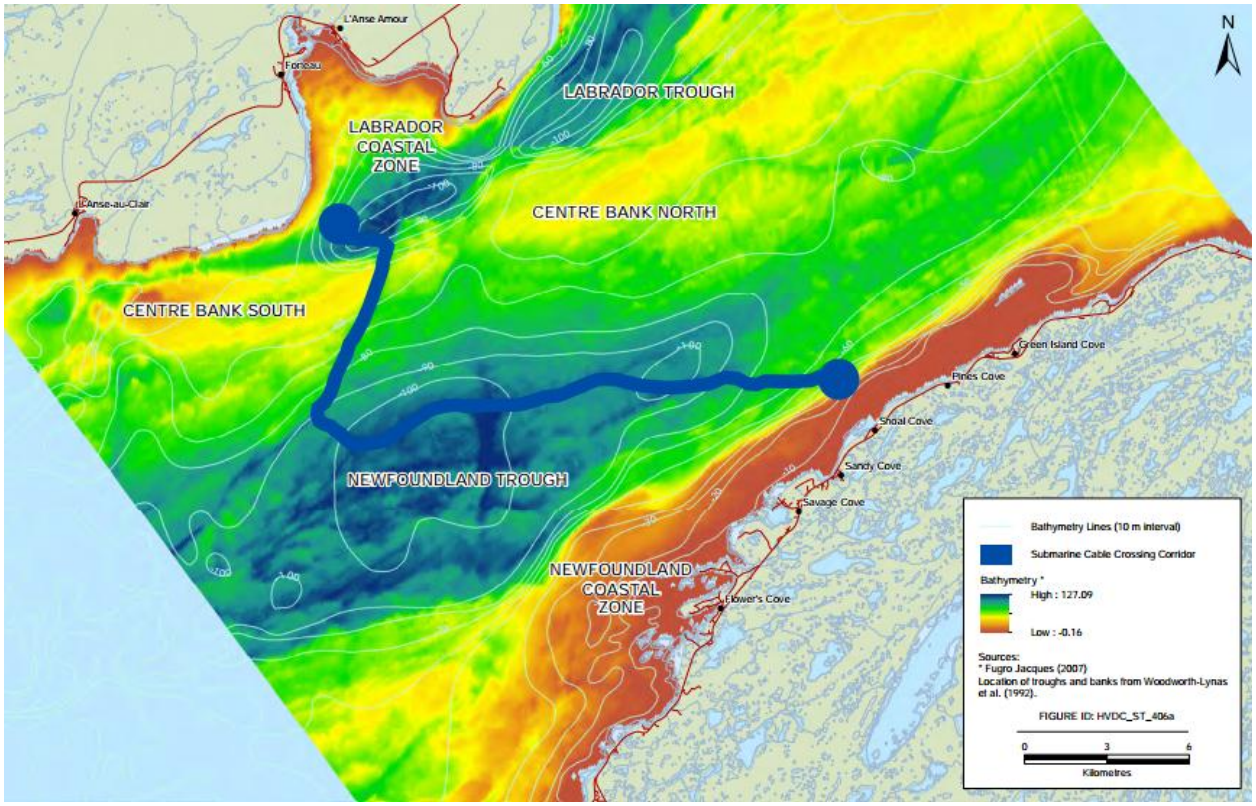

Fig 1: Bathymetry in the Strait of Belle Isle [3]

2.2 Wind

The maximum hourly wind speed recorded in St. Anthony is 97km/h and with a maximum wind gust speed of 148km/h [4]. These values will be similar to a maximum wind that could be seen in the Strait of Belle Isle.

From June to August wind speeds in the strait average between 18 and 36km/h and typically come from the southwest. Wind increases dramatically in September and October and shifts to come from the west and northwest. Winter winds also, generally come from the west or northwest while, northeast and southwest winds dominate during the spring [3].

