newfoundland labrador hydro

Hydro Place. 500 Columbus Drive.
P.O. Box 12400. St. John's. NL
Canada A1B 4K7
t. 709.737.1400 f. 709.737.1800
www.nlh.nl.ca

November 30, 2021

Board of Commissioners of Public Utilities
Prince Charles Building
120 Torbay Road, P.O. Box 21040
St. John's, NL A1A 5B2

Attention: Ms. Cheryl Blundon
Director of Corporate Services & Board Secretary

Dear Ms. Blundon:

Re: *Reliability and Resource Adequacy Study Review* – Root Cause Analysis Report for the L'Anse au Diable Grounding Station Phase 2 Breakwater

In its correspondence dated September 24, 2021,[1] Newfoundland and Labrador Hydro ("Hydro") advised the Board of Commissioners of Public Utilities that it would provide the results of a root cause analysis which was undertaken following significant damage to the breakwater at the Labrador electrode site located in L'Anse au Diable.

The results of this analysis, completed by Tiller Engineering Inc. ("TEI"), are provided in Attachment 1, "Labrador Island Link Limited Partnership Root Cause Analysis Report – L'Anse au Diable Grounding Station Phase 2 Breakwater" ("TEI Report"). TEI's review of the site conditions and design considerations determined that the root cause of the damage is the breakwater's crest not being high enough to protect against extreme site conditions. TEI recommended upgrades to mitigate the impact of significant wave events on the breakwater, better enabling it to protect the electrode site.

The TEI Report includes a design review and an updated wave study that was used to determine the cause of the washouts experienced at the site. The TEI Report recommends the use of different assumptions than those originally used with respect to the available wave data, including a larger design wave at site. Changing these assumptions will result in an increase in the required crest height of the breakwater to protect against these predicted values. TEI notes that its proposed design wave heights and related breakwater crest height are based on extreme conditions representing the worst-case design scenario. TEI recommends the following actions be taken prior to a final determination regarding the next steps:

1. Perform the nearshore wave/period modeling with a numerical model to re assess the worst-case scenario for a wave/period combination given the site geometry, wind generated surge and potential sea level rise for 100 years.
2. Raise the breakwater crest height to the appropriate elevation, thus determined from recommendation 1

[1] "*Reliability and Resource Adequacy Study Review* – Update Regarding the Design Review Pertaining to L'Anse au Diable Electrode Site," Newfoundland and Labrador Hydro, September 24, 2021.

3. Re-assess the armourstone sizes and internal geometry for the breakwater.
4. An inspection of the structure to determine that the deformation is limited or not occurring and evaluation of construction quality.[2]

Hydro is currently evaluating the above recommendations to determine the required actions to confirm both the recommended wave height and required increase in crest height and to refine the forecasts cost of upgrades. Determinations with respect to required upgrades at the L'Anse au Diable Electrode Site will be made in the first quarter of 2022 and would be completed prior to the end of 2022. Costs associated with this work will be borne by the Lower Churchill Project.

Should you have any questions, please contact the undersigned.

Yours truly,

NEWFOUNDLAND AND LABRADOR HYDRO

Shirley A. Walsh
Senior Legal Counsel, Regulatory
SAW/sk

Encl.

ecc: **Board of Commissioners of Public Utilities**
Jacqui H. Glynn
Maureen P. Greene, Q.C.
PUB Official Email

Newfoundland Power
Dominic J. Foley
Lindsay S.A. Hollett
Regulatory Email

Consumer Advocate
Dennis M. Browne, Q.C., Browne Fitzgerald Morgan & Avis
Stephen F. Fitzgerald, Browne Fitzgerald Morgan & Avis
Sarah G. Fitzgerald, Browne Fitzgerald Morgan & Avis
Bernice Bailey, Browne Fitzgerald Morgan & Avis
Bernard M. Coffey, Q.C.

Industrial Customer Group
Paul L. Coxworthy, Stewart McKelvey
Denis J. Fleming, Cox & Palmer
Dean A. Porter, Poole Althouse

Labrador Interconnected Group
Senwung F. Luk, Olthuis Kleer Townshend LLP
Julia K.G. Brown, Olthuis Kleer Townshend LLP

[2] "Labrador-Island Link Limited Partnership Root Cause Analysis Report – L'Anse au Diable Grounding Station Phase 2 Breakwater" Tiller Engineering Inc., November 12, 2021, s 8.0, at p. 20.

Labrador Island Link Limited Partnership Root Cause Analysis Report

L'Anse au Diable Grounding Station Phase 2 Breakwater

Prepared by:

Tiller Engineering Inc.
119 Springdale St.
St. John's, NL, Canada

TEI TM
TILLER ENGINEERING INC

Prepared for:

John Walsh
NL Hydro

Labrador Island Link Limited Partnership

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November 12, 2021	R0 – Issued to Client	2020-227	MT	JS	RT

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1.0 Introduction

Since its completion in 2016 the L'Anse Au Diable Grounding Station Phase 2 Breakwater which was purposed to provide protection for the HVDC shoreline electrodes has experienced significant damage requiring repairs and reinstatement. Damages include shifting armor stones, washouts and evidence of wave overtopping. Shoreline pond electrodes at L'Anse au Diable are protected behind a rubble mound breakwater, located on the southern Labrador coast in the Strait of Belle Isle as seen in Figure 1.1 and Figure 1.2. The electrodes provide protection to the HVDC transmission system from Muskrat Falls to Soldiers Pond. The breakwater is intended to protect these electrodes from damage caused by wave, current and ice forces in the Straight of Belle Isle. TEI was engaged by Labrador Island Link Limited Partnership to provide a root cause analysis report for the repeated damages to the structure and discuss remediation recommendations.

Figure 1.1 Breakwater Location (Google Earth, 2021)

Figure 1.2 Breakwater Location

1.1 Breakwater Structure Background

The client had specified the following criteria in the breakwater design. This criterion is documented in "Shoreline Pond Electrodes – Civil/Marine Design Criteria", The client had the following design criteria for the breakwater summarized below. On top of the specified criteria they had also requested that the breakwater be designed to accommodate "worst case scenario" loading.

Design Current	2 Knots
High Water	1.4m
Sea Level Rise	1.0m
Significant Wave	4.4m
PGA	0.038g
Design life	100 years

Inshore design wave development was documented SLI Document 505573-8610-41ER-001-01 "Wave Climate and Extremes at L'Anse Au Diable, Strait of Belle Isle. Physical design features and design water levels are documented in the as-built drawings and summarized in the table below and in Figure 1.3. All elevation data are in chart datum (CD), unless stated otherwise.

Low Water Level	0.0m	Design Stillwater	4.9m
High Water Level	1.5m	Crest	8.3m
Mean Sea Level	0.8m	Toe	-6.2m
Mean High Water Spring	1.6m	Back Berm	3.5m
Design Wave (AEP_{100})	4.1m	Maximum Height	14.5m($_{+/-}$)
Design Period	Not Specified	Crest Height	8.3m

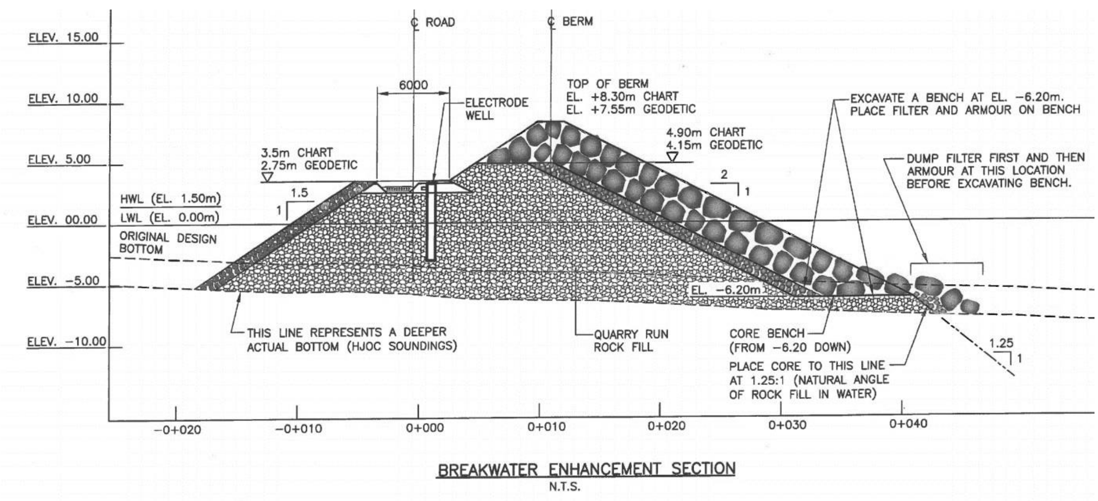

Figure 1.3 Typical Design Section

1.2 Industry Standards & Guidelines

Industry Standards, Guidelines, and data used by TEI in this review included:

i) Shore Protection Manual (US Army Corps of Engineers, 1984)
ii) Meteorological Service of Canada (MSC50 Hindcast data)

1.3 Acronyms

Table of Acronyms

TEI	Tiller Engineering Inc.
LILLP	Labrador Island Link Limited Partnership
SPM	Shore Protection Manual
MSC	Meteorological Service of Canada
LIDAR	Light Detection and Ranging
SWAN	Simulating Waves Nearshore Software
MECO	Mitchelmore Engineering Company Ltd.

2.0 Scope

The L'Anse Au Diable Grounding Station Phase 2 Breakwater, known in this report as The L'Anse Au Diable Breakwater or The Breakwater, finished construction in 2016 and has experienced heavy damage in at least two separate storm events. The breakwater has experienced shifting armor stone and the electrode station has sustained heavy damage due to overtopping, including damage to the electrode well covers and exposure of the concrete encased duct banks. Labrador Island Link Limited Partnership (LILLP) believes that the current structure may require redesign and modification in order to withstand the wave forces experienced in the Strait. TEI's was engaged by LILLP to perform a root cause analysis report on damage sustained to the breakwater. In order to complete the root cause analysis TEI first completed the generation of a new site-specific wave analysis to determine the design wave for the breakwater. TEI's root cause analysis report then will define any potential problem areas in the original design, locate the root cause of the repeated washouts and find corrective and preventative issues that will be outlined in the accompanying SOW documents labeled: *L'anse au Diable Phase 2 Grounding Station Break Water Design Re-Evaluation*.

Figure 2.0 Breakwater Damage Location

3.0 References

[1] - *Technical Memorandum Report - Wind/Wave Analysis and Breakwater Design*

[2] - *ILK-SN-CD-8610-CV-RP-0001001 - Wave Climate and Extremes at L'Anse au Diable, Strait of Belle Isle*

[3] - *LCP-PT-MD-8610-EN-PR-0002-01 - L'Anse au Diable Grounding Station Phase 2 Breakwater Design Re-Evaluation Scope of Work*

[4] - *MFA-SN-CD-6300-CV-DC-0001-01 - SHORELINE POND ELECTRODES CIVIL/MARINE DESIGN CRITERIA*

[5] - *ILK-SN-CD-8610-CV-PL-0009-02 - Electrode Station Breakwater Section A, B, C & D*

[6] - *ILK-HJ-SD-8610-CV-R02-0005-01 - Supply and Install Electrode Sites – L'Anse Au Diable BREAKWATER CONSTRUCTION*

[7] - *ILK-SN-CD-8600-CV-TS-0001-01 - ELECTRODE SITES BREAKWATER INSTALLATION TECHNICAL SPECIFICATION*

[8] – *SLI Document 505573-8610-41ER-001-01*

[9] - *Shoreline Pond Electrodes – Civil/Marine Design Criteria*

4.0 Existing Breakwater Design

TEI evaluated the root cause of the washouts by reviewing the original design of the breakwater. Rubble mound breakwaters such as the one at L'Anse au Diable are designed with an armor stone size and a geometry to resist erosion from wave and ice action that are specific to that site. The geometry of a typical section in Figure 1.3 is governed by the design wave and a design water level. After a review of presented design documentation, it would appear that the breakwater at L'Anse au Diable is designed for a design wave with a 100 year return period, and a design water level with a 1 meter allowance for sea level rise.

The Shore Protection Manual (SPM), US Army Corp of Engineers, 1984 is the referenced standard for breakwater design. The SPM discuss two main types of design criteria for breakwaters; structural stability of the breakwater and functional performance but does not offer firm guidance with respect to values, leaving it with the designer to establish these based on economics. Design criteria from client reference documents further specified the breakwater should be designed to withstand the "expected worst case" site conditions.

4.1 Climate Data Used

During design, wave and wind data was taken from the Meteorological Service of Canada (MSC50) wave hindcast data in the center of the Strait of Belle Isle. There is a total of nine (9) MSC50 data nodes located in the strait, each with 65 years of climactic data. Of the 9 the original design took wind data from the closest node M6018142, and wave data from 3 nodes, M6018212, M60180142 and M60180170 as seen in figure 4.0. The historical wave and wind data is then transposed to the project site at L'Anse au Diable.

Figure 4.1

4.2 Design Wave Height

The most crucial climactic value in determining a breakwater design is its design wave. The general guidance in calculating design waves according to the designer's reference document, the SPM 1984, is to generate a wave in the offshore environment and then analytically propagate those waves to the shoreline for an inshore design wave. An offshore wave should be defined by both the height (m) and the period (s). The original design which took wind data from node M6018142, and wave data from nodes, M6018212, M60180142 and M60180170 together yielded an offshore significant wave of 6.1 meters as illustrated in table 4.1.

Return Period (Years)	Existing Design (Offshore)	Existing Design (Inshore)
2	4.1m	2.5m
10	6.0m	3.3m
100	6.1m	4.1m

Table 4.1: Offshore/Inshore Significant Wave Extreme Values

As the offshore wave is transposed into an inshore wave at the breakwater, the wave is reduced in height due to factors the wave experiences approaching land such as near shore depth, angle of approach and the underwater topography. The original design used existing Light Detection and Ranging (LiDAR) bathymetric data of the project site along with Delft3D & Simulating Waves Nearshore Software (SWAN) to set up a spectral wave model to closely analyze the shore wave climates and project extreme inshore wave conditions at the site. After reviewing the original design values, it appears the significant wave height (H_s) used in the design of the breakwater was 4.1 meters for a 100-year return for a total reduction factor of 0.67 from the offshore wave as seen in table 4.1. The design documents do not specify an offshore or inshore design period.

Return Period (Years)	Extreme Wave, Hs (m)							
	Location							
	1	2	3	4	5	6	7	8
1	2.2 ± 0.1	2.2 ± 0.1	2.3 ± 0.1	2.6 ± 0.1	2.2 ± 0.1	2.2 ± 0.1	2.2 ± 0.1	2.2 ± 0.1
2	2.3 ± 0.1	2.4 ± 0.1	2.5 ± 0.1	2.8 ± 0.1	2.4 ± 0.1	2.3 ± 0.1	2.4 ± 0.1	2.5 ± 0.1
5	2.6 ± 0.1	2.7 ± 0.1	2.8 ± 0.1	3.1 ± 0.2	2.6 ± 0.1	2.6 ± 0.1	2.7 ± 0.1	2.7 ± 0.1
10	2.8 ± 0.2	2.9 ± 0.2	3.0 ± 0.2	3.4 ± 0.2	2.8 ± 0.2	2.8 ± 0.2	2.9 ± 0.2	3.0 ± 0.2
25	3.0 ± 0.3	3.1 ± 0.3	3.2 ± 0.3	3.7 ± 0.3	3.0 ± 0.2	3.0 ± 0.2	3.2 ± 0.3	3.2 ± 0.3
50	3.2 ± 0.3	3.3 ± 0.3	3.5 ± 0.3	3.9 ± 0.4	3.2 ± 0.3	3.2 ± 0.3	3.4 ± 0.4	3.4 ± 0.4
100	3.4 ± 0.4	3.5 ± 0.4	3.7 ± 0.4	4.1 ± 0.5	3.4 ± 0.4	3.4 ± 0.4	3.6 ± 0.4	3.7 ± 0.4
200	3.6 ± 0.4	3.7 ± 0.4	3.9 ± 0.5	4.4 ± 0.5	3.6 ± 0.4	3.6 ± 0.4	3.8 ± 0.5	3.9 ± 0.5

Table 4.2 - Significant Wave Heights From Existing Documents

4.3 Existing Water Levels

Another direct parameter for a breakwater's design is the design water level, which can vary due to many different factors including tides, storm surge, sea level rise and other seasonal variations. There is no direct discussion in the received documents regarding what water level should be used for the breakwater design but there is a mention of a predicted high-water level between 1.4 meters and 1.6 meters. In the received design drawings, it is indicated a water level of 1.5m is used in design.

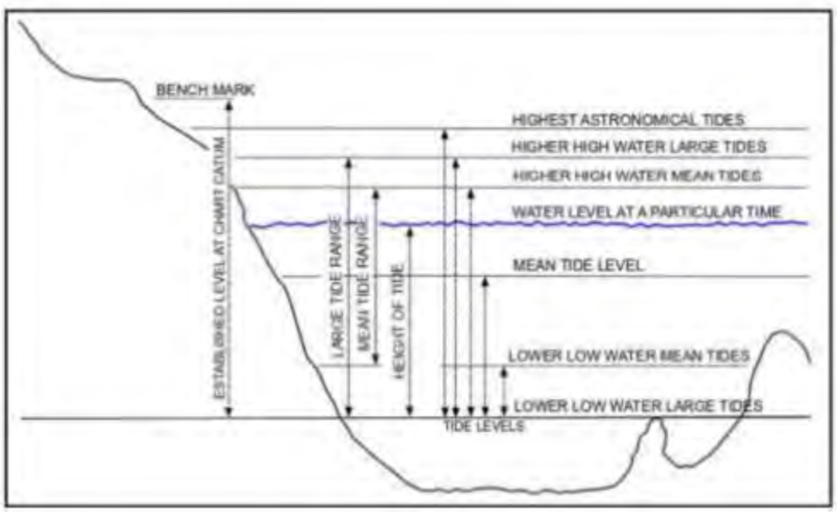

Figure 4.2

In addition to 1.5m high water level a one (1) meter increase for the allowance of sea level rise due to climate change was requested to be used by the client in Nalcor Document No. MFA-SN-CD-6300-CV-DC-001-01. A 1 meter increase in sea level rise is considered a reasonable assumption in the strait of Belle Isle over a 100-year period.

The SPM states that there can be an associated storm surge as a result of a passing low-pressure system that can raise the water level in addition to the raise from tidal levels and sea level rise. In design documents extreme storm surge water levels are not mentioned and it is not known if storm surge is considered in determining the design water level at the breakwater. A summary of the existing design water levels can be seen in Table 4.3 below. Accurate water levels, tidal ranges and storm surges are necessary in determining the elevation of the breakwater.

Breakwater Water Level			
Water Level Variable	Tidal Level	Sea level Increase	Storm Surge
Original Design	1.5m	1.0m	No mention

Table 4.3: Breakwater Water Level Summary

4.5 Design Summary

The L'Anse au Diable breakwater was designed using a design wave (H_s) with a 100-year annual exceedance probability. The offshore design wave chosen from the MSC50 data for the site was 6.1m, after transposing this to the breakwater site we see a wave reduction factor of 0.67 to an inshore design wave of 4.1 meters. At no point in the design documents is the 100-year design wave period mentioned or a wave height/period combination to represent a design condition suitable to a worst-case scenario. The breakwater was also with a design water level of 1.5 meter, with an additional 1 meter added on for sea level change. There is no documentation that extreme water levels associated with a storm surge were taken into account, however this may have been included in the delft 3D/SWAN model. It is these considerations that lead to the geometric design of the L'Anse au Diable breakwater as seen in table 4.4.

The following table summarizes all design values used for the breakwater:

Item	Value
Armor Stone Sizes	6 – 10 Tonnes
Filter Stone Sizes	0.6 – 1.0 Tonnes
Design Wave (AEP_{100}) (Inshore)	4.1 Meters
High Water Line	1.5 Meters
Crest Elevation	8.3 Meters
Filter & Core Stone Elevation	4.9 Meters

Table 4.4: Breakwater Design Summary

5.0 Construction

5.1 General Construction Methodology

Breakwater construction is a unique process to these structures that can have an impact on the structural integrity of the breakwater over its lifetime. Construction of a breakwater includes excavation of the sea bed, laying of the breakwater core, filter and then armor stones. In the case of L'Anse-au-Diable the same processes were undertaken with the additional construction of the electrode wells. Core stones are first placed on the seabed in sections and filter and armor stones are sequentially added to protect the core stones from wave action. This procedure continues until the breakwater is complete. Crest width is an important factor to consider as heavy equipment is needed to lay armor stones and the crest must be wide enough so the equipment can safely reach all points of the breakwater.

Core, filter, armor stone sizes and width layers are all determined through design and the construction requires the breakwater to be built as close as possible to the design to retain the structural resistance and performance against wave action. After reviewing the provided material it would seem the contractor followed standard construction methodology.

5.2 As-Built Elevations

Design documents include a site plan as well as cross sections at various points along the breakwater. Elevations on the design drawings include height for core, filter, and armor stones; as-built elevations are to be as close as possible to these elevations as these elevations are the determined heights for the breakwater to resist wave action.

When reviewing as-built elevations it appears that points along the breakwater have lower elevations than design. The low elevations are not limited to individual layers but are present in the core, filter, and armor stones. In Figure 5.1 the design section D-D is shown with design elevations. Figure 5.2 shows the as-built elevations in the same location as section D-D. When comparing the two section elevations it is apparent that the filter stones and armor stones did not reach the required design height. Filter stones on the seaward side of the breakwater are designed to reach a height of 4.15 meters with reference to the geodetic datum. However, the as-built survey indicates that it extended to approximately 3.2 meters. Elevation differences are not limited to these sections but appear to be present in most of the sections provided. The table below shows areas where as-built elevations do not appear to match with design elevations.

