# 345 kV Submarine Cable - Preliminary Cost Estimate

| | | | | | | |
|---|---|---|---|---|---|---|
| 2015-09-16 | A | For Information | D.Flores / A. Afzal | A. Afzal / F.Liu | F. Liu / L. Murphy | |
| **Date** | **Rev.** | **Status** | **Prepared By** | **Checked By** | **Approved By** | **Approved By** |
| | | | HATCH | | | **Client** |



Safety • Quality • Sustainability • Innovation

© Hatch 2015 All rights reserved, including all rights relating to the use of this document or its contents.

# Table of Contents





Safety • Quality • Sustainability • Innovation

© Hatch 2015 All rights reserved, including all rights relating to the use of this document or its contents.

# 1. Background

Nova Scotia Power Inc. (NSPI) has identified the need for a new 345 kV double circuit overhead transmission line crossing at the Strait of Canso; a body water between the mainland of Nova Scotia and Cape Breton Island.

NSPI has contracted Hatch for the design of this overhead crossing and including the connections to the existing 345 kV circuit (L-7005) at each end of the Crossing. The new overhead crossing, with an approximate length of 3 km, will located near south-east of the existing 230 / 345 kV crossing.

In parallel; NSPI has mandated Hatch to prepare a 'Preliminary Cost Estimate' for the submarine cable option for this crossing.

This brief report provides the preliminary cost estimate for the submarine cable option. An alternate option to install cable in conduits that are HDD (Horizontal Directional Drilling) under the surface of strait is also explored.

# 2. Methodology

The following steps identify the methodology that was adopted for developing this preliminary estimate:

1. Identifying the Installation Scheme
2. Preparation of submarine cable parameters (functional requirements)
3. Preparing shortlist of cable suppliers and approaching them for budgetary prices
4. Review of proposed cable sizes
5. Cost estimate
6. Option for Horizontal Directional Drilling

It is to be noted that these are preliminary evaluations only for the purpose of information and initial planning. Detailed design, field testing and surveys will be required to finalize the cable designs and installations in the event that NSPI proceeds with this cable option.

# 3. Step-1 – Submarine Cable Installation Scheme



© Hatch 2015 All rights reserved, including all rights relating to the use of this document or its contents.

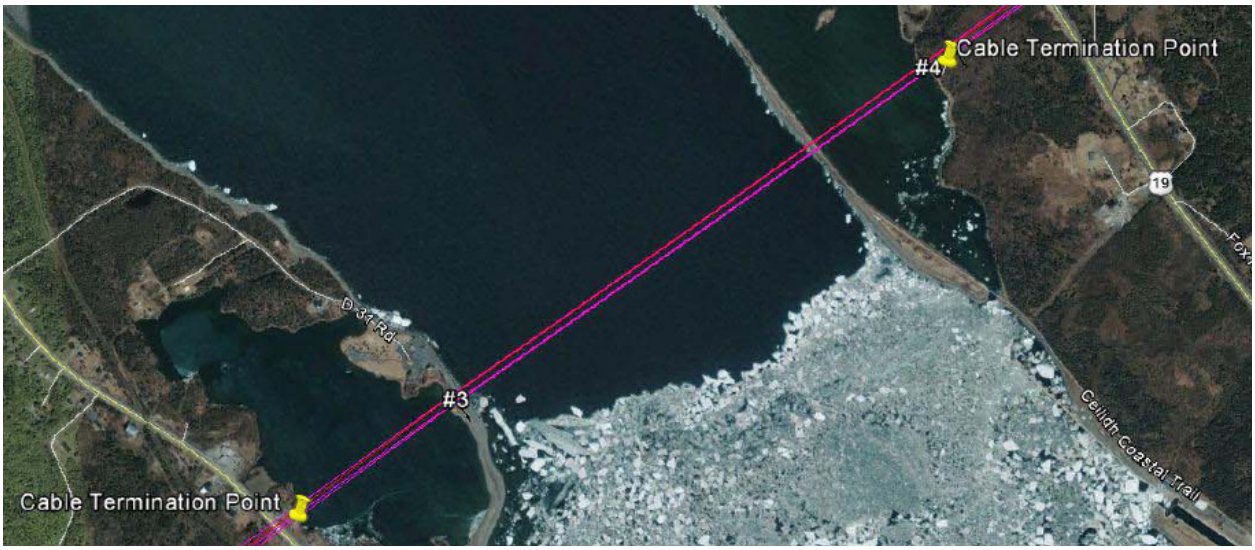



**Figure 1 Submarine Cable Installation - Strait of Canso**

In the absence of engineering activities and detailed analysis, the following installation scheme has been considered:

1. The submarine cable will be jet-plow buried inside the strait.

2. There are two lagoons located on either side of the main strait (See Figure 1. These are anticipated to be of shallow depth; and therefore we have assumed that these lagoons will be trenched. The trench will end for 20 m on all land sides; and protected with articulated pipes. In the event that HDD conduits are required, the cost will increase.

**Figure 2 Articulated Pipes (Ref. ITT Telecom)**

3. The submarine cable will be secured with anchor clamps at the shoreline.



Safety • Quality • Sustainability • Innovation

© Hatch 2015 All rights reserved, including all rights relating to the use of this document or its contents.

4. Underground concrete cable vaults will be installed above the high water mark; and these are expected to be within 20 m of the shore line. The submarine cable will be spliced with land-cable inside the cable vaults. The land cable will extend outside the cable vaults and terminated on individual cable riser structures (See Figure 3).

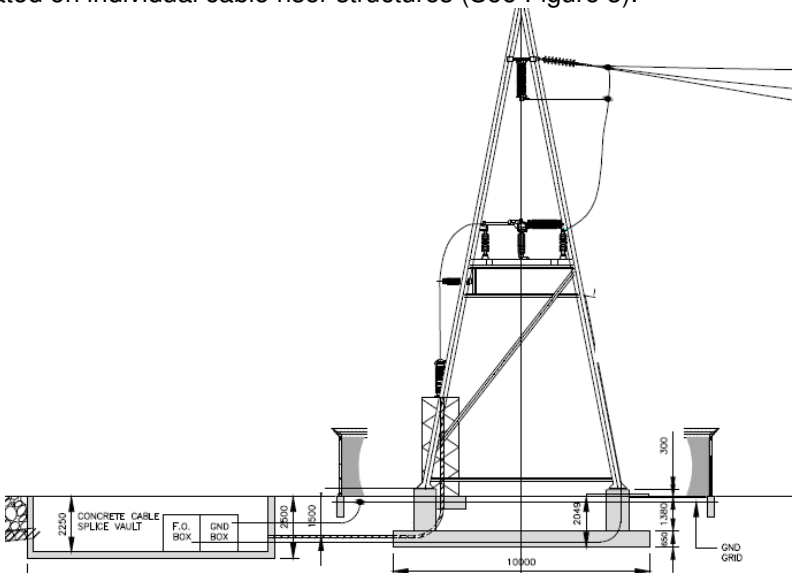



**Figure 3 Cable Vault and Outdoor Termination - Conceptual Arrangement**

5. The overhead line conductor will be terminated on the cable riser structures. Surge arrester and disconnect switches will be installed on the cable riser structure; in line between the overhead conductor and the cable.

# 4. Step-2 – Submarine Cable Parameters

In the absence of detailed engineering, the following parameters have been assumed:

- Project Information
  - Location is Nova Scotia and Cape Breton Island
  - Design temperature at Strait waterbed = 20 deg C
  - Design temperature at near-shore trenched section = 25 deg C
  - Design temperature on-shore section = 25 deg C
  - Elevation above sea-level = 50 m
- Electrical Parameters
  - Nominal operating voltage = 345 kV +/-5%
  - Current carrying capacity = 2370 A/phase



Safety • Quality • Sustainability • Innovation

© Hatch 2015 All rights reserved, including all rights relating to the use of this document or its contents.