2.3 Waves

The largest waves in the Strait of Belle Isle occur between October and January. Similar to the predominant wind, waves typically come from the west and southwest. From a study conducted by SNC-Lavalin in 1981 it was determined that the smallest wave heights occur in August while the largest occur in November. The average wave height in the study was 1.03m and a maximum wave height of 7.7m [3].

During the winter, wave height is dampened by the presence of ice. Assuming there was no ice coverage, the maximum wave height with a return period of 100 years, would be 10m high and occur in January [4].

2.4 Currents and Tides

Currents in the Strait of Belle Isle are quite strong. Dominant currents in the Strait of Belle Isle are a result of the Labrador Current which flows south from the Labrador Sea and the Gaspé Current which flows north from the Gulf of St. Lawrence [3]. The south flowing Labrador Current tends to hug the Labrador coastline as it flows through the Strait. The Gaspé Current, flowing north, flows along the Newfoundland side of the Strait. Fig. 2 below, shows current flow in the Strait of Belle Isle. Surface current is said to be stronger closer to the Labrador side. During studies it was found that current at 15m deep could reach a maximum speed of 3.6m/s while the current at 50m deep could reach a maximum of 2.5m/s [4].

Tides also influence currents in the Strait of Belle Isle as they run perpendicular to the currents described above. Tides in the region are considered mixed, semi-diurnal tides. This means that there are two high tides and two low tides every 24-25 hours. Changes in water level for mean tides are approximately 1.3m but, can reach up to 3m for large tides. When the tide is accompanied by the dominant wind, the tidal stream can reach a maximum speed of 1.3m/s [3].