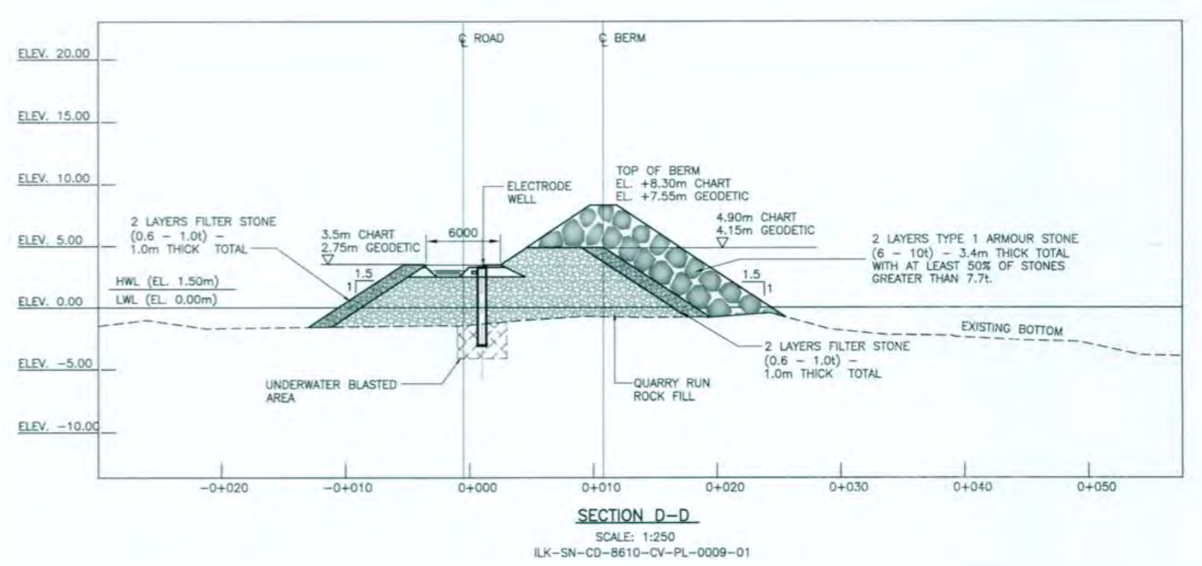

Figure 5.1 Section D-D Cross Section

Figure 5.2 Section D-D As Built Elevations

	Armor		Filter		Core Seaward		Core Landward	
Station – Cross Section	Design	Actual	Design	Actual	Design	Actual	Design	Actual
0+050 – A-A	7.55	7.75	4.15	4.50	4.15	4.25	-	-
0+075	7.55	7.75	4.15	4.50	4.15	4.00	-	-
0+125 – B-B	7.55	7.75	4.15	4.70	4.15	4.00	2.75	2.50
0+175 – C-C	7.55	7.75	4.15	3.95	4.15	4.10	2.75	2.75
0+225 – D-D	7.55	7.80	4.15	3.20	4.15	4.10	2.75	2.60
0+275 – E-E	7.55	7.20	4.15	4.5	4.15	4.15	2.75	2.60

Table 5.1 - As-Built Elevations versus Design Elevation (*m*)

5.3 Material Sizes

Armor stone size in breakwater design is directly related to the design criteria for the structure. Various rock sizes are used to promote interlocking of the structure and provide added structural integrity. As outlined in the L'Anse-au-Diable breakwater design, all armor stones must be a minimum size of 6 Tonnes and over 50 percent must be greater than 7.7 Tonnes. Throughout reviewing of the received documents TEI found two possible documentations that too small of amour stone was laid. First, in documents provided there are descriptions of an instance where two projectiles (boulders) crested the top of the breakwater and caused damage to the landward side, which could be an indication of undersized of armor stones. Furthermore, within the construction documents in the "Fill Placement Checklist" the engineer on site notes to "beware of rock sizes" (Appendix D). More investigation into these two documents are necessary to see if they are in fact a sign of too small of armor stone being used.

5.4 Compressed Rock Strengths

Within the Technical Specification for Breakwater Installation SLI defines the required compressed rock strength to be in exceedance of 170 Mpa [7]. Materials testing on numerous samples from L'Anse-au-Diable concluded the average compressed strength of the rock used was under capacity at just 153.6 Mpa [6].

ROCK CORE COMPRESSIVE STRENGTH REPORT
ASTM C170

PROJECT NO:	TF1559802.2000	SAMPLE DATE:	30-Apr-15
PROJECT:	Electrode Site Breakwater Installation	SAMPLED BY:	A. Guest
	L'Anse Au Diable	ROCK TYPE:	Granodiorite
CLIENT:	H.J. O'Connell Construction	SPEC. COMP. STRENGTH (MPa)	70
SOURCE:	L'Anse Au Diable		

CORE NUMBER	DIAMETER (mm)	LENGTH (mm)	COND. (WET/DRY)	RATIO (L/D)	COMPRESSIVE STRENGTH (MPa)	AVERAGE COMPRESSIVE STRENGTH (MPa)
6384A	57.7	57.7	Wet	1.0	176.2	156.2
6384B	57.7	58.5	Wet	1.0	125.1	
6384C	57.4	59.3	Wet	1.0	166.4	
6384D	57.4	55.6	Wet	1.0	207.5	
6384E	57.6	57.0	Wet	1.0	178.5	
6384F	57.9	56.4	Wet	1.0	133.7	
6384G	57.8	55.2	Wet	1.0	189.6	
6384H	57.9	55.2	Wet	1.0	93.7	
6384I	57.6	57.6	Wet	1.0	202.3	
6384J	57.7	56.0	Wet	1.0	89.2	
6384K	57.9	58.3	Dry	1.0	113.4	150.6
6384L	57.5	55.0	Dry	1.0	181.3	
6384M	57.3	56.4	Dry	1.0	140.6	
6384N	57.8	57.7	Dry	1.0	173.9	
6384O	57.7	59.1	Dry	1.0	153.7	
6384P	57.7	56.7	Dry	1.0	177.0	
6384Q	57.3	59.0	Dry	1.0	105.7	
6384R	57.8	55.5	Dry	1.0	159.3	
					Overall Average:	153.7

Table 5.2 Compressive Strengths

5.5 Construction Summary

After reviewing the provided construction material and reflecting on the topics above we believe the contractor followed standard construction methodology while working on the breakwater. Although there are some minor construction deficiencies in the elevations and the rock strength these seem to be insignificant.

6.0 Independent Wave Analysis Findings

TEI along with its sub-consultant Mitchelmore Engineering Company Ltd. (MECO) performed an independent Wave Analysis for the L'Anse-Au-Diable Breakwater to compare with the wave values which governed the breakwater design. The general wave design guidance in the Shore Protection Manuel (SPM 1984) is to generate waves for an offshore environment and then propagate those waves to the shoreline.

6.1 Climate Data Used

During the independent analysis wind and wave data was taken from all nine (9) of the MSC50 nodes in the Strait of Belle Isle, in contrast to just 3 in the existing design as seen again in Figure 6.1. It is our hope that gathering more climactic data, from more nodes may provide a better insight into wind and wave conditions in the Strait. A summary of the wind and wave data can be seen in table 6.1 below. More information into the climactic data used in the independent analysis can be summarized in Appendix A.

Figure 6.1

Values	Data Node								
	018069	018070	018071	018072	018073	018142	018211	018212	018213
Long	-57.00	-56.90	-56.80	-56.70	-56.60	-56.60	-56.60	-56.50	-56.40
Lat	51.40	51.40	51.40	51.40	51.40	51.50	51.60	51.60	51.60
Depth	50.22	76.22	77.08	78.23	39.13	51.12	76.75	65.99	56.96
Num Years	65	65	65	65	65	65	65	65	65
Mean MaxWs	20.73	20.80	20.86	20.94	21.02	20.96	20.90	21.02	21.14
StDev MaxWs	1.42	1.36	1.36	1.35	1.38	1.42	1.49	1.51	1.55
Mean MaxHs	4.13	4.24	4.06	3.68	3.33	3.23	2.67	2.91	3.10
StDev MaxHs	0.79	0.82	0.78	0.70	0.55	0.52	0.46	0.48	0.48

Table 6.1 MSC50 Node Data

6.2 Wave Height

After reviewing the annual maximum data an extreme value analysis of the data we used a Gumbel distribution on all data sets for different return periods. The significate wave height (H_S) for the offshore wave at each node can be summarized below in table 6.2. For the desired design period of 100 years, we get a significant wave height from between 4.26 meters and 7.06 meters depending on the node, with an average between all nodes of 5.61 meters.

Return Period (Years)	Node								
	018069	018070	018071	018072	018073	018142	018211	018212	018213
2	4.00	4.11	3.94	3.57	3.24	3.15	2.60	2.83	3.02
10	4.00	4.11	3.94	3.57	3.24	3.15	2.60	2.83	3.02
50	6.37	6.57	6.27	5.68	4.88	4.72	3.99	4.26	4.46
100	6.83	7.06	6.73	6.09	5.21	5.03	4.26	4.54	4.74
1000	8.38	8.67	8.25	7.46	6.28	6.05	5.17	5.47	5.68

Table 6.2 MSC50 Node Offshore Waves

As the deep-water waves approach the shoreline, they will get smaller as the water depth decreases. Without having the capacity to complete a wave study with a more accurate numerical software like Delft 3D/SWAN or similar we can transpose the wave with the shoaling coefficient and refraction coefficient which will reduce the wave height as it approaches the coast. The waves shoaling coefficient can be approximated from the below Figure 6.2 from the SPM1984.

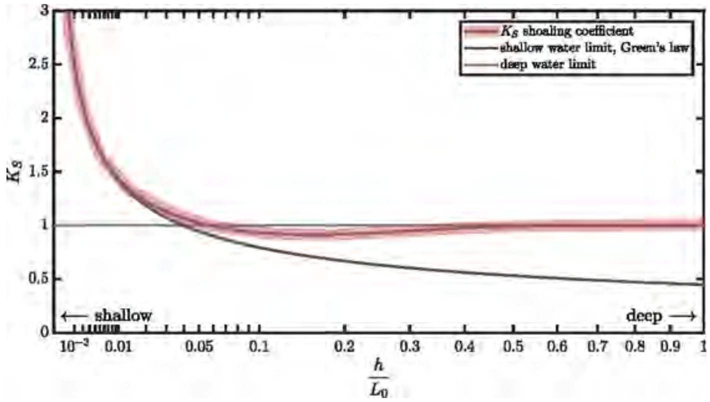

Figure 6.2

The deep water waves approaching the shore will also be reduced if the wave approach the shore at an angle, an effect known as refraction. The amount of wave refraction is further a function of the seaward seabed slope. For the L'Anse au Diable site, the offshore wave refracts approximately 34 degrees from the dominant wave direction, with a seabed slope of 4 to 5 %.

Using tables from the SPM1984 and making preliminary estimates we can get a shoaling coefficient (K_s) of 0.92 and a refraction coefficient (K_r) of 0.96 for an overall reduction factor of 0.88.

In summary we see different design waves from our independent analysis then what was used in the original design. The offshore wave was found from our MCS50 data to be anywhere from 4.3m to 7.1m, depending on the node you take the wave from in the strait. When comparing with the original design offshore wave of 6.1m this seem reasonable, however not the worst-case scenario as described in the design guidance from Nalcor reference documents which specified the breakwater should be designed to withstand the "expected worst case" site conditions. This would lead us to believe a design wave of closer to 7.1 would be a better choice in our opinion.

We also saw a much greater reduction in height as the original offshore wave was transposed into an inshore wave compared to our own investigation. The original offshore wave of 6.1m was reduced to a 4.1m inshore wave, a reduction of 0.67. From our estimates of the wave reduction according to the tables in the SPM1984 we use a reduction of 0.88 as the offshore wave became an inshore design wave. Without a numerical analysis like Delft3D/SWAN we cannot comment on how accurate a reduction of 0.67 is, however it is our opinion it is low, especially considering our estimate of 0.88.

Water Level Variable	Breakwater Wave Height			
	Offshore Wave	Reduction Factor	Reduction Factor Source	Inshore Wave
Original Design	6.1m	0.67	Delft3D/SWAN	4.1m
TEI/Meco (Average)	5.6m	0.88	SPM1984	4.9m
TEI/Meco (worst case)	7.1m	0.88	SPM1984	6.3m

Table 6.3: Breakwater Wave Height

6.3 Wave Period

The MSC50 data set records the period associated with wave height. The period is a measure of time between peaks and can be used to differentiate between wind generated waves and deep-water waves. The larger waves appear to be between 10s and 12s, but the data clearly demonstrate even small waves can have a large period. The design wave period is equivalent to the wave energy and is a significant factor in sizing the armorstone. The technical documentation acknowledged complexity in wave design, but did not provide any guidance on what is the suitable design wave period, such as an extreme value analysis of wave period, as was done for the significant wave.

6.4 Still Water Level

Breakwater design will also be heavily dependent on the depth of water adjacent to the structure. After reviewing the tidal and sea level rise values in the original design it is our belief that these are reasonable, but the inclusion of water level increase due to storm surge would have to also be included. There is no documentation to suggest design considered extreme water levels associated with storm surge, although this may have factored into the Delft3D/SWAN model.

Without performing a more in-depth numerical storm surge analysis of the site location it would be our opinion that for the strait of Belle Isle a storm surge of 1.5m-2.0m is adequate and should be included on top of the high tide level and storm surge.

Breakwater Water Level			
Water Level Variable	Tidal Level	Sea Level Increase	Storm Surge
Original Design	1.5m	1.0m	No mention
TEI/Meco	1.5m	1.0m	1.5-2.0

Table 6.4: Breakwater Water Level

7.0 Conclusions

The breakwater design for L'anse au Diable is developed using an extreme significant wave with an annual exceedance probability of 100 years. Breakwater design was documented in SLI Document 505573-8610-41ER-001-01, "Wave Climate and Extremes a L'Anse Au Diable, Strait of Belle Isle. The design wave was developed using the MSC50 hindcast dataset. There is no documentation to suggest design considered extreme water levels associated with storm surge which is important to consider under a "worst case scenario design".

The direction and wave height for an offshore significant wave was verified with the current dataset. There is some variation, depending on which station is selected as governing design, with a maximum 100-year wave of 7.1 m compared with the 6.1 m used in design of the breakwater. There are nine (9) nodes reported in the MSC50 data set, with the 100-year wave varying from 4.26 m to 7.06 m. The reported value of 6.1 m is considered reasonable, but not the worst case as required in the original design criteria.

The inshore design wave is developed in a Delft3D/SWAN numerical model that predicted a 100-year design wave of 4.1m. The predicted wave for design is approximately two-thirds of the offshore wave. The design document identified a complex wave environment and did not provide any guidance on the design wave period.

In the SPM1984 there is an additional guidance for the design of breakwaters with high economic consequences and adding additional capacity to the design. The additional capacity for these can be one of three options, depending on the economic risk the designer assigns to the breakwater;

- breakwaters be designed with an additional capacity of at least a 10% wave, that is 27% higher than the design wave
- an additional capacity up to a 5% wave that is 37% higher than the design wave.
- an additional capacity up to a 1% wave that is 67% higher than the design wave.

There is no mention of any of these additional design capacity's being considered on the design wave, given the economic importance of this breakwater in protecting the HVDC lines electrodes, it would have been wise to have some of this additional capacity was added but again there is no evidence this was done.

To meet the clients criteria of worst-case scenario for the site, the design wave and period should be one that corresponds to the most likely worst-case wave that will impact the structure for the depth of water at the actual site. This criterion would indicate an offshore wave larger than 6.1m and an inshore wave larger than 4.1m

The design documentation did not discuss storm surge as contributing to the design water level and the design wave that will impact the breakwater. Also, the design documentation did not provide clarification on what is a 100-year design wave period, or a wave height/period combination to represent a design condition suitable for a worst-case scenario.

The specified design requirements was for the "expected worst case site condition" for wave, tide and ice design. The document references the Shore Protection Manual (SPM 1984) as the guidance document which in turn offers guidance on wave design. A review of documents indicates three potential issues:

1. It is not possible to confirm from the given information that the worst-case scenario wave condition was considered, a more in-depth data analysis may yield a higher design wave, but additional information is required to confirm this.
2. There was limited discussion on the design wave period, which is complicated for the site and failure to consider all wave period/wave combinations may not have resulted in the worst-case site condition.
3. There was limited discussion on the design water level and little consideration of storm surge water levels.

With such an advanced numerical analysis being out of the current scope of this report the wave height and water level had to be estimated as worst-case values gathered from our independent analysis. Basing our conclusion off of this data we would conclude the root cause of the breakwater damage is the breakwaters crest is not high enough to protect against extreme site conditions.

8.0 Recommendations

The following recommendations are suggested to help mitigate the damage to the breakwater and confirm the root cause analysis.

The failure mode for the breakwater appears to be performance based rather than structural, i.e., wave overtopping, but no associated deformation. At this stage, the recommended action is to increase the crest elevation. Prior to a final determination, the following actions are recommended.

1. Perform the nearshore wave/period modelling with a numerical model to re asses the worst-case scenario for a wave/period combination given the site geometry, wind generated surge and potential sea level rise for 100 years.
2. Raise the breakwater crest height to the appropriate elevation, thus determined from recommendation 1
3. Re-assess the armourstone sizes and internal geometry for the breakwater.
4. An inspection of the structure to determine that the deformation is limited or not occurring and evaluation of construction quality.

Without performing another more in-depth numerical model to determine the most accurate design wave we can estimate the waves height using extreme values gathered from the independent wave analysis. We have designed remediation drawings to remediate the breakwater under these extreme conditions, using the worst-case design scenario as seen in *table 6.3* we take an offshore wave of 7.06m, reduce it by a factor of 0.88 for an inshore design wave of 6.3m. This gives us a design wave that is 53% larger than the 4.1m wave the existing breakwater was designed for. From this new design wave, we recommend increasing the crest height to a proposed 10.90m as shown in the accompanying drawings titled *L'anse au Diable Phase 2 Grounding Station Break Water Design Re-Evaluation*. However, these are based on the worst-case scenario of design conditions from tables in the SPM1984, we would recommend a re-evaluation of wave and water levels in the strait so these remediations can be designed to the most economical elevation.

Appendix A: Wave Analysis Report

WIND AND WAVE ANALYSIS
DRAFT REPORT

L'ANSE-AU-DIABLE BREAKWATER

Prepared by:
Tiller Engineering Inc.
PO Box 403
50 Hamlyn Rd. Plaza
St. John's, NL, Canada
A1E 5X7

TEI

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TECHNICAL MEMORANDUM REPORT

Project:	L'Anse-Au-Diable Breakwater	**Date:**	October 5, 2021
Subject:	Wind/Wave Analysis and Breakwater Design		
From:	Perry Mitchelmore, P.Eng., PMP	**Title:**	Principal
Review By:	Rick Tiller, M.Eng., P.Eng., FEC, FEIC	**Title:**	Senior Structural Engineer

DRAFT

1 INTRODUCTION

Shoreline pond electrodes at L'Anse au Diable, located on the Labrador cost in the Strait of Belle Isle, are constructed behind a rubble mound breakwater. The electrodes provide protection to the HVDC transmission system from Muskrat Falls to Soldier's Pond. The purpose of the breakwater is to protect the electrodes from damage due to wave, current and ice forces in the Strait of Belle Isle. The breakwater was constructed in 2015 as located in Figure 1.1.

Figure 1.1 As-Built Breakwater Location (Google Earth, 2021)

Since commissioning, the breakwater structure has experienced two incidents of large projectiles, i.e., boulders, cresting the top of the breakwater and causing damage on the landward side. The purpose of this interim technical memorandum report (TMR) is to update on initial assessment results with respect to the design wave and breakwater configuration.

1.1 BACKGROUND

The breakwater design criteria are documented in "Shoreline Pond Electrodes – Civil/Marine Design Criteria", Nalcor Document No. MFA-SN-CD-6300-CV-DC-001-01, Revision B2, December 2012, and summarized as

Design Current	2 Knots
High Water	1.4m
Sea Level Rise	1.0m
Significant Wave	4.4m
PGA	0.038g
Design life	100 years

Inshore design wave development was documented SLI Document 505573-8610-41ER-001-01, "Wave Climate and Extremes a L'Anse Au Diable, Strait of Belle Isle (SNC Lavalin, 2013). Physical design features and design water levels are documented in the as-built drawings and summarized below and in Figure 1.2. All elevation data are in chart datum (CD), unless stated otherwise.

Low Water level	0.0 m	Design Stillwater	4.9 m
High Water level	1.5 m	Crest	8.3 m
Mean Seal Level	0.8 m	Toe	-6.2 m
Mean High-Water Spring	1.6 m	Back Berm	3.5 m
Design Wave (AEP_{100})	4.1m	Maximum Height	14.5m (+/-)
Design Period	Not Specified		

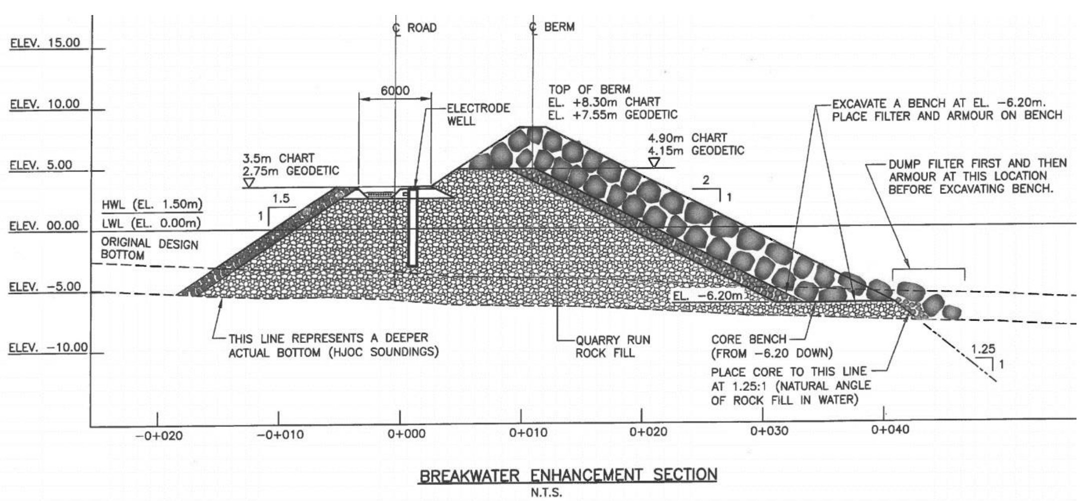

Figure 1.2 Typical Design Section (2015)

A drawing of the breakwater with three (3) seaward profiles are presented in Attachment A. The vertical elevations were contained in AutoCAD drawing provided and are assumed to be referenced to geodetic datum. The profiles indicate the central part of the breakwater is constructed to elevation 7.8m (+/-) geodetic (8.55m CD). They further indicate the seabed is relatively flat for 30 to 40 meters seaward, before gently sloping away at a 4 to 5 percent to beyond 300m from the structure. The extend of the gentle sloping bank is not known, other than the shoreline is steep beyond the bank.