- BIL = 1300 kV
- Operating frequency = 60 Hz

- Quantities
  - No. of circuit = 1
  - Cables per phase = 2 cables
  - Total number of cables = 6 cables
  - Line-of-sight length = 1.855 km
  - Submarine-to-land cable splice = 12 nos
  - Outdoor termination for land cable = 12 nos

- Burial and Protection
  - Laying depth in main strait = 65 m
  - Laying methodology = Jet Plow 1.5 m

    (alternate may be to install directly on the strait floor and protect with concrete mattresses)
  - Burial (trench) depth at shore and lagoon = 2 m
  - Protection at shores = Articulated pipes
  - Submarine cable support = Anchor clamps
  - Riser structures (twin cable) = 6 nos
  - Disconnect switches = 12 nos
  - Surge arresters = 12 nos

# 5. Shortlist of Vendors

The following vendors were shortlisted and approached for budgetary prices:

- Nexans
- ABB
- IT Telecom (installation only)
- Mitsubish / Sumitomo
- Global Marine
- Prysmian

Budgetary quotes were received from Mitsubishi/Sumitomo and Prysmian; and these quotes have been reviewed based upon earlier project experiences.



© Hatch 2015 All rights reserved, including all rights relating to the use of this document or its contents.

# 6. Review of Proposed Cable Sizes

Both Mitsubishi/Sumitomo and Prysmian have proposed two(2) XLPE cables of 1400 sq.mm each per phase. Hatch carried out preliminary reviews of these proposed sizes using IEEE 835; and the cable sizes were reasonable for the parameters that have been considered. Some variation may be expected during the detailed design.

The reference water temperature is assumed as 20 deg C, which has a thermal conductivity of 0.6 W/m/K (http://hyperphysics.phy-astr.gsu.edu/hbase/tables/thrcn.html), which is in the 167 Rho range.

2627

345 kV 1/c Self Contained Liquid Filled Aluminum Sheathed Power Cable

Direct Buried - 1 Circuit - Three Cables - Spaced

25°C Earth Ambient

| Condr Size | Sheath Res | 60 Rho Interface Temp | 60 Rho Flux Amps | 60 Rho Flux °C w/ft² | 90 Rho Interface Temp | 90 Rho Flux Amps | 90 Rho Flux °C w/ft² | 120 Rho Interface Temp | 120 Rho Flux Amps | 120 Rho Flux °C w/ft² | delta Td for .0024 pf & Rho 60 | 90 | 120 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 100% LF | | | | | | | | |
| 85°C - Copper Conductor - Hollow Core Concentric Strand | | | | | | | | | | | | | |
| 1000 | Open | 58 | 853 | 12.1 | 64 | 747 | 9.9 | 68 | 664 | 8.3 | 9.8 | 12.8 | 15.8 |
| 1250 | Open | 59 | 957 | 12.3 | 65 | 834 | 10.0 | 69 | 739 | 8.3 | 10.1 | 13.3 | 16.4 |
| 1500 | Open | 61 | 1061 | 13.5 | 67 | 914 | 10.7 | 71 | 800 | 9.0 | 11.1 | 14.7 | 18.2 |
| 1750 | Open | 61 | 1142 | 13.5 | 68 | 979 | 10.8 | 72 | 854 | 8.9 | 11.4 | 15.2 | 18.9 |
| 2000 | Open | 62 | 1212 | 13.6 | 68 | 1036 | 10.8 | 72 | 901 | 8.9 | 11.6 | 15.5 | 19.3 |
| 2250 | Open | 63 | 1275 | 13.7 | 69 | 1085 | 10.8 | 73 | 940 | 8.9 | 11.9 | 15.9 | 19.9 |
| 85°C - Copper Conductor - Hollow Core Segmental Strand | | | | | | | | | | | | | |
| 2000 | Open | 62 | 1229 | 13.6 | 68 | 1050 | 10.8 | 72 | 914 | 8.9 | 11.6 | 15.4 | 19.3 |
| 2250 | Open | 63 | 1296 | 13.7 | 69 | 1102 | 10.8 | 73 | 955 | 8.9 | 11.9 | 15.9 | 19.9 |
| 2500 | Open | 63 | 1358 | 13.8 | 69 | 1152 | 10.8 | 73 | 996 | 8.9 | 12.1 | 16.2 | 20.3 |
| 2750 | Open | 64 | 1418 | 13.9 | 70 | 1198 | 10.8 | 74 | 1032 | 8.9 | 12.4 | 16.6 | 20.8 |
| 3000 | Open | 64 | 1465 | 14.0 | 70 | 1234 | 10.9 | 74 | 1061 | 8.8 | 12.6 | 16.9 | 21.2 |

**Figure 4 IEEE 835 - Table 2627**

The 1400 sq.mm (2750 kcmil) cable has a rating of 1032 A (2064 A for twin cables). If Rho is considered to be 90 Rho, the ampacity for twin cables becomes 1198 A x 2 = 2396 A.