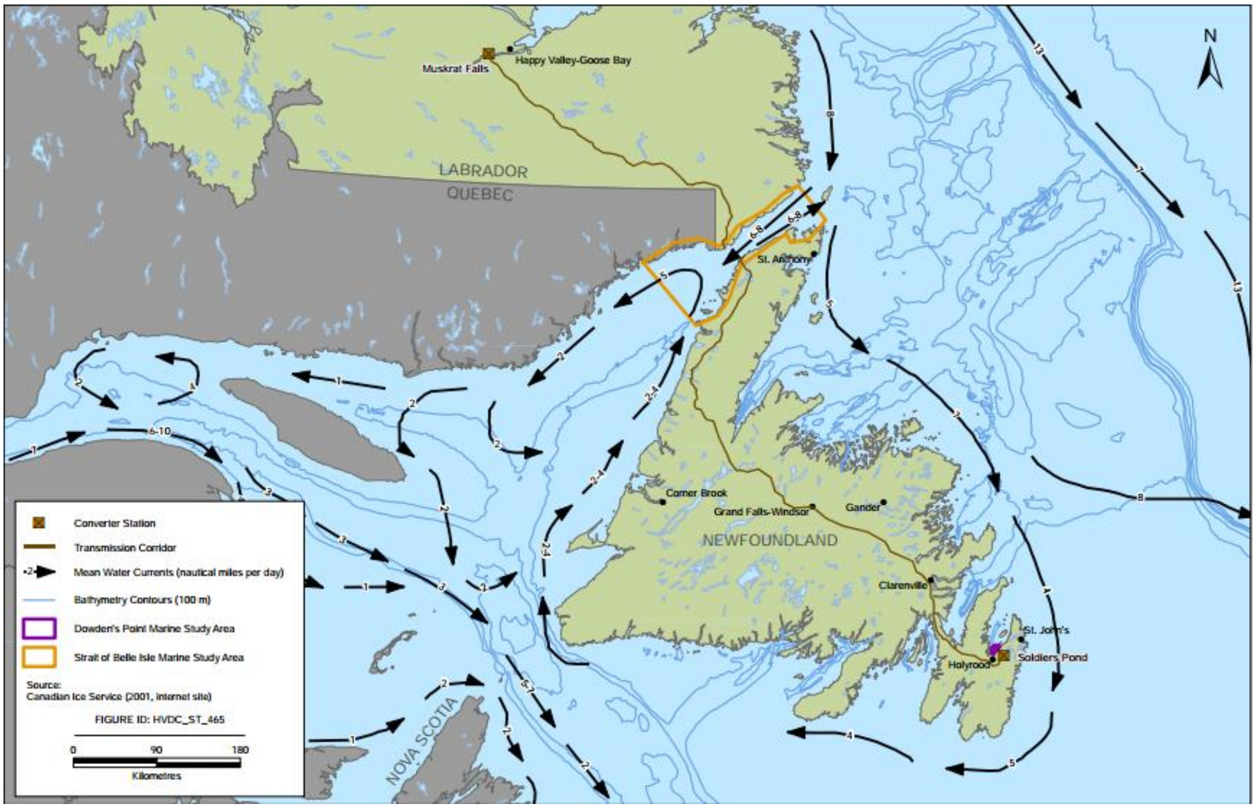

Fig. 2: Currents in the Strait of Belle Isle and Gulf of St. Lawrence [3]

2.5 Sea Ice

There are two types of sea ice found in the Strait of Belle Isle. Land-fast ice, which begins to form in December along the coastline and specifically in areas where wave action is slightly dampened like coves and harbours. Land-fast ice in the area is generally less than 0.6m thick [3]. The other form of sea ice found in this region is pack ice. Pack ice is formed in the Labrador Sea and drifts down into the Strait of Belle Isle beginning usually in January. With these two ice forms combined, on average the Strait of Belle Isle has 70-90% ice coverage by the end of January, and 90% coverage by the middle of February. Ice conditions can remain at close to 90% coverage until the end of March [3].

The thickness of a single floe of pack ice is typically less than 1m. The thickness increases dramatically however, when floes of pack ice collide. Although the ice has a greater thickness the collision causes ice to break into smaller pieces which have less strength than the single ice floe prior to the collision. Pack ice moves in and out of the Strait of Belle Isle influenced by winds, currents and tides. Due to the fact that the ice is influenced by all 3 of these variables the movement can be quite unpredictable [4].

2.6 Icebergs

Each year, usually in May and June, between 60 and 90 icebergs enter the Strait of Belle Isle. This makes up approximately 10-15% of all of the ice bergs that pass south of this latitude that drift from the Labrador Sea. Due to the dominating currents icebergs generally drift into the Strait with the Labrador Current and typically stay closer to the Labrador side of the Strait. Icebergs exit the Strait through the northern opening as they drift north along the Newfoundland side with the Gaspé Current. Icebergs in the Strait of Belle Isle can be very large. Evidence of this is scouring found on the seabed at depths of 90 – 110m.

A study of the Jakobshavn Glacier suggests that with the higher temperatures associated with global warming a higher quantity of icebergs will be produced [5]. If this is the case, it can likely, also be applied to the glaciers that provide icebergs to the Labrador Sea. Inevitably, if the number of icebergs in the Labrador Sea increases, so will the amount of icebergs in the Strait of Belle Isle. With increased iceberg presence in the Strait of Belle Isle the risk of large, potentially damaging icebergs increases.

3 PROJECT DESCRIPTION

Based on environmental hazards and geographical features discussed in the previous sections, including geology, bathymetry, waves, current, tides, wind, sea ice and icebergs a proposed design for the installation of the subsea cable has been conceived. Three cables will be installed in the proposed cable corridor, two will be used for normal transmission and the third will be a spare, to be used in the case that one of the other cables is damaged [2].