1.2 BREAKWATER DESIGN CRITERIA

The Shore Protection Manual (US Army Corp of Engineers, 1984) is the referenced standard for breakwater design. The wave design criteria in the SPM discusses two criteria, (1) structural stability criteria and (2) functional performance criteria, but does not offer any firm guidance with respect to values, deferring to the developer to establish criteria, based on economics. Design guidance from Nalcor reference documents further specified the breakwater should be designed to withstand the "expected worst case" site conditions.

From a design perspective, the geometry of the typical section in Figure 1.2 is governed by the design wave and the design water level. The general guidance provided in the SPM is to determine the appropriate offshore design wave condition, then transpose that wave to the shoreline while considering shoaling, refraction, etc. effects that change the design wave. The offshore wave condition is defined by a wave height and period, although there is a full spectrum of height/period combinations during any storm event. The design water level is a function of tides, but also surge related to storm winds, hurricanes, etc.

As Waves approach the shoreline, they may be either nonbreaking, breaking, or broken waves, which have different impacts on the nearshore wave parameters and structure performance. For nonbreaking waves, rubble mound breakwaters that can absorb energy and deform without structural failure and the SPM indicates they can be designed for a smaller wave than and rigid structure, that might fail catastrophically. Waves transform from offshore waves in shallow water, generally starting at a depth equal to 50% of the wavelength and accelerating at 5% of the wavelength. The higher the period, the more likely the wave will transform before impacting the structure. For shallow water conditions, water depth may govern design.

From a structural perspective, the SPM indicates that rubble-mound breakwaters are typically design for a range of waves varying from the significant wave, Hs, to H_5, but that H_{10} is the more favored standard for coastal structures. The recommended design wave can be further increase to H_5 for if economic costs are excessive for damage. The different design wave standards are represented as follows

Hs	Average of highest one-third of all waves
H_{10}	Average of highest 10% of all waves, or Hs*1.27
H_5	Average of Highest 5% of all waves, or Hs*1.37
H_1	Average of Highest 1% of all waves, or Hs*1.67

A breaking wave will have a different impact on the structure than a non-breaking wave. The SPM indicates a wave will break on a structure if it is more than 30% higher than the depth of water at the toe of the structure, although this rule is not always applicable.

As noted, the depth of water at the structure will vary with tides and storm surge. There was limited guidance on design seaward water levels in the design documents. Two water levels are defined, (1) Mean Sea Level and (2) Mean High Water Spring. There was also a reference to Highest High Water as well, but no guidance is provided on when to use which level. The best estimate is the breakwater is designed for a maximum Stillwater level seaward of between 1.4m (CD) and 1.6m (CD).

Tidal elevations generally follow the Metonic lunar cycle with a cycle interval between 19 and 20 years. A list of normal reference water levels relative to chart datum are provided in Figure 1.3. While all documents do not agree, it appears the breakwater structural and functional criteria is based on a 100-year design life, or five (5) tidal cycles, which was translated into expected maximum loads with a 100 year return period, but this was not clearly articulated anywhere. There was no analysis of 100-year tide levels, other than the reference document recommended adding one (1) mete to the design water level to account for sea level rise.

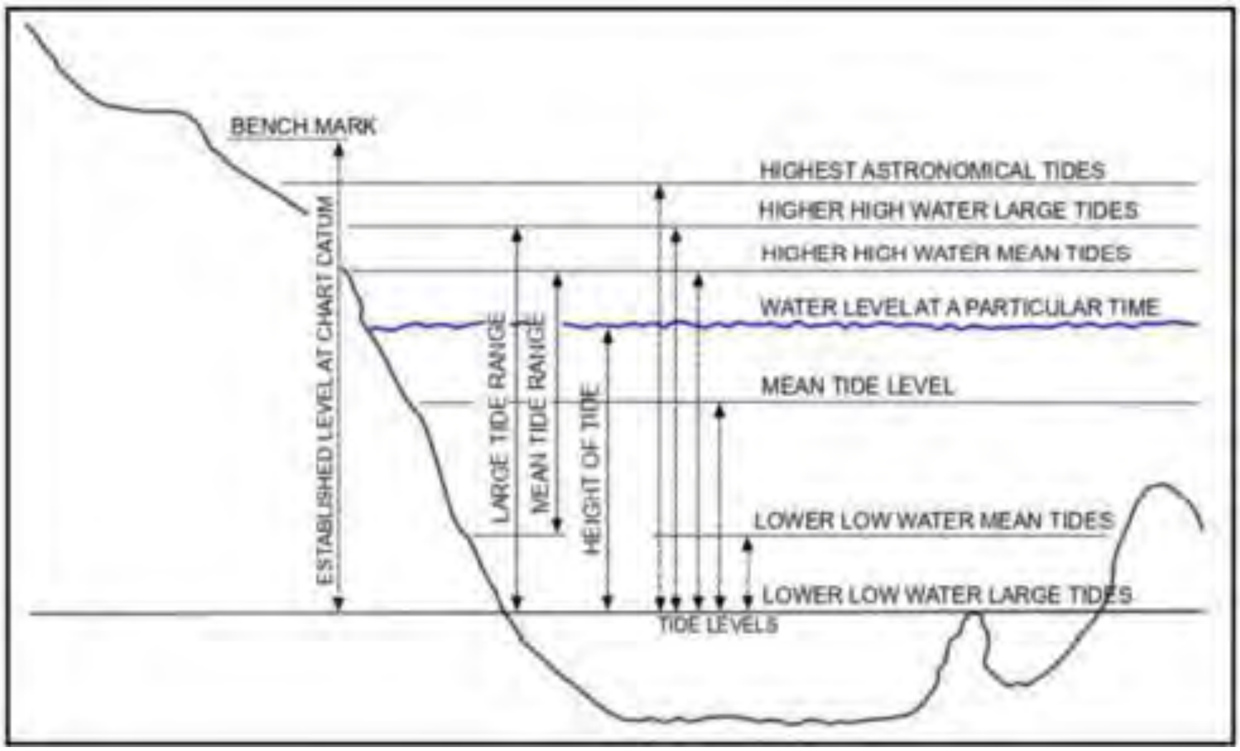

Figure 1.3 Relative Sea Level Terminology

1.3 Other Coastal Structures Design Criteria

For guidance on which water level to use in design, the Guidelines for *Safety of Coastal and Estuarine Dykes and Aboiteaux in New Brunswick and Nova Scotia* (AMEC Foster Wheeler, 2018(a)); was considered. Although these structures are different than breakwaters, they provide guidance for storm surge and wind speeds or different water levels and based on the consequences of damage to the structure, as outlined in Table 1.1. The classification is like the system for dam failures and is not transferrable to breakwaters, where the consequences are primarily economic.

Table 1.1 Target Water Levels for Coastal Dykelands

Classification	Return Period	
	Mean Tide level	Higher High Water Large Tide
Very Low	10	2
Low	100	10
Significant	100-1,000	25 – 250
High	2,500	500
Very high	5,000	1,000
Extreme	10,000	2,500

2 AVAILABLE DATA

Wave climate and extremes are documented in SLI Document 505573-8610-41ER-001-01, "Wave Climate and Extremes a L'Anse Au Diable, Strait of Belle Isle (SNC Lavalin, 2013). Some aspects of the data are also present in a related document prepared for the Labrador – Island transmission Link (AMEC, 2013). Both reports reference the Meteorological Services of Canada (MSC50 Hindcast data) to define the wind and wave environment in the Strait of belle Isle. Another source of environmental loading data is the National Building Code of Canada (NBCC, 2015).

There are nine (9) MSC50 data nodes available in the Strait of Belle Isle, located as shown in **Error! Reference source not found.**, with 65 years of data represented for each node. A summary of data is Table 2.1. The hindcast model predicts the significant wave size tended to decrease from west to east but provides a consistent wind distribution. This may represent wave growth due to the narrow strait to the west, or some other feature. All MSC50 wave data was modified to remove null data, presented as "0" in the databases. The null data was not applicable to wind and wind direction but did have an influence on wave data. Only "0" data was removed, no other data were altered.

Table 2.1 Statistical Summary of MSC50 Data

Values	Data Node								
	018069	018070	018071	018072	018073	018142	018211	018212	018213
Long	-57.00	-56.90	-56.80	-56.70	-56.60	-56.60	-56.60	-56.50	-56.40
Lat	51.40	51.40	51.40	51.40	51.40	51.50	51.60	51.60	51.60
Depth	50.22	76.22	77.08	78.23	39.13	51.12	76.75	65.99	56.96
Num Years	65	65	65	65	65	65	65	65	65
Mean MaxWs	20.73	20.80	20.86	20.94	21.02	20.96	20.90	21.02	21.14
StDev MaxWs	1.42	1.36	1.36	1.35	1.38	1.42	1.49	1.51	1.55
Mean MaxHs	4.13	4.24	4.06	3.68	3.33	3.23	2.67	2.91	3.10
StDev MaxHs	0.79	0.82	0.78	0.70	0.55	0.52	0.46	0.48	0.48

Figure 2.1 MSC50 Grid Points Used in Analysis

2.1 WIND SPEED

An extreme value analysis of the annual maximum series data was performed using a Gumbel distribution on all data sets. Results are presented in Table 2.2. The average wind speed for all sites with a 100-year return period is 25.8 m/s, Also presented in the far right column is extrapolated estimates of wind speed from the national Building Code of Canada. The NBCC winds ae between 30 to 50 percent higher than the hindcast wind speeds. Wind direction is not available for the NBCC dataset.

Table 2.2 Extreme Value Analysis -Wind (m/s)

Return Period (Years)	Node									NBCC (2015)
	018069	018070	018071	018072	018073	018142	018211	018212	018213	
2	20.5	20.6	20.6	20.7	20.8	20.7	20.7	20.8	20.9	27.1
10	22.8	22.8	22.8	22.9	23.0	23.0	23.0	23.2	23.4	32.2
50	24.8	24.7	24.7	24.8	24.9	25.0	25.1	25.3	25.5	36.7
100	25.6	25.5	25.5	25.6	25.8	25.8	26.0	26.2	26.5	38.6
1000	28.4	28.1	28.2	28.2	28.4	28.6	28.9	29.1	29.5	44.9

2.2 Wind Direction

The MSC50 data provides wind direction for corresponding wind speeds. The direction of wind in the Strait of Belle Isle is predominantly from the Southwest direction, and to a lesser extent in the Northwest. A wind rose of aggregated data for the Strait of Belle Isle is presented in Figure 2.2.

The wind is further evaluated by month in Figure 2.3. During the summer months, from June to September, the predominant wind is from the southwest and, to a lesser extend the Northeast. During the late Fall and through Winter, the wind direction is more varied, with a significant wind pattern from the Northwest, and even the Northeast. It is noted that after December, the Strait of Belle Isle is often filled with ice to May, and these winds may not generate any wave, or very small waves.

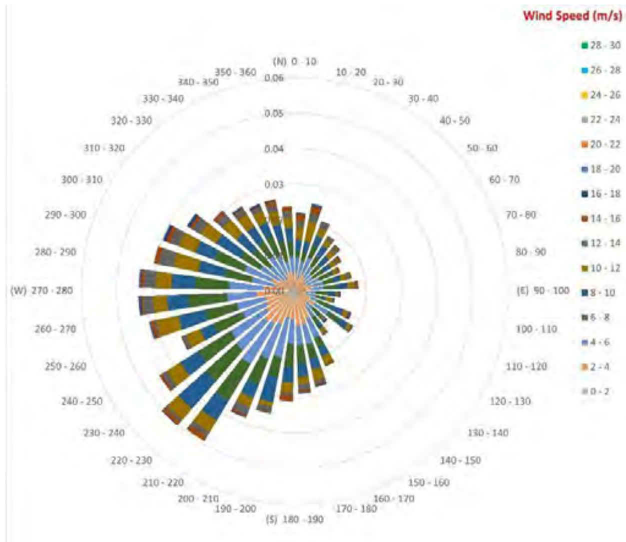

Figure 2.2 Annual Wind Rose – Strait of Belle Isle

2.3 Wave Height

An extreme value analysis of the annual maximum series data was performed using a Gumbel distribution on all data sets. Results are presented in Table 2.3. The significant wave height (Hs), in meters, varies from 7.1 to 4.3 for the 100-year return period with an average over the area of 5.61 m,

Table 2.3 MSC50 Extreme Value Analysis – Significant Wave (m)

Return Period (Years)	Node								
	018069	018070	018071	018072	018073	018142	018211	018212	018213
2	4.00	4.11	3.94	3.57	3.24	3.15	2.60	2.83	3.02
10	4.00	4.11	3.94	3.57	3.24	3.15	2.60	2.83	3.02
50	6.37	6.57	6.27	5.68	4.88	4.72	3.99	4.26	4.46
100	6.83	7.06	6.73	6.09	5.21	5.03	4.26	4.54	4.74
1000	8.38	8.67	8.25	7.46	6.28	6.05	5.17	5.47	5.68

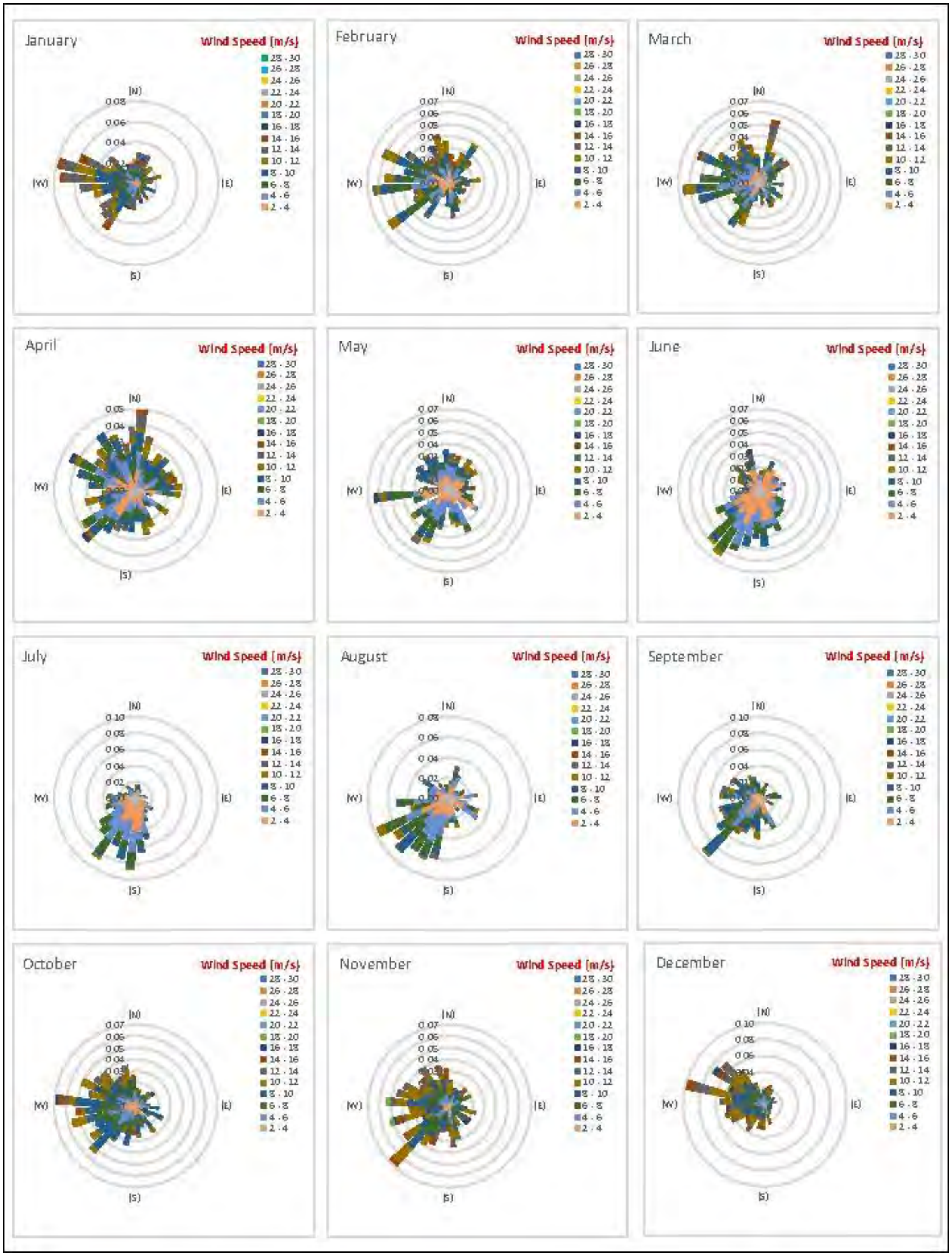

Figure 2.3 Monthly Wind Rose – Strait of Belle Isle

2.4 WAVE DIRECTION

The MSC50 data provides wave direction for corresponding wave height. The direction of a wave in the Strait of Belle Isle is predominantly from the Southwest direction, and to a lesser extent in the Northeast. The reason for the strong directional preference is due to ice cover in winter.

A wave rose of aggregated data for the Strait of Belle Isle is presented in Figure 2.4. For presentation purposes, wave direction is plotted in the opposite direction of the travel vector. For example, a southwest wind will generate a wave travelling in a northeast direction. By plotting the wave in the opposite direction, the reader will see the wave associated with the wind direction, not necessarily the direction the wave is travelling.

The wave rose is further evaluated by month in Figure 2.5. During the late Fall and through Winter, the wave direction is a little more varied, but much less so than for wind direction.

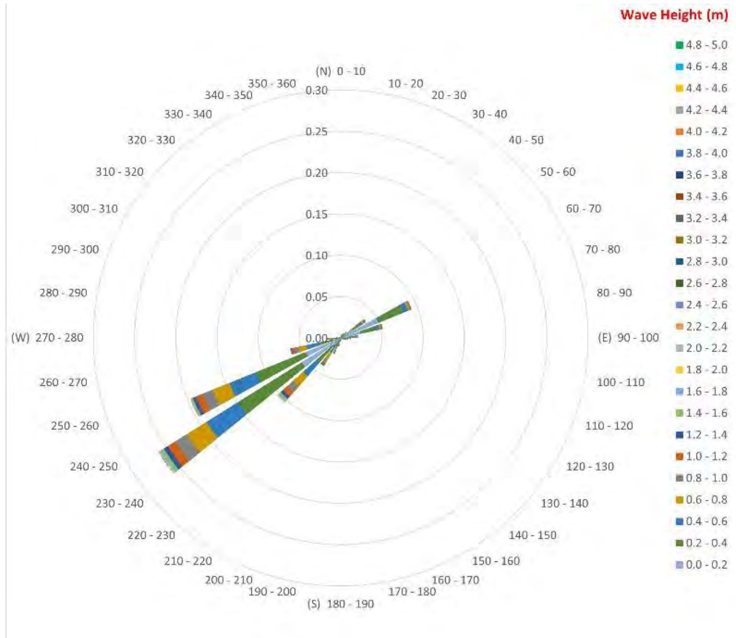

Figure 2.4 Annual Wave Rose – Strait of Belle Isle

Wave height distribution with respect to the directional is further assessed with respect to the annual exceedance probabilities, The colors represent AEP' of 2, 10, 25, 100, 250 and 1,000 years, increasing with the period. The southwest winds generate the larger waves within a fairly tight rabe, from about 220 degrees to 250 degrees, consistent with the wave rose. For a 100 year AEP significant wave, the calculated wave is 4.5 m for a northeast wave and 6.3 m for a southwest wave.

2.5 WAVE PERIOD

The MSC50 data set records the period associated with wave height. The period is a measure of time between peaks and can be used to differentiate between wind generated waves and deep-water waves. The full spectrum of wave period for all waves in the data set are plotted in Figure 2.6. The larger waves appear to be between 10s and 12s, but the data clearly demonstrate even small waves can have a large period. The design wave period is equivalent to the wave energy and is a significant factor in sizing the armourstone. Wave period is also significant in determining is a wave is a breaking wave or a non-breaking wave, with water depth seaward of the structure as the determining factor. The technical documentation acknowledged complexity in wave design, but did not provide any guidance on what is the suitable design wave period, such as an extreme value analysis of wave period, as was done for the significant wave.