© Hatch 2015 All rights reserved, including all rights relating to the use of this document or its contents.

The above IEEE cable is for 25 deg C ambient temperature, which is slightly higher than the 20 deg C water temperature that is currently being considered.

It is to be noted that IEEE standard is for liquid filled cables only and not directly applicable to XLPE cable. Therefore, some variations to the above numbers are expected; and that can be checked during detailed design using actual cable geometry.

# 7. Cost Estimate

The preliminary estimate for the submarine cable option is as follows; and is subject to further designs, survey and vendor pricing.

| No. | Description | Unit | Qty. | Unit Price | Cost (CAD) | Remarks |
|---|---|---|---|---|---|---|
| 1 | 345 kV XLPE 1400 sq.mm | m | 12,600 | 1,693 | 21,335,000 | Budgetary quote received and compared to past project experience. Compared with CAD 900/m from an avg weight of 330 t of cable and prices from similar project. |
| 2 | Transportation from manufacture location to site | L/S | 1.00 | 1,000,000 | 1,000,000 | Reference from past project CAD 1,000,000$ for transportation to project site in Ontario. |
| 3 | Anchor clamps | EA | 12 | 5,400 | 65,000 | Hatch estimate |
| 4 | Submarine-to-land cable splice | EA | 12 | 71,566 | 860,000 | Assumed same price as that of terminations. |
| 5 | Outdoor Termination | EA | 12 | 71,566 | 860,000 | According to budgetary quote received and compare to hatch similar experience |
| 6 | Cable protection at land (eg. articulated pipes) | m | 480 | 600 | 290,000 | According to past project experience. CAD 600 per meter of articulated pipe (supply and install) |
| 7 | Installation (Transportation of cable, vessels, site work, trenching, cable installation jet plowing and termination) | L/S | - | - | 15,000,000 | Budgetary quote received is CAD 12 M. Compared with Hatch referenced price of CAD 15 M from another project. |



© Hatch 2015 All rights reserved, including all rights relating to the use of this document or its contents.

| No. | Description | Unit | Qty. | Unit Price | Cost (CAD) | Remarks |
|---|---|---|---|---|---|---|
| 8 | Rock excavation for Cable concrete vault. 5m x 3m x 2.5m. Price includes excavation | EA | 6 | 12,500 | 75,000 | Considering CAD 300 per cu.m. According to past project experience. |
| 9 | Concrete vault for outdoor termination. 5m x 3m x 2.5m. Concrete wall thickness 0.3m. (Concrete) | EA | 6 | 20,000 | 120,000 | According to a CAD 1100 per cu.m of reinforced concrete and framework. Estimate of concrete volume required 17.44 cu.m per concrete vault. |
| 10 | Riser structures c/w arresters and disconnect switches | EA | 6 | 100,000 | 600,000 | |
| 11 | Engineering, Consultancy and Survey | LS | 1 | 150,000 | 150,000 | |
| | Contingency | | | 15% | 6,055,000 | |
| | **Preliminary Estimate of Cost (CAD)** | | | | **46,410,000** | |
| | Note: All totals are rounded-up to '5,000 | | | | | |