Instead of choosing the shortest route across the Strait of Belle Isle which would be approximately 14.5km a route approximately 35km in length has been chosen. This is mainly due to bathymetry in the Strait of Belle Isle. It allows the cable to be laid in the deepest regions which aids in the protection of the cable from sea ice and icebergs. You can see in Fig. 1 the cable leaves Forteau Point and passes in the deepest region between the Centre Bank North and Centre Bank South. It then travels south into the deepest section of the Strait known as the Newfoundland Trough. From there the cable travels east through the Newfoundland Trough until the seabed rises to the shoreline in Shoal Cove. The bathymetry at Shoal Cove becomes deeper closer to shore than most other areas on the Newfoundland coastline in the Strait of Belle Isle Region. The deeper water the cable can be laid in the safer it will be from sea ice and icebergs. This in turn decreases the need for extensive and expensive cable protection. A corridor, 500m wide has been set for the cable to be laid in on the seabed allowing the cables to be spaced apart by approximately 150m. This width allows for field-fit installation which will help avoid damage to the cable due to cable suspension over jagged seabed features or extreme cable bending around features. The width apart also decreases the likelihood of more than one cable being damaged at a time should extreme conditions cause damage to one of the cables [2].

To protect the cable from sea ice and icebergs that can be most damaging in the shallower areas along the coastline of either side of the Strait of Belle Isle it is proposed that the transmission cables will be placed inside underground conduits. These conduits will be formed by using horizontal directional drilling on both sides of the Strait of Belle Isle. They will begin drilling on either side of the Strait until the boreholes pierce the seabed between 1.5 and 2.5km from shore and have a water depth of approximately 65m. The boreholes will be drilled approximately 20m below the seabed until it has reached the desired point where it will pierce the seabed and enter the Strait of Belle Isle. Each conduit will be lined with steel or high density polyethylene to protect the cable from the surrounding rock [2].

Once the cables have pierced through the seabed they will be laid within the proposed corridor on the seafloor. They will then be covered by a rock berm comprised of rocks between 50-200mm in size. The rock berm will have an overall base width between 8 and 12m, a slope of 4:1 and a height of between 0.8 and 1.5m. The rock berm is intended to provide some protection from ice bergs should it be needed. Iceberg and sea ice protection should be mostly accomplished by the underground conduits. Icebergs tend to flow closer to the shoreline allowing the conduits to offer protection. Once the cables exit the conduits and are laid on the seabed, the water depth will likely prevent ice from damaging the cable. Another purpose of the rock berm is to protect the cables from local fishing gear [2].

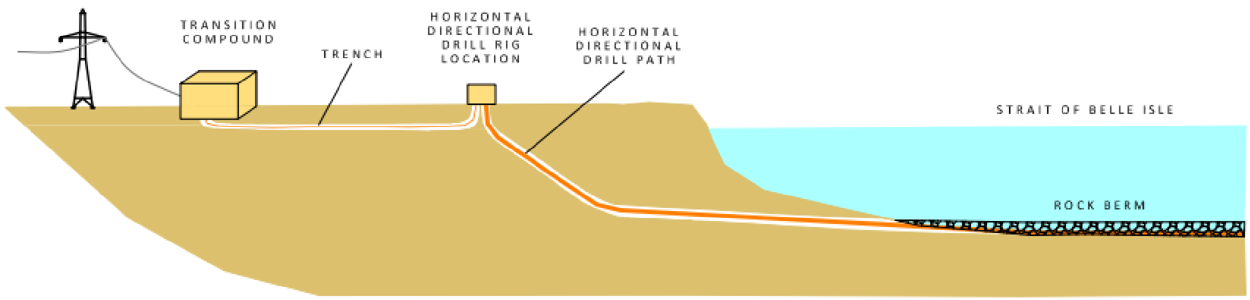

Fig. 3: Side View of Proposed Cable Crossing [2]