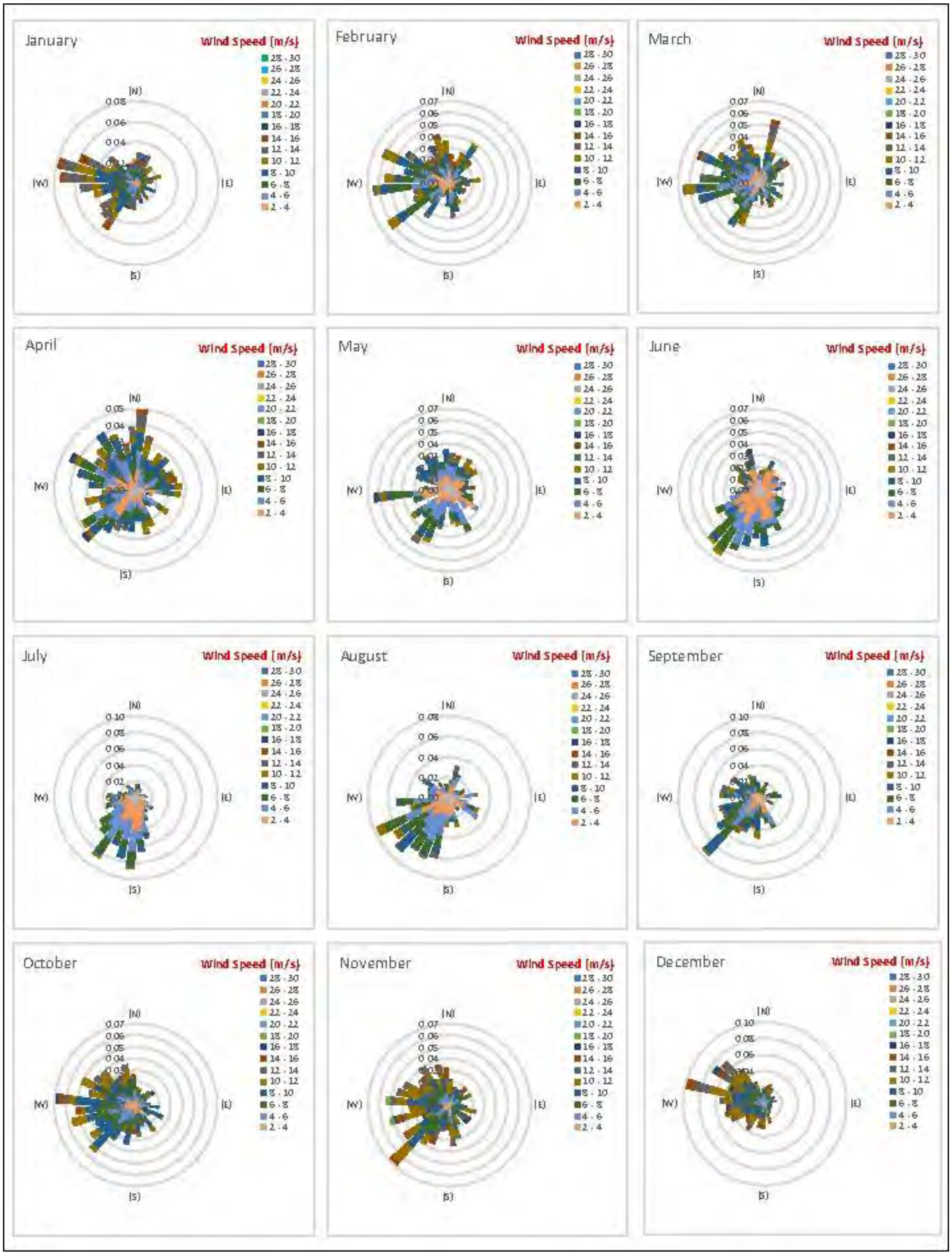

Figure 2.5 Monthly Wave Rose – Strait of Belle Isle

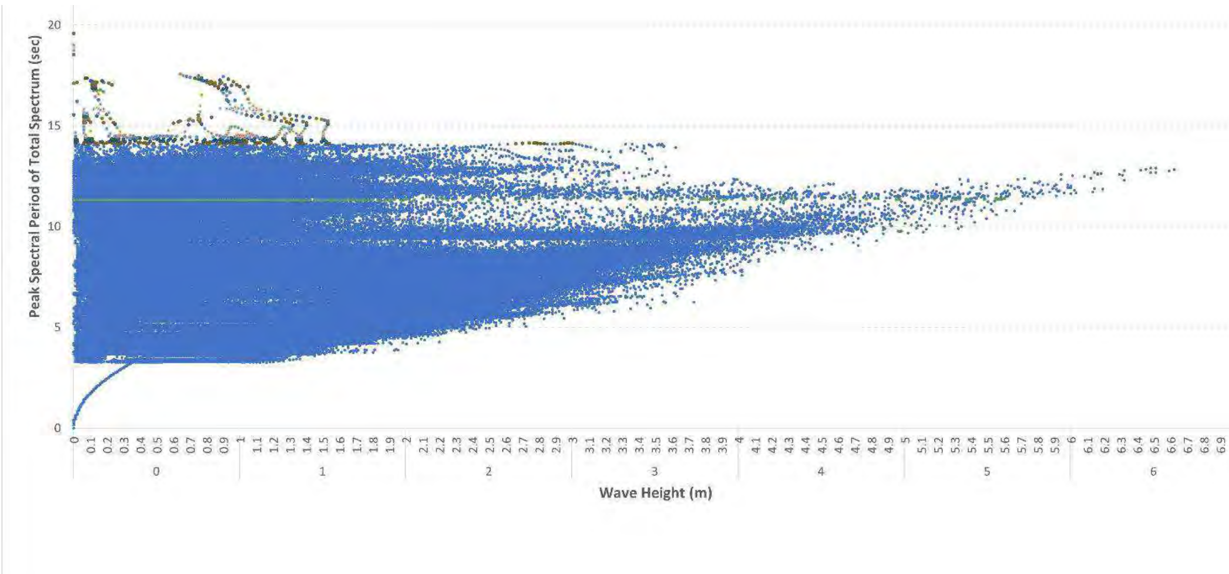

Figure 2.6 Wave Period vs Significant Wave

2.6 STILLWATER LEVEL

Design for shoreline protection may vary depending on the depth of water adjacent to the breakwater. AMEC report tide elevations for Pinware, but do not specify the datum, i.e., chart datum or geodetic. The reported tidal range is 1.45 compares with 1.91 at Blanc Sablon.

Minimum	2.22 m
Maximum	3.67 m
Average	2.93 m

The drawings indicate the following elevations are used for design

Low Water Level	0.00 m CD	-0.75 m Geodetic
High Water Level	1.50 m CD	0.75 m Geodetic

SNC Lavalin report the mean sea level is about 0.8m CD with a Mean Spring High Water Level 1.6m CD. There is a reference to High Spring Water Levels, 1.7m CD in the documentation, as well. The AMEC levels provide the same order of magnitude range as those used in design and the assumption is they are to some non-relevant datum.

There is no guidance provided as to when to use the different water levels in determining the top of the breakwater. Further, there is no documentation of storm surge in determining the design water level at the breakwater. Given the constriction presented by the strait between the Atlantic Ocean and the Gulf, storm surge is expected to be significant. Other areas of the of the Gulf of St. Lawrence predict storm surge residuals of a metre or more based on tide gauge data. We are not aware of tide gauge data near L'Anse au Diable that could be used for this type of analysis.

3 L'ANSE AU DIABLE BREAKWATER DESIGN

Rubble mound Breakwaters such at the structure are L'Anse au Diable are designed with a geometry and armourstone size to resist erosion from waves and ice action and overtopping from wave runup and maximum water levels. A review of design documentation indicated the breakwater at L'Anse au Diable is designed for a significant wave with a 100 year return period, and a mean high water tide. The is a one (1) meter allowance for sea level rise due to climate change over the life of the structure.

3.1 DESIGN WATER LEVELS

The drawings indicate the following elevations are used for design

Low Water Level	0.00 m CD	-0.75 m Geodetic
High Water Level	1.50 m CD	0.75 m Geodetic

There is no discussion on water level was used for design, but the assumption is the mean high water tide was used to establish the crest elevation of the breakwater. The reference elevation datum is chart datum, which is standard for marine design. The chart datum reference applies to standard temperature and pressure and actual water levels at a site can vary based on air pressure and other factors. For wind generated waves, the SPM recommends there can be an associated storm surge as a result of the low pressure which is in addition to the tide. There is no discussion on storm surge in the design documents.

3.2 DESIGN WAVE CONDITIONS

The document references the Shore Protection Manual (SPM 1984) as the guidance document. The general guidance in the SPM is to generate waves for an offshore environment and then analytically propagate those waves to the shoreline. An offshore and nearshore wave should be defined by the height (m) and period (s). The design documents did not specify an offshore or nearshore design period.

The reported design offshore wind is based on observations at MSC50 station M6018142. When transposing the offshore wave to the nearshore, the design documentation referred to a Delft3D/SWAN model using three MSC50 stations; M6018212 for north to east wave, M1680142 for east-west waves and M1680170 for west to north waves. All analysis, both for the offshore waves and near shore wind generated waves appear to be based on significant wave height, as summarized in Table 3.1. The recommended an inshore significant wave approximately 2/3^{rds} the offshore wave. As noted, the design document was ambiguous on the design wave period, and recommended breakwater design be checked for a range of periods. There was no documentation to verify if this was considered.

Table 3.1 Inshore Significant Wave (Hs) Extreme Values

Return Period (years)	SNC Lavalin (Offshore)	SNC Lavalin (Inshore)
2	4.1	2.5
10	5.0	3.3
100	6.2	4.1

3.3 WAVE TRANSPOSITION

As deep water waves approach the shoreline, they will transform, getting smaller when water depth is less than one-half the offshore wavelength to about 5% of the offshore wavelength, then increasing in height for more shallow waters. Wavelength is a function of the wave period being considered. The wave shoaling coefficient can be approximated according to Figure 3.1. For example, using approximate lower bound coupling of height and period is recommended in **Error! Reference source not found.**, a 4-meter significant wave with design period 8s, will reduce in size from approximately 50 meter deep water to about 5 meter deep water depth, at which point the wave height increases.

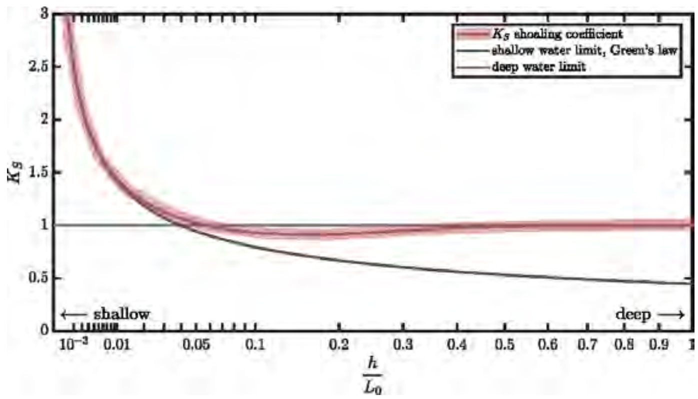

Figure 3.1 Shoaling Coefficient, Ks

Deep water waves will also transform if the approach the shoreline at an angle, likewise getting smaller through a process known as refraction. The amount of wave refraction is further a function of the seaward seabed slope. For the L'Anse au Diable site, the offshore wave refracts approximately 34 degrees from the dominant wave direction, with a seabed slope of 4 to 5 %.

As a preliminary estimate, the shoaling coefficient, Ks, was estimated as 0.92 at the breakwater toe based on tables in the SPM. The corresponding refraction coefficient, Kr, was estimated as 0.96 for a combined reduction factor of 0.88. Shoaling and refraction may vary depending on many factors and it is noted that the Delft3D model had a design offshore wave transposition factor was 0.67.

3.4 BREAKING WAVES

Waves will also transform by breaking or not breaking as they approach the shoreline. Whether a wave breaks or not is a function of the offshore wave height and period. Based on the scatter of MSC50 observations of significant wave height and period, there are a mixture of possible wave height and period combinations that could impact the breakwater.

For the nearshore slope at L'Anse au Diable, the long wave deep-water waves are likely to break before encountering the breakwater. At mean sea level, water depth in front of the breakwater is 7 meters deep, and a significant wave greater than 3.5m with a short period is likely to break offshore from the breakwater and is unlikely to govern design of the structure. However, if the wave is associated with a storm surge, waves with a height of five (5) meters or more make each the breakwater before breaking. The possibility of different wave combinations was not discussed in the documentation.

3.5 WIND GENERATED WAVES

If the long period offshore waves do not govern design, then local wind generated waves are likely to have a greater influence of breakwater performance. Local wind generated waves, referred to as hurricane winds in the SPM, are developed as a function of fetch, wind speed and duration. The Strait of belle Isles has a fetch of 17 kilometers (Distance across the strait). Sources of wind data include Environment Canada and the National Building Code.

The MSC50 hindcast presents wind data for each node. The MSC50 hindcast data is much lower than a typical wind growth for different on-land wind events (for example, those used for building design on land). A comparison of significant wave (Hs) predicted from MSC50 wind data and alternate sources of wind speed data are presented in Table 3.2. For example, a 2-year wind speed of 75 km/h will grow to only 92 km/h for a 100-year event using the MSC50 datasets. Using other data sources, alternate estimates of 100 km/h and 140 km/h are derived for the same events. The significant wave for the higher wind speeds are provided in the last column of Table 3.2.

Table 3.2 Wave Development Based on MSC50 Hindcast

Return Period (years)	Wind Speed (m/s)	Deepwater Significant Wave (Hs)	Shallow Water Significant Wave (Hs)	Wave Period (s)	Alternate Significant Wave (Hs)
2	20.7	1.9	1.5	4.3	2.0
10	23.0	2.2	1.7	4.5	2.3
100	25.8	2.6	1.9	4.7	2.7

3.6 WAVE RUN-UP

Waves wash up the slope of breakwaters and run-up is defined as the vertical projection of the wave momentum representing the parameter to design the height of wave above the maximum water level. The SPM guidance recommends runup of 85 to 90 percent of the offshore wave for rubble mound slopes. The impact of offshore waves on the shoreline may be depth controlled and large offshore waves may break before impacting the breakwater. When considering the shoreline and the breakwater structure, the following relationship between runup and wave at the breakwater is developed.

Table 3.3 Wave and Runup

Wave Impact Height (m)	Runup (m)
2	3.5
3	4.2
4	4.9
5	5.5
6	6.0

If the 4.1m significant wave with a 100-year return period is the design wave, the corresponding wave runup is 4.9m.

APPENDIX A – PROJECT SKETCHES

LOCATION

NOTES

- BASELINE BATHYMETRY FROM DRAWING
  SJ DOC: 505573-8610-4100-2002-SH1_02
  NE DOC: ILK-SN-CD-8610-CV-PL-0009-01

REVISION	DESCRIPTION	DATE
A	FOR INFORMATION	2021-09-20

FOR INFORMATION

Meco — Innovation I Reliability I Performance

STAMPS

CLIENT

nalcor energy

PROJECT

L'ANSE AU DIABLE BREAKWATER

TITLE

L'ANSE AU DIABLE – BREAKWATER PLAN

DESIGNED BY	P.M.	APPROVED BY	P.M.
DRAFTED BY	N.J.M.	MANAGER	P.M.
DATE	2021-09-03	SCALE	AS SHOWN
PROJECT #	10641	DRAWING No.	FIGURE-1

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1-09-20 10:04:54 AM
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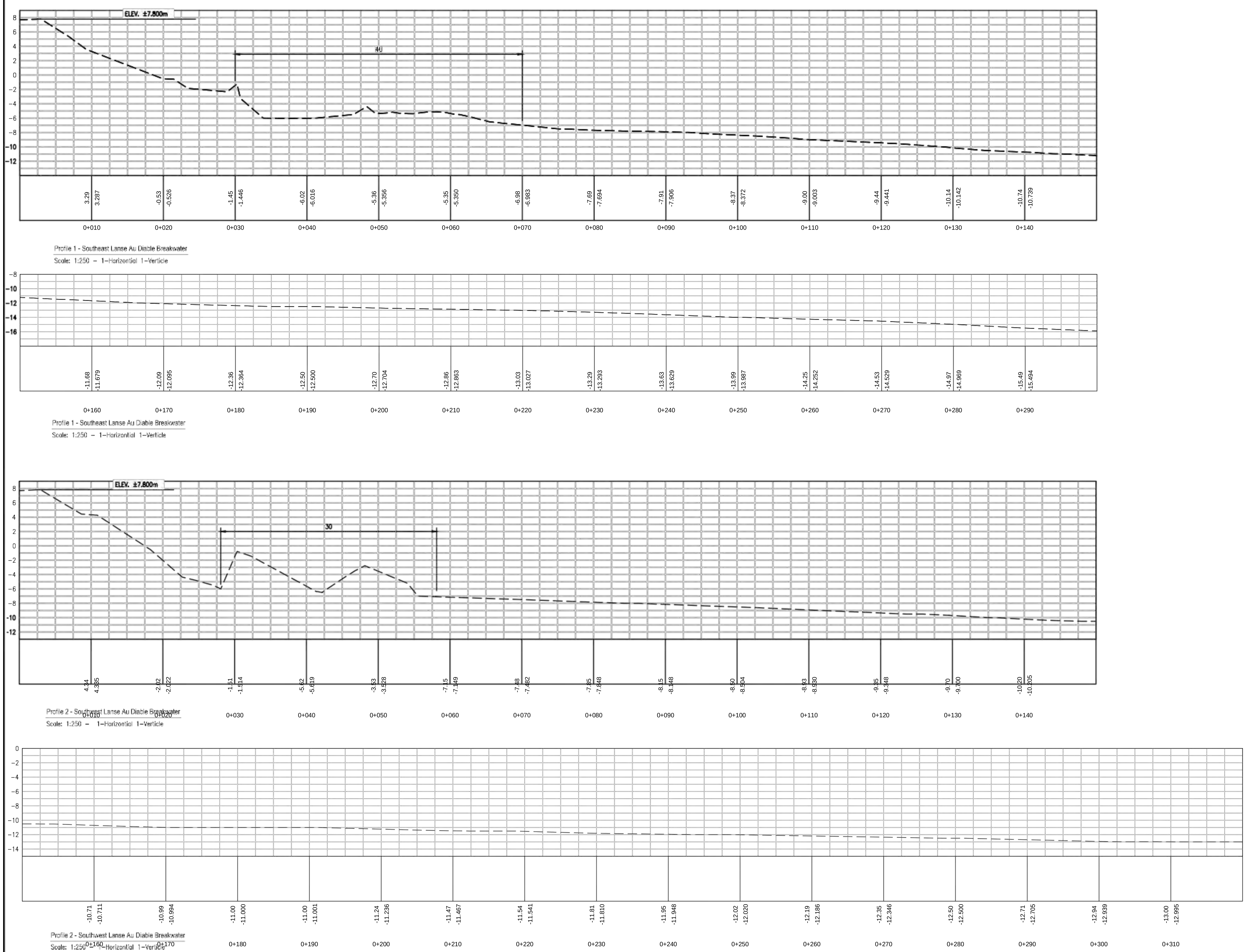

LOCATION

NOTES

REVISION	DESCRIPTION	DATE
A	FOR INFORMATION	2021-09-20

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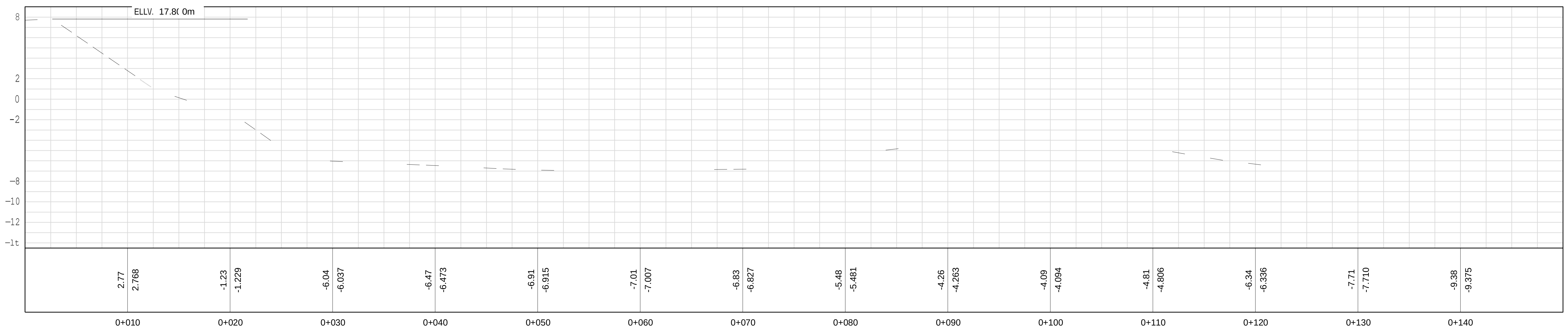
PROJECT

LANSE AU DIABLE BREAKWATER

TITLE

L'ANSE AU DIABLE BREAKWATER – PROFILE (1 OF 2)

DESIGNED BY: P.M.	APPROVED BY: P.M.
DRAFTED BY: N.J.M.	MANAGER: P.M.
DATE: 2021-09-03	SCALE: AS SHOWN
PROJECT #: 10641	DRAWING NO.: FIGURE-2



Profile 3 - South Lanse Au Diable Breakwater

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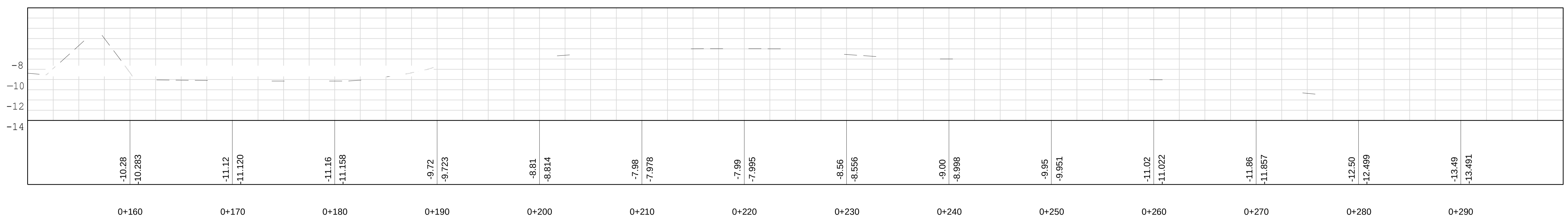

Profile 3 - South Lanse Au Diable Brealater

Scae: 1:250 1—Horizonia 1—Vectice

LOCATION:

NOTES:

REVISION	DESCRIPTION	DATE
A	FOR INFORMATION	2021–09–20

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PROJECT:

TITLE: LANSE AU DIABLE BREAKWATER

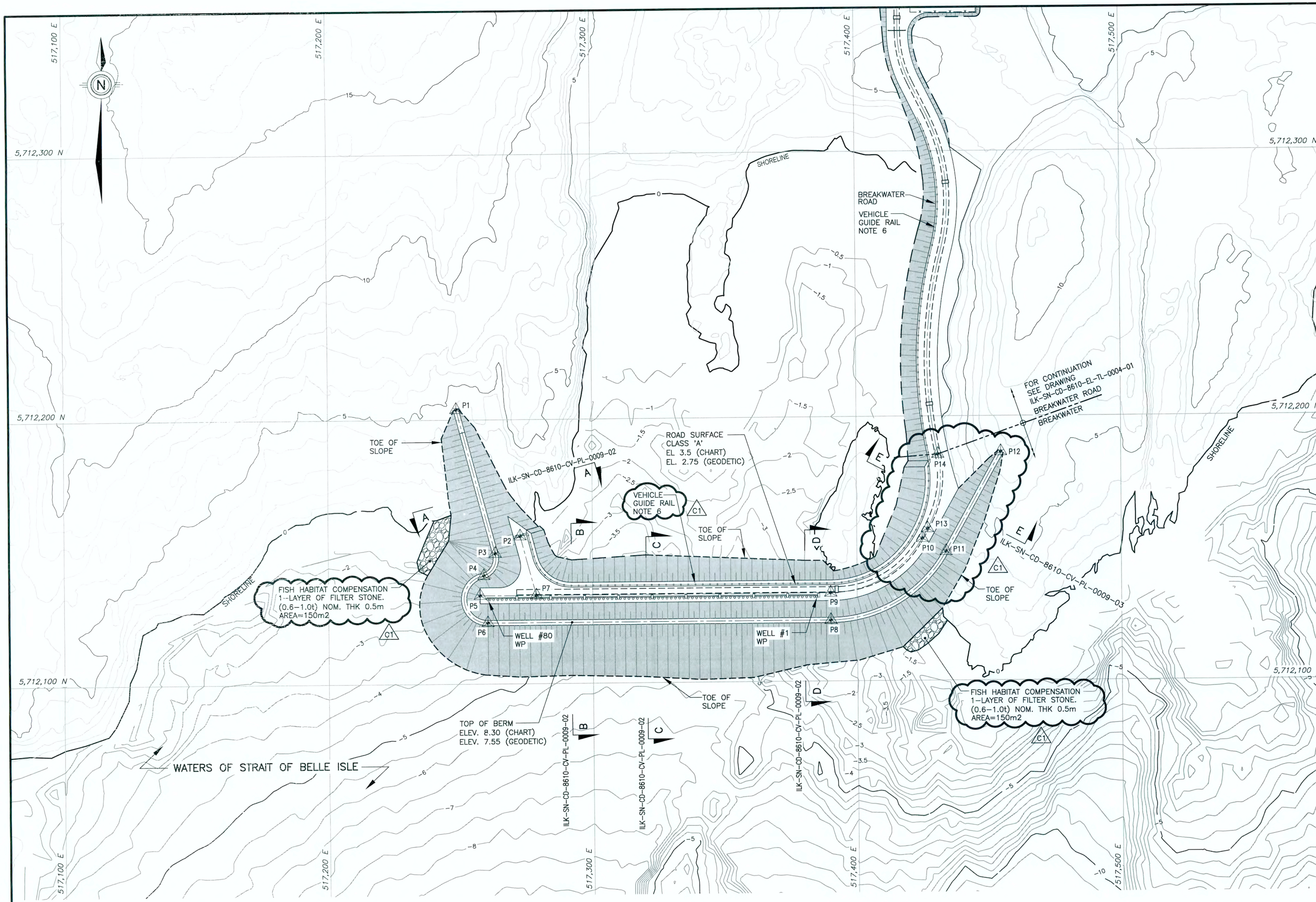
BREAKWATER – PROFILE (2 OF 2)
L'ANSE AU DIABLE

DESIGNED BY:	APPROVED BY:
DRAFTED BY: P.M.	MANAGER: P.M.
DATE: N.J.M.	SCALE: P.M.
PROJECT #: 10641 2021–09–03	DRAWING No. FIGURE-3

202- 09 20 0:\PROJEC T8\ Diable Break a ter\5 CAD0 Z Breakwater Plans\Sect. 09

Appendix B: Design Overview & Sections

List of Documents:
ILK-SN-CD-8610-CV-PL-0009-01
ILK-SN-CD-8610-CV-PL-0009-02
ILK-SN-CD-8610-CV-PL-0009-03



BREAKWATER PLAN

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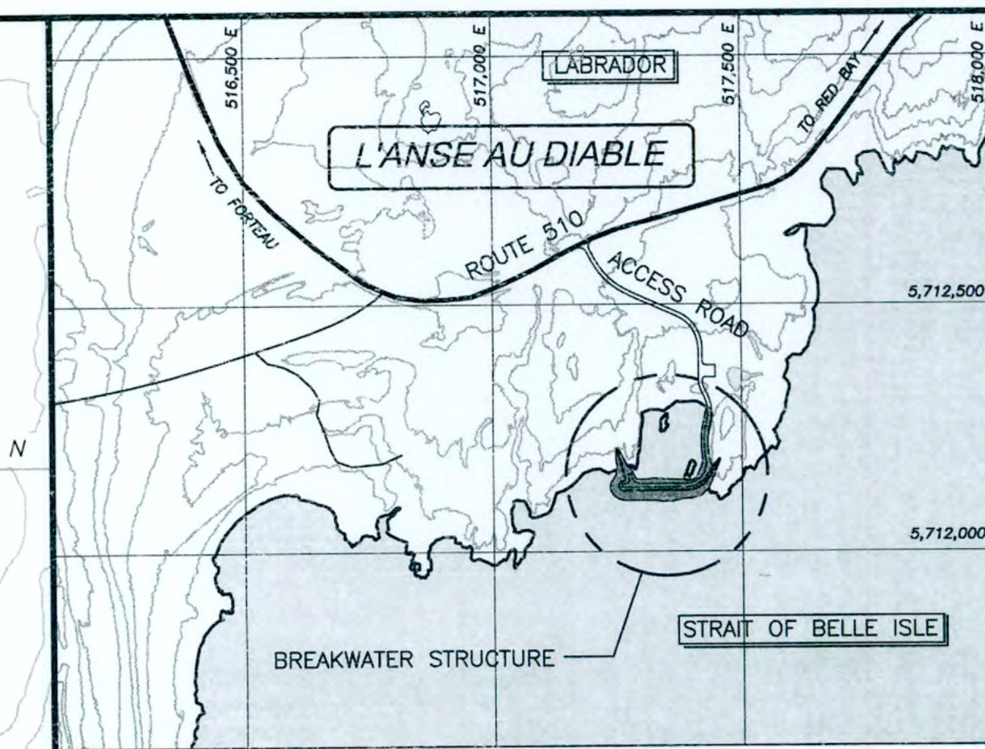

LOCATION PLAN

LEGEND:

- SHORELINE
- BATHYMETRIC CONTOUR (CHART)
- TOPOGRAPHIC CONTOUR (GEODETIC)
- EMBANKMENT SLOPE

NOTES:

1. PROJECTION NAD 83 (CSRS) UTM ZONE 21
2. ALL BREAKWATER ELEVATIONS ARE IN CHART DATUM.
3. 0.0m GEODETIC = 0.75m CHART ELEVATION.
4. SOUNDING ELEVATIONS BASED ON LIDAR MAPPING SUPPLIED BY NALCOR.
5. FOR AREAS OF UNDERWATER BLASTING REFER TO DWG. ILK-SN-CD-8610-CV-PL-0009-03
6. VEHICLE GUIDE RAIL SPECIFICATION AS PER THE DEPT OF TRANSPORTATION AND PUBLIC WORKS SPECIFICATION BOOK (LATEST EDITION), DIVISION 9, SECTION 923. PROVIDE FLARED ENDS. NO BURIED ENDS

C1

LOCATION POINTS

POINT	NORTHING	EASTING
P1	5712203.9	517248.6
P2	5712155.9	517272.6
P3	5712149.4	517263.2
P4	5712141.1	517258.9
P5	5712133.5	517257.4
P6	5712123.2	517260.3
P7	5712133.5	517278.7
P8	5712123.2	517390.0
P9	5712133.5	517390.0
P10	5712153.9	517424.7
P11	5712148.9	517433.7
P12	5712186.6	517454.6
P13	5712157.6	517426.8
P14	5712185.8	517430.8
WELL #1 WP	5172132.0	517384.7
WELL #80 WP	5712132.0	517260.3

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1	B1	03-MARCH-2014	ISSUED FOR BID

ISSUE REGISTER

No.	REFERENCE DRAWING
ILK-SN-CD-8610-CV-PL-0008-01	L'ANSE AU DIABLE ELECTRODE STATION - YARD PLAN - SITE GRADING AND LEVELLING
ILK-SN-CD-8610-CV-PL-0009-04	L'ANSE AU DIABLE ELECTRODE STATION - PARTIAL BREAKWATER PLANS AND DETAILS
ILK-SN-CD-8610-CV-PL-0009-03	L'ANSE AU DIABLE ELECTRODE STATION - BREAKWATER SECTIONS E AND BLASTING LIMITS
ILK-SN-CD-8610-CV-PL-0009-02	L'ANSE AU DIABLE ELECTRODE STATION - BREAKWATER SECTIONS A, B, C AND D
ILK-SN-CD-8610-EL-LT-0004-01	L'ANSE AU DIABLE ELECTRODE STATION - GENERAL ARRANGEMENT PLAN

No.	DATE	REVISION	MOD.	VER.	APP.
C1	25-FEB-2015	BREAKWATER REVISED AT ROAD APPROACH, FISH HABITAT COMPENSATION ADDED			
B2	11-JUN-2014	DESIGN OPTIMIZATION - GENERAL REVISION			

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NE-LCP MANAGEMENT: N/A Date (dd-mmm-yyyy):
PROJECT MANAGER: Date (dd-mmm-yyyy):

PROFESSIONAL STAMP
REGISTERED PROFESSIONAL ENGINEER
PEGL
CHRISTOPHER M. FUDGE
SIGNATURE
2015-02-27
DATE
NEWFOUNDLAND & LABRADOR

SNC·LAVALIN

DESIGNED: N. GILLIS
DRAWN: B. MURRAY / ... LAING
VERIFIED: C. FUDGE
DATE: 03-OCT-2013
APPROVED (Discipline Lead Engineer)
APPROVED (Engineering Manager)
SCALE: 1:750

CLIENT: nalcor energy
PROJECT: LOWER CHURCHILL PROJECT
TITLE: L'ANSE AU DIABLE ELECTRODE STATION BREAKWATER PLAN

SLI DOC No.: 505573-8610-41DD-2002-SH1_02
NE DOC No.: ILK-SN-CD-8610-CV-PL-0009-01
Rev.: C1

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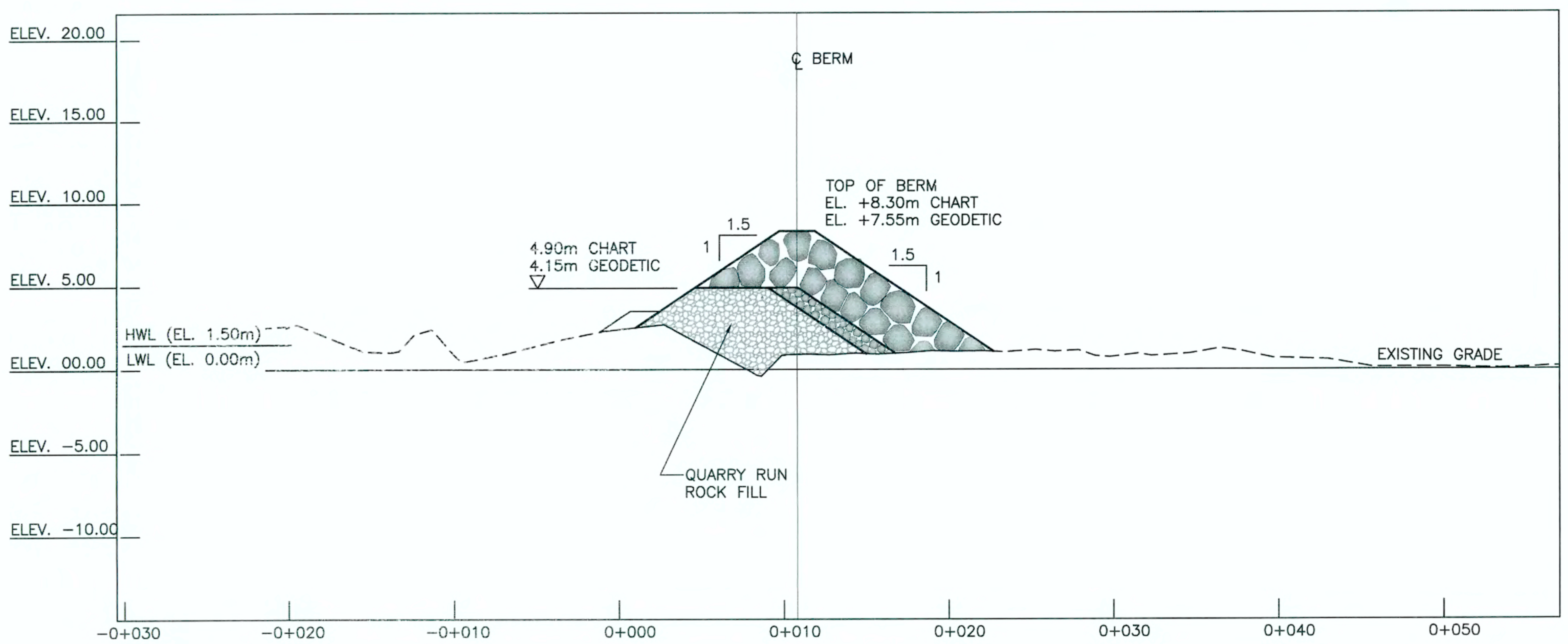

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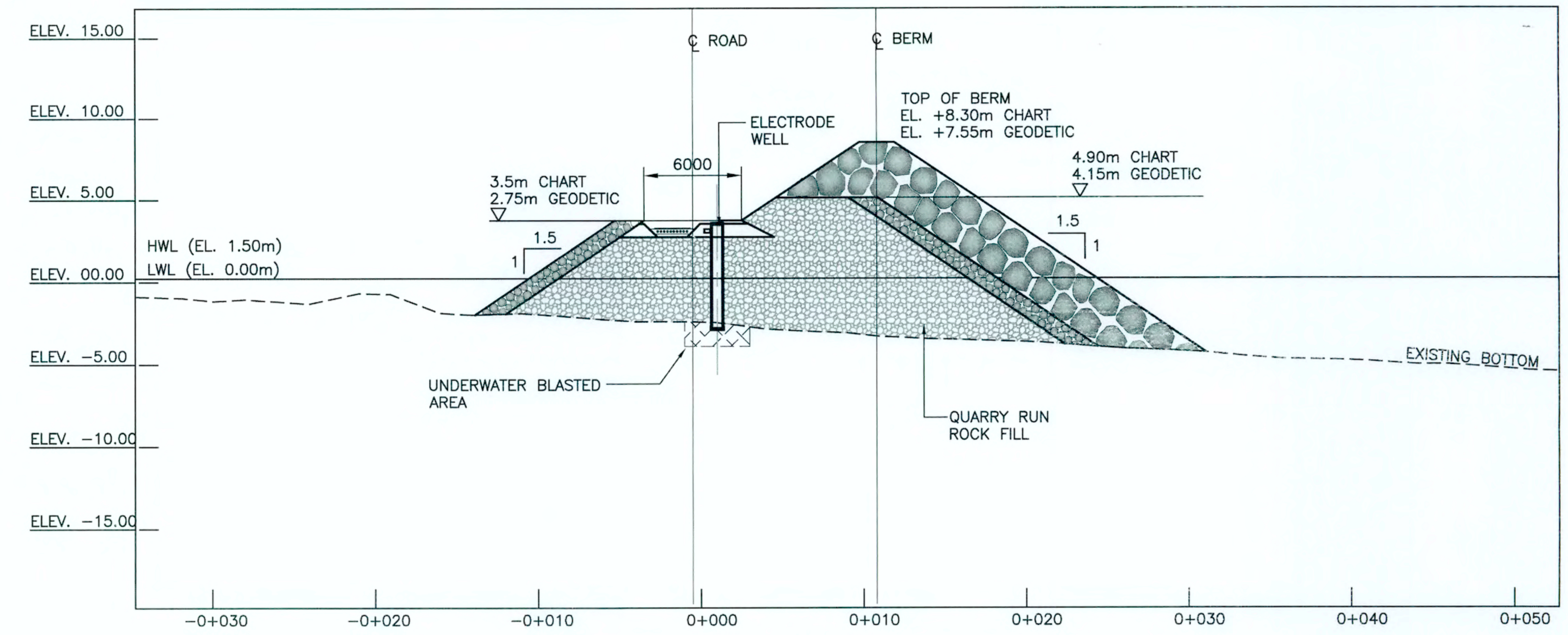

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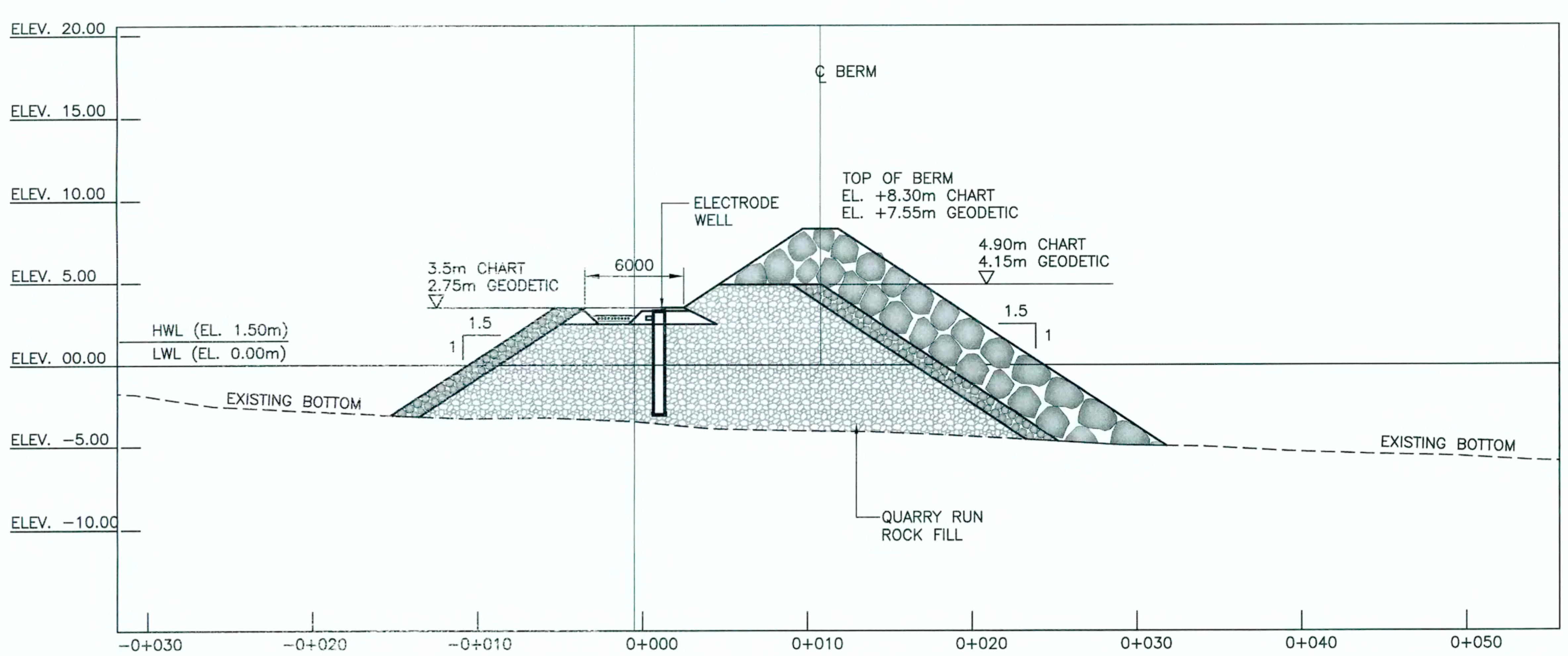

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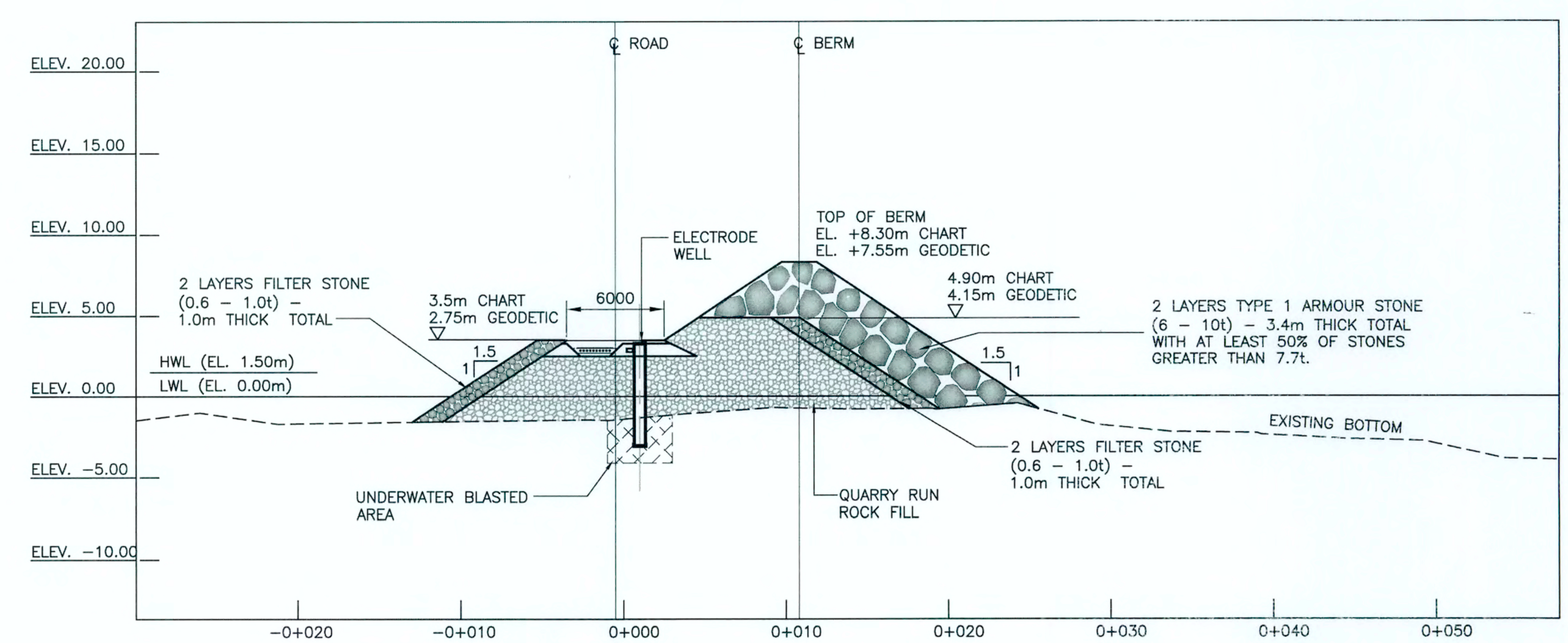

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NOTES:

1. PROJECTION NAD 83 (CSRS) UTM ZONE 21
2. ALL BREAKWATER ELEVATIONS ARE IN CHART DATUM.
3. 0.0m GEODETIC = 0.75m CHART ELEVATION.