## 8. Horizontal Directional Drilling

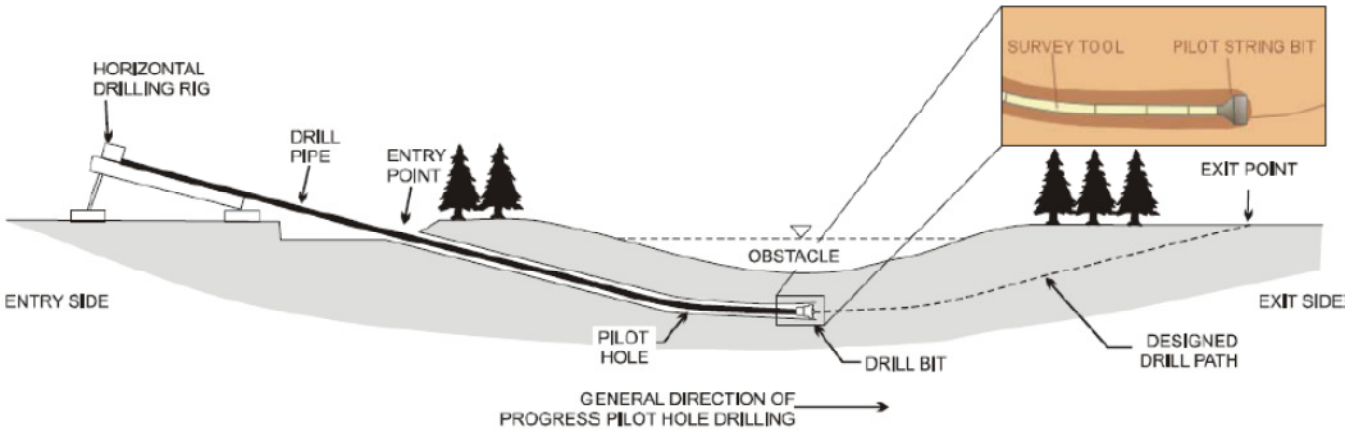
Another possible option that can be explored is installation of conduits below the surface of strait using horizontal directional drilling (HDD). This option offers lesser environmental impact on the marine and increased security for the cable itself. Also, concrete vaults are not required; since the cable can directly be terminated onto riser structures.

**A critical unknown is the cost for HDD which needs to be investigated further.**

For the HDD option, the required cable ampacity can be met using single 3000 sq.mm XLPE stainless steel sheathed cable per phase.



© Hatch 2015 All rights reserved, including all rights relating to the use of this document or its contents.




Source: CAPP Publication 2004-0022

**Figure 5 HDD Option Schematic**

The preliminary estimate for this option is as follows.

| No. | Description | Unit | Qty. | Unit Price | Cost (CAD) | Remarks |
|---|---|---|---|---|---|---|
| 1 | 345 kV XLPE 3000 sq.mm | m | 6,300 | 1,500 | 9,450,000 | CAD 10,000,000 advised by Mitsubishi |
| 2 | Transportation from manufacture location to site | L/S | 1.00 | 1,000,000 | 1,000,000 | |
| 3 | Anchor clamps | EA | 12 | 5,400 | 65,000 | |
| 4 | Submarine-to-land cable splice | EA | - | | N/A | |
| 5 | Outdoor Termination | EA | 6 | 71,566 | included in Item-1 | |
| 6 | Cable protection at land (eg. articulated pipes) | m | - | - | N/A | |



© Hatch 2015 All rights reserved, including all rights relating to the use of this document or its contents.

| No. | Description | Unit | Qty. | Unit Price | Cost (CAD) | Remarks |
|---|---|---|---|---|---|---|
| 7 | HDD pipe | m | 6300 | 500 | 3,354,000 | |
| 8 | HDD and cable pulling | m | 6300 | 1500 (4500) | 9,450,000 (28,350,000) | Unit price of 1500 for normal soil, 4500 for rock less than 100MPa. Rock over 100Mpa is not practical |
| 9 | Rock excavation for Cable concrete vault. 5m x 3m x 2.5m. Price includes excavation | EA | - | - | N/A | |
| 10 | Concrete vault for outdoor termination. 5m x 3m x 2.5m. Concrete wall thickness 0.3m. (Concrete) | EA | - | - | N/A | |
| 11 | Riser structures c/w arresters and disconnect switches | EA | 6 | 100,000 | 600,000 | |
| 12 | Engineering, Consultancy and Survey | LS | 1 | 150,000 | 150,000 | |
| | Contingency | | | 15% | 3,580,000 (6,415,000) | |
| | **Preliminary Estimate of Cost (CAD)** | | | | **27,445,000 (49,180,000)** | Normal Soil (Rock Less than 100Mpa) |
| | Note: All totals are rounded-up to '5,000 | | | | | |



Safety • Quality • Sustainability • Innovation

© Hatch 2015 All rights reserved, including all rights relating to the use of this document or its contents.