4 SIMILAR PROJECTS

Two of the better known submarine transmission cables in the world are: Fenno-Skan 1 and BritNed. Fenno-Skan 1 is a submarine transmission link which is 200km long. It crosses the Gulf of Bothnia in the Baltic Sea from Rauma, Finland to Dannebo, Sweden. The Fenno-Skan 1 was commissioned in 1989 and was upgraded in 2012. Due to its 24 year lifetime in operation this can be considered a successful engineering project. If the Fenno-Skan 1 is compared with the proposed submarine cable crossing in the Strait of Belle Isle, one major difference is the protection method of the subsea cable. The Fenno-Skan was laid directly on the seabed for the majority of the crossing. Near both shores the cable was laid in trenches capped with concrete [6]. This is used to protect the cable from the pack ice that forms in the Baltic Sea. The trenches capped with concrete can be compared to the directionally drilled holes which will house each cable on each side of the Strait of Belle Isle. The difference in these environments is the fact that it is a normal occurrence to have large icebergs in the Strait of Belle Isle. Although the pack ice may rift and form rugged looking ice floes in the Baltic Sea, ice bergs are not an issue. Because of this, ice conditions in the Strait of Belle Isle are more likely to cause damage to subsea cables than the conditions in the Baltic Sea.

BritNed is a 250km long subsea cable that spans across the North Sea from the Isle of Grain in Great Britain to Maasvlakte in the Netherlands. BritNed is buried no less than 1m below the seafloor. The reason for this is to avoid damage from any fishing activity in the area. The cable was laid in seven sections between September 2009 and June 2010. When compared with the proposed cable crossing in the Strait of Belle Isle the main difference is the lack of need to protect the cable from ice damage. Because the BritNed cable is buried at least 1m below the seafloor it is well protected from fishing activity. Unfortunately, BritNed does not provide confidence toward the proposed plan for the cable crossing in the Strait of Belle Isle because there is no risk that it will be damaged by ice and thus, has not been designed with such risk in mind.

5 PROJECT EVALUATION

Due to the fact that the submarine cable crossing the Strait of Belle Isle has not yet been installed it is difficult to determine whether it will be a successful engineering endeavour. Another reason that this is difficult to evaluate is the fact that there are no other subsea transmission cables in the world that must deal with the same engineering challenges. There are certain aspects of the plan for the Strait of Belle Isle cable crossing that will likely be very successful and others that may not.

If we look first at the horizontal directional drill paths that will be drilled under the seafloor of the Strait on either side extending between 1.5 and 2.5km into the Strait. It seems very likely that this system will be successful in protecting the cable from damage due to land-fast ice, pack ice and even icebergs. This success will be attributed mostly to the fact that the plan indicates that the boreholes will be drilled approximately 20m below the seabed [2]. This is more than enough coverage to ensure the cables do not sustain damage.

When evaluating the rock berm, it is likely that the rock berm should be successful in avoiding damage to the cables by fishing gear or by slight movement of the cable due to the very strong currents. Unfortunately, if an iceberg comes in contact with the berm it is unlikely that it will remain intact and keep the cables from sustaining damage.

The cable will not be laid in a straight path across the Strait of Belle Isle. Instead it will be laid at in a path where the water is the deepest. This is done in hopes that large ice bergs will be held up by shallower areas on either side of the cable. Although this method is well thought out, it still leaves quite a large amount of risk that the cable will be damaged by an iceberg. There was evidence found in the area of the cable corridor of iceberg scour on the seafloor in water depths ranging from 90-110m [3]. This is significant due to the fact; the maximum depth in the Strait is 125m. In addition, the number of icebergs is likely to increase due to global warming [5] thus, increasing the probability that an iceberg could damage to the cable.

6 CONCLUSION

The cable crossing in the Strait of Belle Isle will allow Newfoundland and Labrador to reap the rewards of the hydroelectric project at Muskrat Falls. There has been a great deal of work conducted in the Strait of Belle Isle region to study the physical ocean environment factors of the region. Although there is a much better understanding of these factors, the unpredictability of these factors was also emphasized. Forecasting the direction, speed and size of an ice floe or the number of icebergs in a season is nearly impossible. For this reason any feasible plan for the subsea cable crossing will be associated with some risk. Unfortunately, based on the evidence it seems that the risk that the cable may be damaged by an iceberg is high. The true test of the proposed plan will not be conducted until the cable has been laid, put into operation and operated without damage for several years.

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