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ILK-SN-CD-8600-CV-DD-0018-01	ELECTRODE STATION – ELECTRODE WELLS – PLAN AND SECTION
ILK-SN-CD-8600-CV-DD-0019-01	ELECTRODE STATION – ELECTRODE WELLS – DETAILS
ILK-SN-CD-8600-CV-SE-0001-01	ELECTRODE SITES BURIED CABLE DUCT BANKS & PULL BOXES – DETAILS AND SECTIONS
ILK-SN-CD-8610-CV-PL-0009-01	L'ANSE AU DIABLE ELECTRODE STATION – BREAKWATER PLAN

No.	DATE	REVISION	MOD.	VER.	APP.
B2	11-JUNE-2014	DESIGN OPTIMIZATION – GENERAL REVISION			

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NE-LCP MANAGEMENT: N/A — Date (dd-mmm-yyyy): —
PROJECT MANAGER: — Date (dd-mmm-yyyy): 27 Feb 2015

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REGISTERED PROFESSIONAL ENGINEER — PEGNL — CHRISTOPHER M. FUDGE — SIGNATURE — 2015-02-27 DATE — NEWFOUNDLAND & LABRADOR

SNC·LAVALIN
DESIGNED: N. GILLIS
DRAWN: B. MURRAY / C. LAING
VERIFIED: C. FUDGE
DATE: 03-OCT-2013
APPROVED (Discipline Lead Engineer)
APPROVED (Engineering Manager)
SCALE: AS NOTED

CLIENT: nalcor energy — LOWER CHURCHILL PROJECT
PROJECT: LOWER CHURCHILL PROJECT
TITLE: L'ANSE AU DIABLE
ELECTRODE STATION
BREAKWATER
SECTION A, B, C & D

SLI DOC No.: 505573-8610-41DD-2002-SH2_02
NE DOC No.: ILK-SN-CD-8610-CV-PL-0009-02
Rev.: C1

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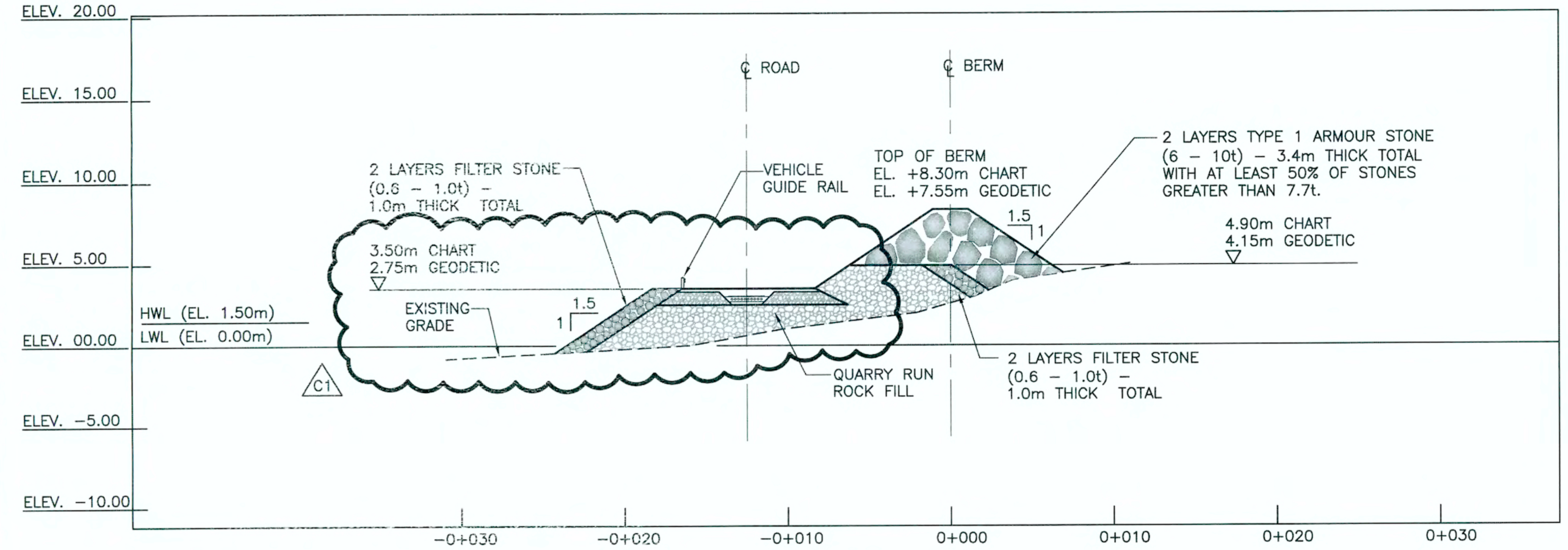

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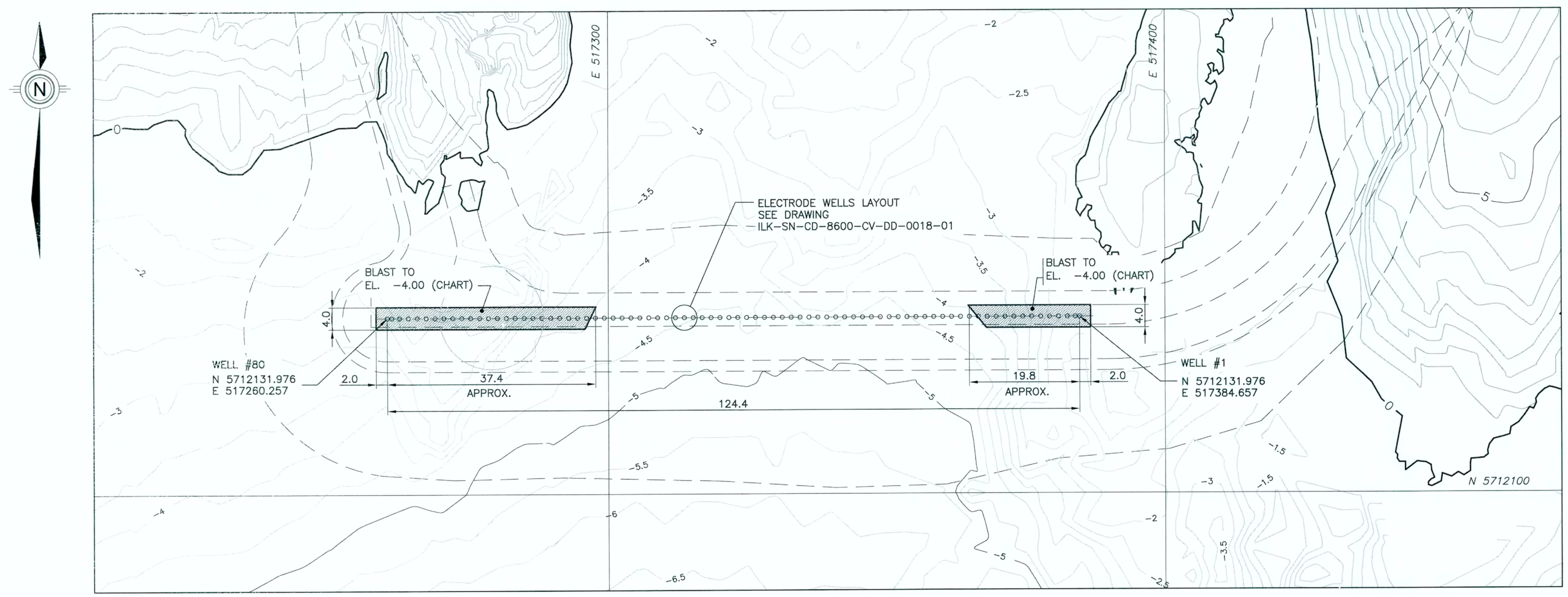

PLAN - SUBSEA BLASTING LIMITS

SCALE: 1:500
ILK-SN-CD-8610-CV-PL-0009-01

NOTES:

1. PROJECTION NAD 83 (CSRS) UTM ZONE 21
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ILK-SN-CD-8600-CV-DD-0018-01	ELECTRODE STATION - ELECTRODE WELLS - PLAN AND SECTION
ILK-SN-CD-8600-CV-DD-0019-01	ELECTRODE STATION - ELECTRODE WELLS - DETAILS
ILK-SN-CD-8600-CV-SE-0001-01	ELECTRODE SITES BURIED CABLE DUCT BANKS & PULL BOXES - DETAILS AND SECTIONS
ILK-SN-CD-8610-CV-PL-0009-01	L'ANSE AU DIABLE ELECTRODE STATION - BREAKWATER PLAN

No.	DATE	REVISION	MOD.	VER.	APP.
C1	25-FEB-2015	SECTION F-F DELETED, SECTION E-E REVISED			
B2	11-JUNE-2014	DESIGN OPTIMIZATION - GENERAL REVISION			

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LEAD REVIEWER: Date (dd-mmm-yyyy): 27-FEB-2015
NE-LCP MANAGEMENT: N/A Date (dd-mmm-yyyy): —
PROJECT MANAGER: Date (dd-mmm-yyyy): 27Feb2015

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PROFESSIONAL ENGINEER
PEGNL
CHRISTOPHER M. FUDGE
SIGNATURE
2015-02-27
DATE
NEWFOUNDLAND & LABRADOR

SNC·LAVALIN
CLIENT: nalcor energy LOWER CHURCHILL PROJECT
DESIGNED: N. GILLIS
APPROVED (Discipline Lead Engineer)
DRAWN: B. MURRAY / C. McCARTHY
APPROVED (Engineering Manager)
VERIFIED: C. FUDGE
DATE: 03-OCT-2013
SCALE: AS NOTED
PROJECT: LOWER CHURCHILL PROJECT
TITLE: L'ANSE AU DIABLE ELECTRODE STATION BREAKWATER SECTION E AND BLASTING LIMITS
SLI DOC No.: 505573-8610-41DD-2002-SH3_02
NE DOC No.: ILK-SN-CD-8610-CV-PL-0009-03
Rev.: C1

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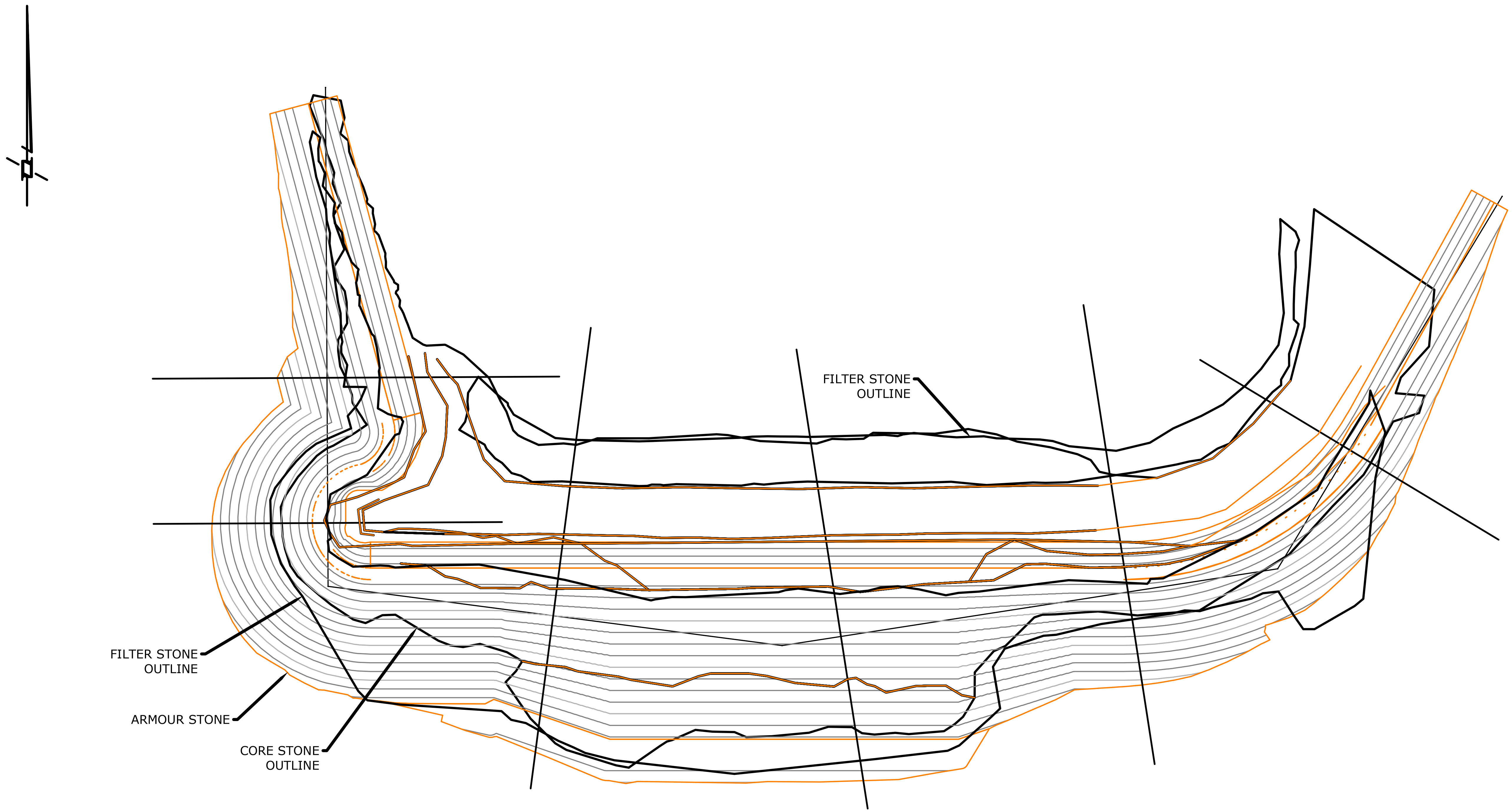
Appendix C: As-Built Drawings



SITE/SURVEY NOTES:
1. ALL DIMENSIONS ARE SHOWN IN METERS AND DECIMAL PLACES THEREOF, UNLESS SPECIFIED OTHERWISE ON PLAN.
2. SURVEY BASED ON CONTROL PROVIDED BY NALCOR. BENCHMARKS 13LD001, 13LD002, 13LD003 & 13LD004. COORDINATES ARE REFERENCED TO NAD83 UTM ZONE 21. ALL ELEVATIONS ARE GEODETIC UNLESS NOTED OTHERWISE.
3. BREAKWATER HAL USED FOR REFERENCE AND CROSS SECTIONS.

***** **DATUM REFERENCE:** *ALL ELEVATIONS ARE IN METRES REFERENCED TO GEODETIC.* **COORDINATE REFERENCE:** *UTM 6° (UNIVERSAL TRANSVERSE MERCATOR) PROJECTION, NAD83, ZONE 21 CENTRAL MERIDIAN 57° 00' W LONGITUDE.* *****

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ISSUE	REV.	DATE	DISTRIBUTION & STATUS
L2	01	08-JAN-2016	CLIENT REVIEW
L1	00	30-NOV-2015	CLIENT REVIEW

No.	REFERENCE DRAWING

REVISION REGISTER

No.	DATE	REVISION	MOD.	VER.	APP.
01	08-JAN-2016	REMOVE SECTIONS			
00	30-NOV-2015	FINAL AS-BUILT			

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PROJECT MANAGER: Date (dd-mmm-yyyy):

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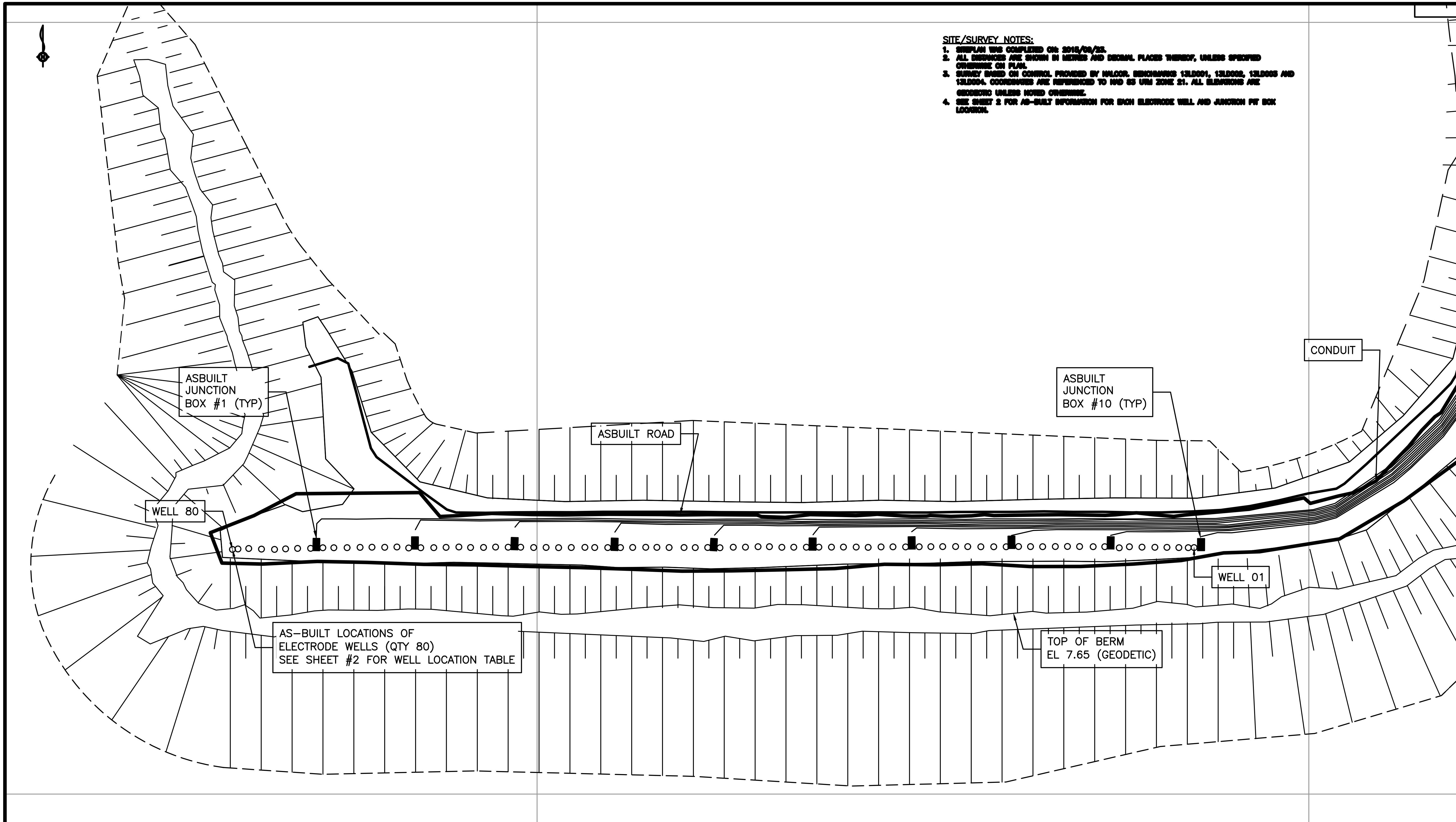
90 O'LEARY AVENUE, 1ST FLOOR
ST. JOHN'S, NEWFOUNDLAND & LABRADOR
A1B 2C7
PHONE: (709) 726-9095 FAX: (709) 726-9106

DESIGNED
DRAWN SJ
VERIFIED GH
DATE 30-NOV-2015
APPROVED (Discipline Lead Engineer)
APPROVED (Engineering Manager)
SCALE NTS

CLIENT nalcor energy LOWER CHURCHILL PROJECT
PROJECT LOWER CHURCHILL PROJECT
TITLE AS-BUILT L'ANSE AU DIABLE BREAKWATER SHT 1 OF 7

SUPPLIER DOC No. ES-CD0508001-01-AB-0003-001_01
NE DOC No. ILK-HJ-SD-8610-CV-B02-0004-01
Rev. L2

2021.11.10/10:54am



SITE/SURVEY NOTES:
1. SITEPLAN WAS COMPLETED ON: 2015/09/23.
2. ALL DISTANCES ARE SHOWN IN METRES AND DECIMAL PLACES THEREOF, UNLESS SPECIFIED OTHERWISE ON PLAN.
3. SURVEY BASED ON CONTROL PROVIDED BY NALCOR. BENCHMARKS 13LD001, 13LD002, 13LD003 AND 13LD004. COORDINATES ARE REFERENCED TO NAD 83 UTM ZONE 21. ALL ELEVATIONS ARE GEODECTIC UNLESS NOTED OTHERWISE.
4. SEE SHEET 2 FOR AS-BUILT INFORMATION FOR EACH ELECTRODE WELL AND JUNCTION PIT BOX LOCATION.

***** DATUM REFERENCE: ALL ELEVATIONS ARE IN METRES REFERENCED TO GEODETIC. COORDINATE REFERENCE: UTM 6° (UNIVERSAL TRANSVERSE MERCATOR) PROJECTION, NAD83, ZONE 21 CENTRAL MERIDIAN 57° 00' W LONGITUDE. *****

ISSUE	REV.	DATE	DISTRIBUTION & STATUS
L2	01	06-JAN-2016	CLIENT REVIEW
L1	00	09-DEC-2015	CLIENT REVIEW

ISSUE REGISTER

No.	REFERENCE DRAWING

No.	DATE	REVISION	MOD.	VER.	APP.
01	06-JAN-2016	ADJUSTED LABELING			
00	09-DEC-2015	FINAL AS-BUILT			

REVISION REGISTER

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LEAD REVIEWER: Date (dd-mmm-yyyy):
NE-LCP MANAGEMENT: Date (dd-mmm-yyyy):
PROJECT MANAGER: Date (dd-mmm-yyyy):

PROFESSIONAL STAMP

H.J. O'CONNELL CONSTRUCTION LTD.

DESIGNED —	APPROVED (Discipline Lead Engineer)
DRAWN KJM	APPROVED (Engineering Manager)
VERIFIED GH	
DATE 06-JAN-2016	SCALE NTS

CLIENT: nalcor energy

PROJECT: LOWER CHURCHILL PROJECT

TITLE: AS-BUILT – L'ANSE AU DIABLE ELECTRODE WELLS & JUNCTION BOX LOCATIONS SHT 1 OF 2

SUPPLIER DOC No. ES-CD0508001-01-AB-0004-001_01
NE DOC No. ILK-HJ-SD-8610-CV-B02-0005-01
Rev. L2

2021.11.10/11:00am

NAME	RAW DESCRIPTION	EASTING	NORTHING	ELEVATION
1	COVER	517385.14	5712131.943	2.382
2	COVER	517384.39	5712131.929	2.364
3	COVER	517383.163	5712131.939	2.398
4	COVER	517381.624	5712131.967	2.366
5	COVER	517380.056	5712131.975	2.359
6	COVER	517378.386	5712131.995	2.346
7	COVER	517376.758	5712132.05	2.331
8	COVER	517375.443	5712131.911	2.391
9	COVER	517373.564	5712132.057	2.36
10	COVER	517372.057	5712132.058	2.39
11	COVER	517370.305	5712132.072	2.361
12	COVER	517368.727	5712132.083	2.364
13	COVER	517367.159	5712132.072	2.37
14	COVER	517365.514	5712132.051	2.366
15	COVER	517363.947	5712132.062	2.329
16	COVER	517362.389	5712132.072	2.348
17	COVER	517360.794	5712132.041	2.363
18	COVER	517359.178	5712132.041	2.363
19	COVER	517357.504	5712132.041	2.352
20	COVER	517355.809	5712132.062	2.35

NAME	RAW DESCRIPTION	EASTING	NORTHING	ELEVATION
21	COVER	517354.239	5712132.072	2.347
22	COVER	517352.571	5712132.061	2.38
23	COVER	517351.038	5712132.051	2.392
24	COVER	517349.517	5712132.041	2.346
25	COVER	517347.765	5712132.03	2.384
26	COVER	517346.12	5712132.04	2.386
27	COVER	517344.576	5712132.03	2.396
28	COVER	517342.904	5712131.967	2.372
29	COVER	517341.353	5712132.009	2.425
30	COVER	517339.709	5712132.009	2.428
31	COVER	517338.15	5712131.999	2.403
32	COVER	517336.524	5712131.999	2.422
33	COVER	517334.901	5712131.988	2.373
34	COVER	517333.269	5712131.988	2.359
35	COVER	517331.723	5712131.981	2.365
36	COVER	517330.117	5712132.053	2.388
37	COVER	517328.638	5712132.06	2.427
38	COVER	517327.005	5712132.001	2.398
39	COVER	517325.425	5712131.987	2.355
40	COVER	517323.704	5712131.915	2.347

NAME	RAW DESCRIPTION	EASTING	NORTHING	ELEVATION
41	COVER	517322.113	5712131.9	2.367
42	COVER	517320.505	5712131.9	2.363
43	COVER	517319.045	5712131.9	2.358
44	COVER	517317.109	5712131.9	2.379
45	COVER	517315.533	5712132	2.414
46	COVER	517314.087	5712132	2.38
47	COVER	517312.397	5712132	2.372
48	COVER	517310.816	5712131.9	2.365
49	COVER	517309.166	5712131.9	2.398
50	COVER	517307.473	5712131.9	2.361
51	COVER	517306.202	5712132	2.38
52	COVER	517304.436	5712131.9	2.381
53	COVER	517302.796	5712131.9	2.414
54	COVER	517301.179	5712132	2.4
55	COVER	517299.559	5712131.9	2.351
56	COVER	517297.885	5712132	2.41
57	COVER	517296.264	5712132	2.343
58	COVER	517294.634	5712132	2.383
59	COVER	517293.072	5712132	2.341
60	COVER	517291.393	5712131.9	2.332

NAME	RAW DESCRIPTION	EASTING	NORTHING	ELEVATION
61	COVER	517289.878	5712132.018	2.333
62	COVER	517288.211	5712131.968	2.356
63	COVER	517286.618	5712131.924	2.35
64	COVER	517284.933	5712131.922	2.294
65	COVER	517283.365	5712131.893	2.32
66	COVER	517281.843	5712132.021	2.295
67	COVER	517280.265	5712131.981	2.299
68	COVER	517278.618	5712131.987	2.303
69	COVER	517277.067	5712131.965	2.294
70	COVER	517275.393	5712131.933	2.293
71	COVER	517273.67	5712131.922	2.295
72	COVER	517272.248	5712131.922	2.301
73	COVER	517270.665	5712131.836	2.312
74	COVER	517268.97	5712131.828	2.393
75	COVER	517267.423	5712131.776	2.423
76	COVER	517265.986	5712131.704	2.339
77	COVER	517264.295	5712131.742	2.349
78	COVER	517262.64	5712131.817	2.363
79	COVER	517261.253	5712131.765	2.357
80	COVER	517260.532	5712131.7	2.342

NAME	RAW DESCRIPTION	EASTING	NORTHING	ELEVATION
1	JUNCTION BOX	517271.3855	5712132.307	2.57975
2	JUNCTION BOX	517284.163	5712132.5	2.57075
3	JUNCTION BOX	517297.0793	5712132.405	2.5915
4	JUNCTION BOX	517310.036	5712132.346	2.59475
5	JUNCTION BOX	517322.885	5712132.283	2.604
6	JUNCTION BOX	517335.6993	5712132.36	2.617
7	JUNCTION BOX	517348.5498	5712132.521	2.59375
8	JUNCTION BOX	517361.4765	5712132.566	2.61
9	JUNCTION BOX	517374.3175	5712132.542	2.602
10	JUNCTION BOX	517386.0625	5712132.3	2.6205

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ISSUE REGISTER

ISSUE	REV.	DATE	DISTRIBUTION & STATUS
L2	01	06-JAN-2016	CLIENT REVIEW
L1	00	09-DEC-2015	CLIENT REVIEW

REFERENCE DRAWING

No.	REFERENCE DRAWING

REVISION REGISTER

No.	DATE	REVISION	MOD.	VER.	APP.
01	06-JAN-2016	UPDATESD TABLES			
00	09-DEC-2015	FINAL AS-BUILT			

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NE-LCP MANAGEMENT: Date (dd-mmm-yyyy):

PROJECT MANAGER: Date (dd-mmm-yyyy):

PROFESSIONAL STAMP

H.J. O'CONNELL CONSTRUCTION LTD.

DESIGNED —

APPROVED (Discipline Lead Engineer)

DRAWN KJM

APPROVED (Engineering Manager)

VERIFIED GH

DATE 06-JAN-2016

SCALE NTS

CLIENT nalcor energy

PROJECT LOWER CHURCHILL PROJECT

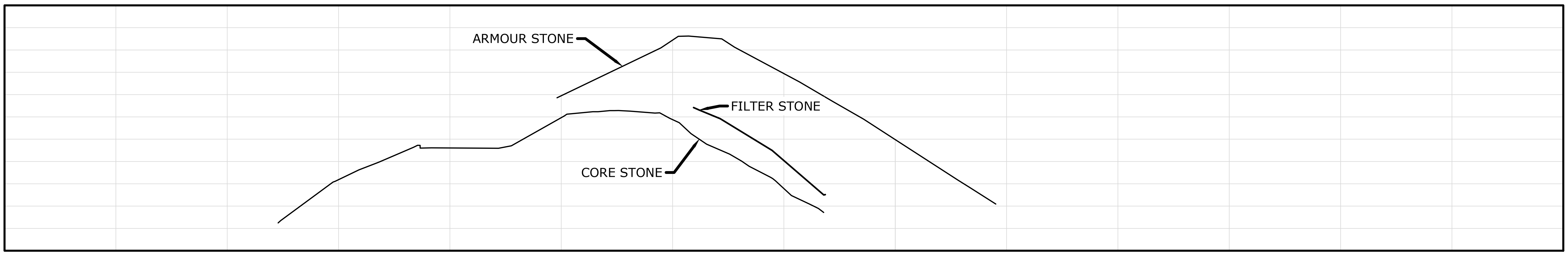
TITLE AS-BUILT – L'ANSE AU DIABLE ELECTRODE WELLS & JUNCTION BOX LOCATIONS SHT 2 OF 2

SUPPLIER DOC No. ES-CD0508001-01-AB-0004-002_01

NE DOC No. ILK-HJ-SD-8610-CV-B02-0005-02

Rev. L2

2021.11.10/11:00am



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3. BREAKWATER HAL USED FOR REFERENCE AND CROSS SECTIONS.

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ISSUE REGISTER

ISSUE	REV.	DATE	DISTRIBUTION & STATUS
L2	01	06-JAN-2016	CLIENT REVIEW
L1	00	30-NOV-2015	CLIENT REVIEW

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No.	REFERENCE DRAWING

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No.	DATE	REVISION	MOD.	VER.	APP.
01	06-JAN-2016	REMOVE SECTIONS			
00	30-NOV-2015	FINAL AS-BUILT			

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NE-LCP MANAGEMENT:	Date (dd-mmm-yyyy):
PROJECT MANAGER:	Date (dd-mmm-yyyy):

PROFESSIONAL STAMP

H.J. O'CONNELL CONSTRUCTION LTD.
90 O'LEARY AVENUE, 1ST FLOOR
ST. JOHN'S, NEWFOUNDLAND & LABRADOR
A1B 2C7
PHONE: (709) 726-9095 FAX: (709) 726-9106

DESIGNED	APPROVED (Discipline Lead Engineer)
DRAWN SJ	APPROVED (Engineering Manager)
VERIFIED GH	
DATE 30-NOV-2015	SCALE NTS

CLIENT: nalcor energy LOWER CHURCHILL PROJECT

PROJECT: LOWER CHURCHILL PROJECT

TITLE: AS-BUILT L'ANSE AU DIABLE BREAKWATER SHT 2 OF 7

SUPPLIER DOC No.	NE DOC No.	Rev.
ES-CD0508001-01-AB-0003-002_01	ILK-HJ-SD-8610-CV-B02-0004-02	L2

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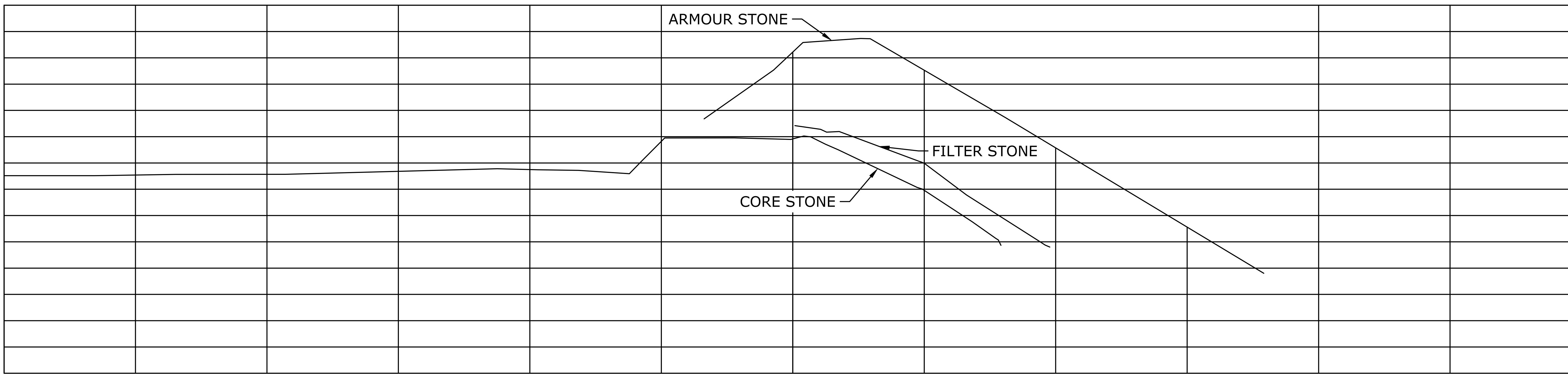

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ISSUE	REV.	DATE	DISTRIBUTION & STATUS
L2	01	06-JAN-2016	CLIENT REVIEW
L1	00	30-NOV-2015	CLIENT REVIEW

ISSUE REGISTER

No.	REFERENCE DRAWING

No.	DATE	REVISION	MOD.	VER.	APP.
01	06-JAN-2016	REMOVE SECTIONS			
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LEAD REVIEWER: Date (dd-mmm-yyyy):

NE-LCP MANAGEMENT: Date (dd-mmm-yyyy):

PROJECT MANAGER: Date (dd-mmm-yyyy):

PROFESSIONAL STAMP

H.J. O'CONNELL CONSTRUCTION LTD.
90 O'LEARY AVENUE, 1ST FLOOR
ST. JOHN'S, NEWFOUNDLAND & LABRADOR
A1B 2C7
PHONE: (709) 726-9095 FAX: (709) 726-9106

DESIGNED | APPROVED (Discipline Lead Engineer)

DRAWN SJ | APPROVED (Engineering Manager)

VERIFIED GH

DATE 30-NOV-2015 | SCALE NTS

SUPPLIER DOC No. ES-CD0508001-01-AB-0003-003_01

CLIENT nalcor energy

PROJECT LOWER CHURCHILL PROJECT

TITLE AS-BUILT L'ANSE AU DIABLE BREAKWATER SHT 3 OF 7

NE DOC No. ILK-HJ-SD-8610-CV-B02-0004-03 | Rev. L2

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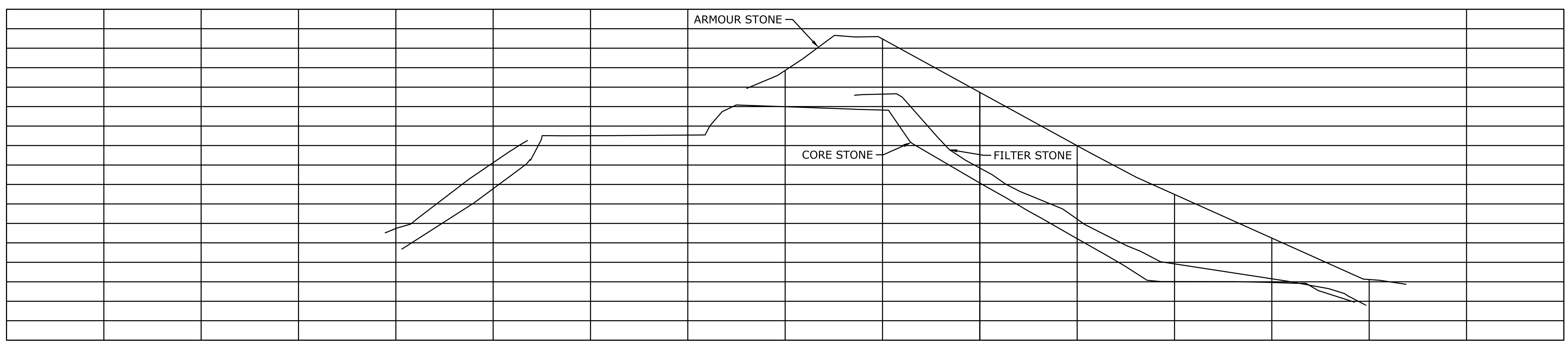

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ISSUE REGISTER

ISSUE	REV.	DATE	DISTRIBUTION & STATUS
L2	01	06-JAN-2016	CLIENT REVIEW
L1	00	30-NOV-2015	CLIENT REVIEW

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01	06-JAN-2016	REMOVE SECTIONS			
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LEAD REVIEWER: Date (dd-mmm-yyyy):
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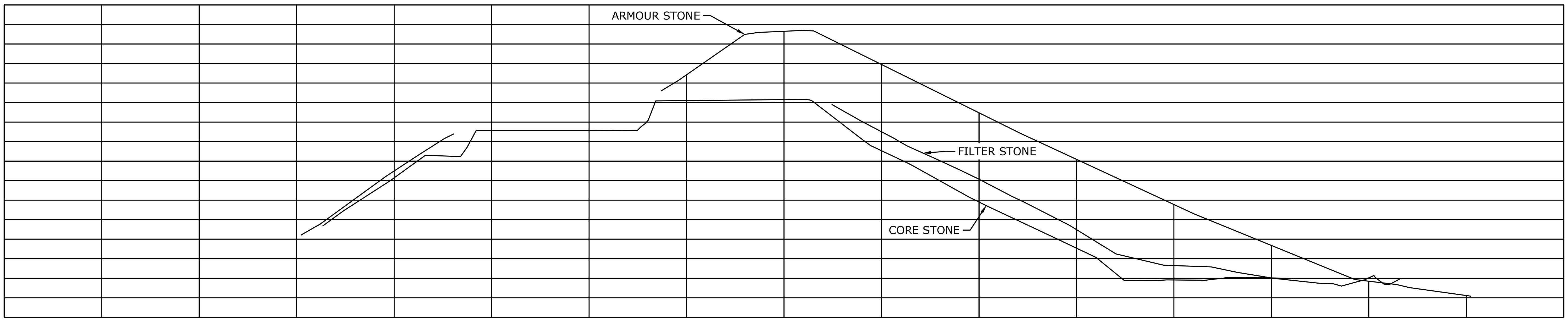
90 O'LEARY AVENUE, 1ST FLOOR
ST. JOHN'S, NEWFOUNDLAND & LABRADOR
A1B 2C7
PHONE: (709) 726-9095 FAX: (709) 726-9106

DESIGNED	APPROVED (Discipline Lead Engineer)
DRAWN SJ	APPROVED (Engineering Manager)
VERIFIED GH	
DATE 30-NOV-2015	SCALE NTS

CLIENT: nalcor energy LOWER CHURCHILL PROJECT
PROJECT: LOWER CHURCHILL PROJECT
TITLE: AS-BUILT L'ANSE AU DIABLE BREAKWATER SHT 4 OF 7

SUPPLIER DOC No. ES-CD0508001-01-AB-0003-004_01
NE DOC No. ILK-HJ-SD-8610-CV-B02-0004-04
Rev. L2

2021.11.10/10:54am



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L2	01	06-JAN-2016	CLIENT REVIEW
L1	00	30-NOV-2015	CLIENT REVIEW

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PHONE: (709) 726-9095 FAX: (709) 726-9106

DESIGNED	APPROVED (Discipline Lead Engineer)
DRAWN SJ	APPROVED (Engineering Manager)
VERIFIED GH	
DATE 30-NOV-2015	SCALE NTS

CLIENT: nalcor energy LOWER CHURCHILL PROJECT

PROJECT: LOWER CHURCHILL PROJECT

TITLE: AS-BUILT L'ANSE AU DIABLE BREAKWATER SHT 5 OF 7

SUPPLIER DOC No. ES-CD0508001-01-AB-0003-005_01

NE DOC No. ILK-HJ-SD-8610-CV-B02-0004-05

Rev. L2

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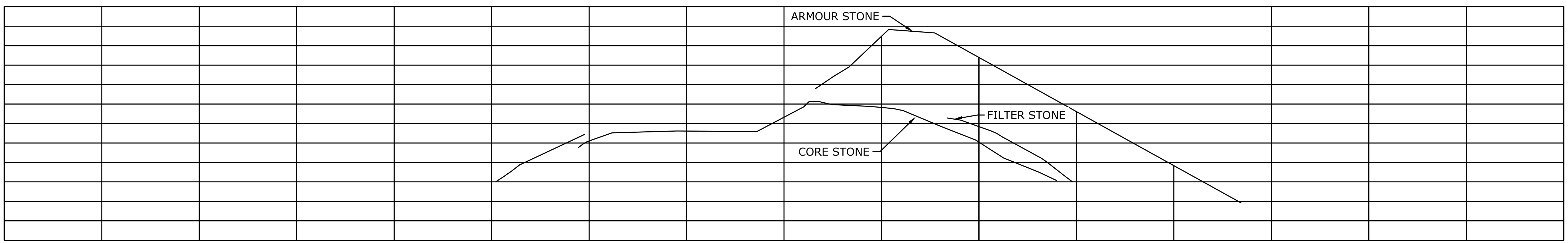

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LEAD REVIEWER: Date (dd-mmm-yyyy):

NE-LCP MANAGEMENT: Date (dd-mmm-yyyy):

PROJECT MANAGER: Date (dd-mmm-yyyy):

PROFESSIONAL STAMP

H.J. O'CONNELL CONSTRUCTION LTD.
90 O'LEARY AVENUE, 1ST FLOOR
ST. JOHN'S, NEWFOUNDLAND & LABRADOR
A1B 2C7
PHONE: (709) 726-9095 FAX: (709) 726-9106

CLIENT: nalcor energy

DESIGNED	APPROVED (Discipline Lead Engineer)
DRAWN SJ	APPROVED (Engineering Manager)
VERIFIED GH	
DATE 30-NOV-2015	SCALE NTS

PROJECT: LOWER CHURCHILL PROJECT

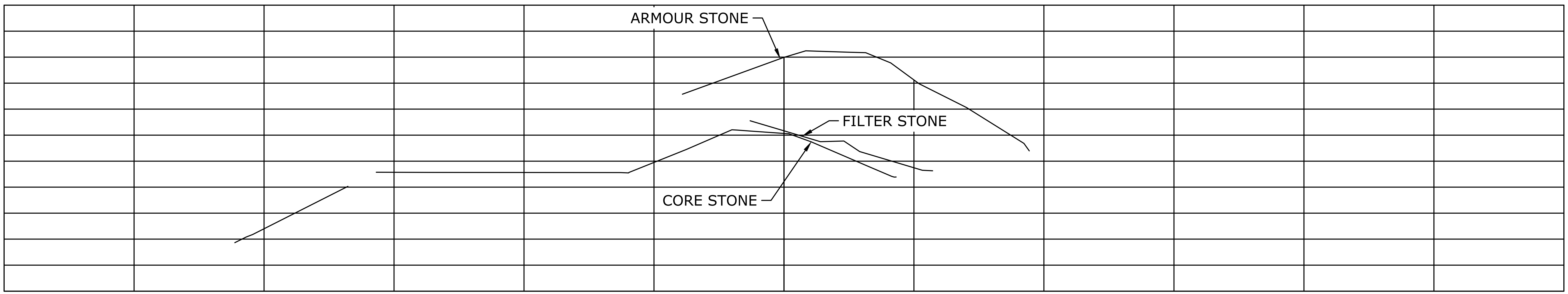
TITLE: AS-BUILT L'ANSE AU DIABLE BREAKWATER SHT 6 OF 7

SUPPLIER DOC No. ES-CD0508001-01-AB-0003-006_01

NE DOC No. ILK-HJ-SD-8610-CV-B02-0004-06

Rev. L2

2021.11.10/10:54am



SITE/SURVEY NOTES:
1. ALL DIMENSIONS ARE SHOWN IN METERS AND DECIMAL PLACES THEREOF, UNLESS SPECIFIED OTHERWISE ON PLAN.
2. SURVEY BASED ON CONTROL PROVIDED BY NALCOR. BENCHMARKS 13LD001, 13LD002, 13LD003 & 13LD004. COORDINATES ARE REFERENCED TO NAD83 UTM ZONE 21. ALL ELEVATIONS ARE GEODETIC UNLESS NOTED OTHERWISE.
3. BREAKWATER HAL USED FOR REFERENCE AND CROSS SECTIONS.

***** DATUM REFERENCE: *ALL ELEVATIONS ARE IN METRES REFERENCED TO GEODETIC.* COORDINATE REFERENCE: *UTM 6° (UNIVERSAL TRANSVERSE MERCATOR) PROJECTION, NAD83, ZONE 21 CENTRAL MERIDIAN 57° 00' W LONGITUDE.* *****

ISSUE	REV.	DATE	DISTRIBUTION & STATUS
L2	01	06-JAN-2016	CLIENT REVIEW
L1	00	30-NOV-2015	CLIENT REVIEW

ISSUE REGISTER

No.	REFERENCE DRAWING

No.	DATE	REVISION	MOD.	VER.	APP.
01	06-JAN-2016	REMOVE SECTIONS			
00	30-NOV-2015	FINAL AS-BUILT			

REVISION REGISTER

* * * * * * * * * FOR INTERNAL USE ONLY * * * * * * * * *

REVIEW CLASS: | EQUIPMENT TAG NUMBER:

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- ☐ 3. REVIEWED - NOT ACCEPTED
- ☐ 4. INFORMATION ONLY
- ☐ 5. NOT REVIEWED

LEAD REVIEWER: Date (dd-mmm-yyyy):

NE-LCP MANAGEMENT: Date (dd-mmm-yyyy):

PROJECT MANAGER: Date (dd-mmm-yyyy):

PROFESSIONAL STAMP

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ST. JOHN'S, NEWFOUNDLAND & LABRADOR
A1B 2C7
PHONE: (709) 726-9095 FAX: (709) 726-9106

DESIGNED	APPROVED (Discipline Lead Engineer)
DRAWN SJ	APPROVED (Engineering Manager)
VERIFIED GH	
DATE 30-NOV-2015	SCALE NTS

CLIENT: nalcor energy LOWER CHURCHILL PROJECT

PROJECT: LOWER CHURCHILL PROJECT

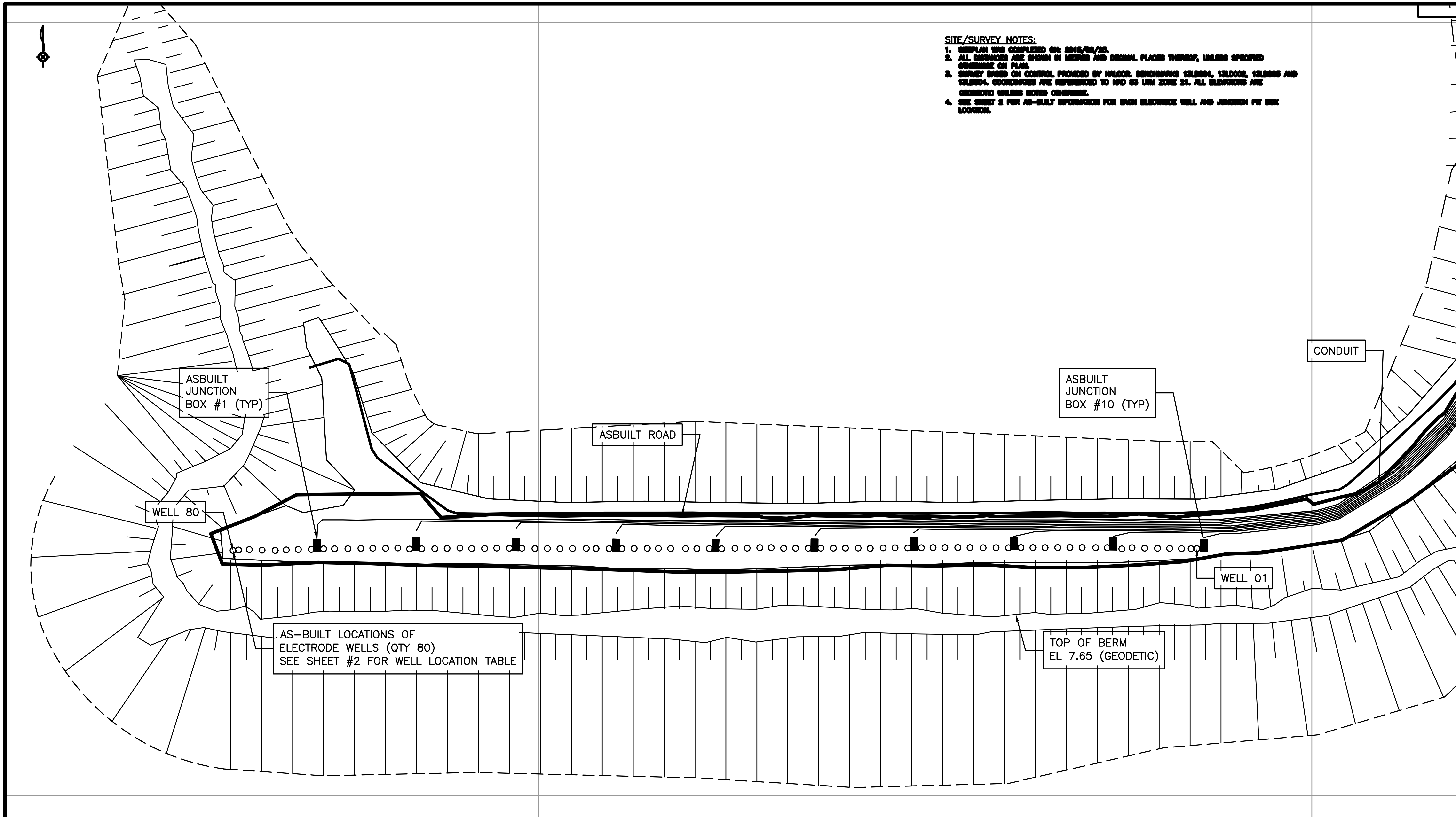
TITLE: AS-BUILT L'ANSE AU DIABLE BREAKWATER SHT 7 OF 7

SUPPLIER DOC No. ES-CD0508001-01-AB-0003-007_01

NE DOC No. ILK-HJ-SD-8610-CV-B02-0004-07

Rev. L2

2021.11.10/10:54am



***** **DATUM REFERENCE:** *ALL ELEVATIONS ARE IN METRES REFERENCED TO GEODETIC.* **COORDINATE REFERENCE:** *UTM 6° (UNIVERSAL TRANSVERSE MERCATOR) PROJECTION, NAD83, ZONE 21 CENTRAL MERIDIAN 57° 00' W LONGITUDE.* *****

ISSUE	REV.	DATE	DISTRIBUTION & STATUS
L2	01	06-JAN-2016	CLIENT REVIEW
L1	00	09-DEC-2015	CLIENT REVIEW

ISSUE REGISTER

No.	REFERENCE DRAWING

No.	DATE	REVISION	MOD.	VER.	APP.
01	06-JAN-2016	ADJUSTED LABELING			
00	09-DEC-2015	FINAL AS-BUILT			

REVISION REGISTER

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LEAD REVIEWER: Date (dd-mmm-yyyy):

NE-LCP MANAGEMENT: Date (dd-mmm-yyyy):

PROJECT MANAGER: Date (dd-mmm-yyyy):

PROFESSIONAL STAMP

H.J. O'CONNELL CONSTRUCTION LTD.

DESIGNED: --
APPROVED (Discipline Lead Engineer):
DRAWN: KJM
APPROVED (Engineering Manager):
VERIFIED: GH
DATE: 06-JAN-2016
SCALE: NTS

CLIENT: nalcor energy LOWER CHURCHILL PROJECT

PROJECT: LOWER CHURCHILL PROJECT

TITLE: AS-BUILT – L'ANSE AU DIABLE ELECTRODE WELLS & JUNCTION BOX LOCATIONS SHT 1 OF 2

SUPPLIER DOC No.: ES-CD0508001-01-AB-0004-001_01

NE DOC No.: ILK-HJ-SD-8610-CV-B02-0005-01

Rev.: L2

2021.11.10/11:00am

NAME	RAW DESCRIPTION	EASTING	NORTHING	ELEVATION
1	COVER	517385.14	5712131.943	2.382
2	COVER	517384.39	5712131.929	2.364
3	COVER	517383.163	5712131.939	2.398
4	COVER	517381.624	5712131.967	2.366
5	COVER	517380.056	5712131.975	2.359
6	COVER	517378.386	5712131.995	2.346
7	COVER	517376.758	5712132.05	2.331
8	COVER	517375.443	5712131.911	2.391
9	COVER	517373.564	5712132.057	2.36
10	COVER	517372.057	5712132.058	2.39
11	COVER	517370.305	5712132.072	2.361
12	COVER	517368.727	5712132.083	2.364
13	COVER	517367.159	5712132.072	2.37
14	COVER	517365.514	5712132.051	2.366
15	COVER	517363.947	5712132.062	2.329
16	COVER	517362.389	5712132.072	2.348
17	COVER	517360.794	5712132.041	2.363
18	COVER	517359.178	5712132.041	2.363
19	COVER	517357.504	5712132.041	2.352
20	COVER	517355.809	5712132.062	2.35

NAME	RAW DESCRIPTION	EASTING	NORTHING	ELEVATION
21	COVER	517354.239	5712132.072	2.347
22	COVER	517352.571	5712132.061	2.38
23	COVER	517351.038	5712132.051	2.392
24	COVER	517349.517	5712132.041	2.346
25	COVER	517347.765	5712132.03	2.384
26	COVER	517346.12	5712132.04	2.386
27	COVER	517344.576	5712132.03	2.396
28	COVER	517342.904	5712131.967	2.372
29	COVER	517341.353	5712132.009	2.425
30	COVER	517339.709	5712132.009	2.428
31	COVER	517338.15	5712131.999	2.403
32	COVER	517336.524	5712131.999	2.422
33	COVER	517334.901	5712131.988	2.373
34	COVER	517333.269	5712131.988	2.359
35	COVER	517331.723	5712131.981	2.365
36	COVER	517330.117	5712132.053	2.388
37	COVER	517328.638	5712132.06	2.427
38	COVER	517327.005	5712132.001	2.398
39	COVER	517325.425	5712131.987	2.355
40	COVER	517323.704	5712131.915	2.347

NAME	RAW DESCRIPTION	EASTING	NORTHING	ELEVATION
41	COVER	517322.113	5712131.9	2.367
42	COVER	517320.505	5712131.9	2.363
43	COVER	517319.045	5712131.9	2.358
44	COVER	517317.109	5712131.9	2.379
45	COVER	517315.533	5712132	2.414
46	COVER	517314.087	5712132	2.38
47	COVER	517312.397	5712132	2.372
48	COVER	517310.816	5712131.9	2.365
49	COVER	517309.166	5712131.9	2.398
50	COVER	517307.473	5712131.9	2.361
51	COVER	517306.202	5712132	2.38
52	COVER	517304.436	5712131.9	2.381
53	COVER	517302.796	5712131.9	2.414
54	COVER	517301.179	5712132	2.4
55	COVER	517299.559	5712131.9	2.351
56	COVER	517297.885	5712132	2.41
57	COVER	517296.264	5712132	2.343
58	COVER	517294.634	5712132	2.383
59	COVER	517293.072	5712132	2.341
60	COVER	517291.393	5712131.9	2.332

NAME	RAW DESCRIPTION	EASTING	NORTHING	ELEVATION
61	COVER	517289.878	5712132.018	2.333
62	COVER	517288.211	5712131.968	2.356
63	COVER	517286.618	5712131.924	2.35
64	COVER	517284.933	5712131.922	2.294
65	COVER	517283.365	5712131.893	2.32
66	COVER	517281.843	5712132.021	2.295
67	COVER	517280.265	5712131.981	2.299
68	COVER	517278.618	5712131.987	2.303
69	COVER	517277.067	5712131.965	2.294
70	COVER	517275.393	5712131.933	2.293
71	COVER	517273.67	5712131.922	2.295
72	COVER	517272.248	5712131.922	2.301
73	COVER	517270.665	5712131.836	2.312
74	COVER	517268.97	5712131.828	2.393
75	COVER	517267.423	5712131.776	2.423
76	COVER	517265.986	5712131.704	2.339
77	COVER	517264.295	5712131.742	2.349
78	COVER	517262.64	5712131.817	2.363
79	COVER	517261.253	5712131.765	2.357
80	COVER	517260.532	5712131.7	2.342

NAME	RAW DESCRIPTION	EASTING	NORTHING	ELEVATION
1	JUNCTION BOX	517271.3855	5712132.307	2.57975
2	JUNCTION BOX	517284.163	5712132.5	2.57075
3	JUNCTION BOX	517297.0793	5712132.405	2.5915
4	JUNCTION BOX	517310.036	5712132.346	2.59475
5	JUNCTION BOX	517322.885	5712132.283	2.604
6	JUNCTION BOX	517335.6993	5712132.36	2.617
7	JUNCTION BOX	517348.5498	5712132.521	2.59375
8	JUNCTION BOX	517361.4765	5712132.566	2.61
9	JUNCTION BOX	517374.3175	5712132.542	2.602
10	JUNCTION BOX	517386.0625	5712132.3	2.6205

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ISSUE	REV.	DATE	DISTRIBUTION & STATUS
L2	01	06-JAN-2016	CLIENT REVIEW
L1	00	09-DEC-2015	CLIENT REVIEW

ISSUE REGISTER

No.	REFERENCE DRAWING

No.	DATE	REVISION	MOD.	VER.	APP.
01	06-JAN-2016	UPDATESD TABLES			
00	09-DEC-2015	FINAL AS-BUILT			

REVISION REGISTER

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REVIEW CLASS: EQUIPMENT TAG NUMBER:

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LEAD REVIEWER: Date (dd-mmm-yyyy):

NE-LCP MANAGEMENT: Date (dd-mmm-yyyy):

PROJECT MANAGER: Date (dd-mmm-yyyy):

PROFESSIONAL STAMP

N.J. O'CONNELL CONSTRUCTION LTD.

DESIGNED — | APPROVED (Discipline Lead Engineer)

DRAWN KJM | APPROVED (Engineering Manager)

VERIFIED GH

DATE 06-JAN-2016 | SCALE NTS

SUPPLIER DOC No. ES-CD0508001-01-AB-0004-002_01

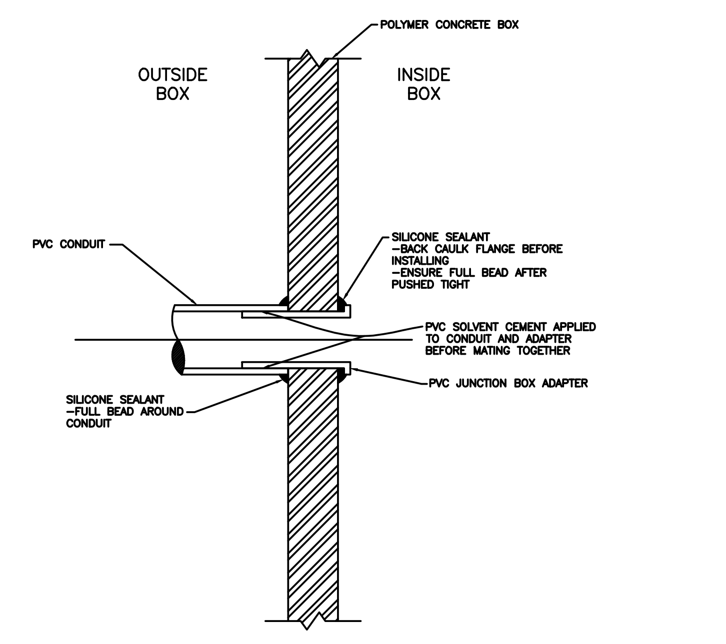
CLIENT nalcor energy

PROJECT LOWER CHURCHILL PROJECT

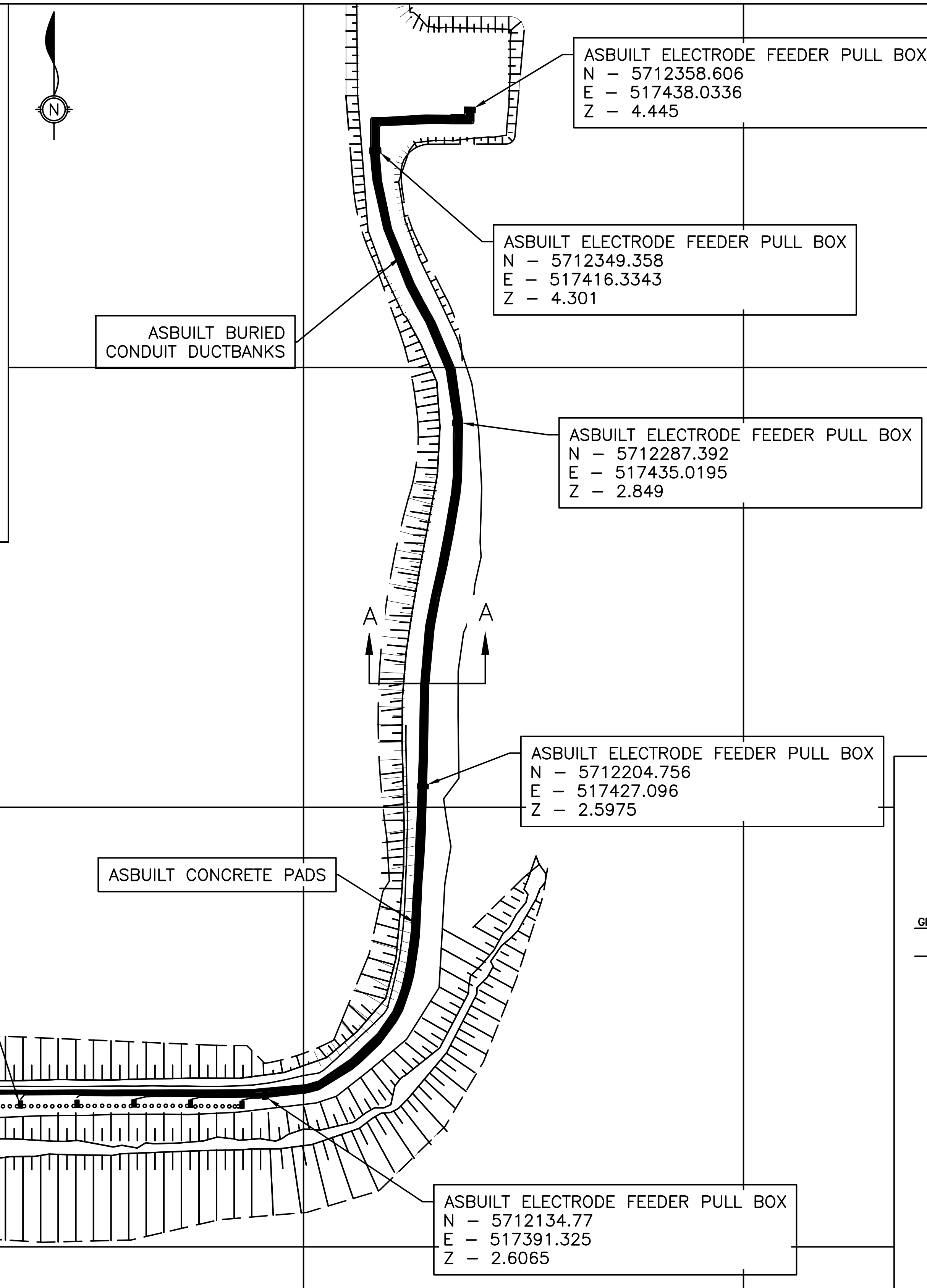
TITLE AS-BUILT – L'ANSE AU DIABLE ELECTRODE WELLS & JUNCTION BOX LOCATIONS SHT 2 OF 2

NE DOC No. ILK-HJ-SD-8610-CV-B02-0005-02 | Rev. L2

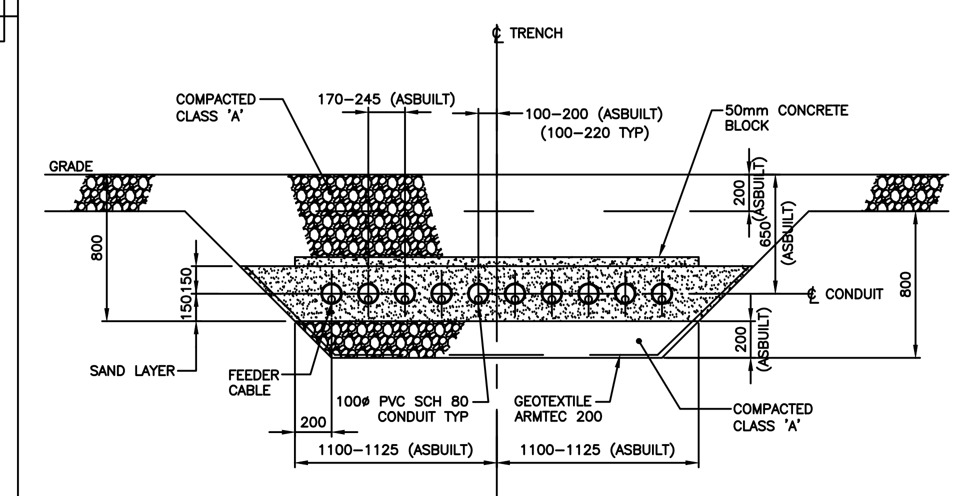
2021.11.10/11:00am



PVC CONDUIT/POLYMER CONCRETE ADAPTER INSTALLATION DETAILS



SITE/SURVEY NOTES:
1. ALL DISTANCES ARE SHOWN IN METRES AND DECIMAL PLACES THEREOF, UNLESS SPECIFIED OTHERWISE ON PLAN.
2. SURVEY BASED ON CONTROL PROVIDED BY NALCOR. BENCHMARKS 13LDD001, 13LD002, 13LD003 AND 13LD004. COORDINATES ARE REFERENCED TO NAD 83 UTM ZONE 22. ALL ELEVATIONS ARE GEODECTIC UNLESS NOTED OTHERWISE.



SECTION A–A
ASBUILT BURIED CABLE DUCTBANK

***** DATUM REFERENCE: *ALL ELEVATIONS ARE IN METRES REFERENCED TO GEODETIC.* COORDINATE REFERENCE: *UTM 6° (UNIVERSAL TRANSVERSE MERCATOR) PROJECTION, NAD83, ZONE 22 CENTRAL MERIDIAN 51° 00' W LONGITUDE.* *****

ISSUE	REV.	DATE	DISTRIBUTION & STATUS
L2	01	06–JAN–2016	CLIENT REVIEW
L1	00	09–DEC–2015	CLIENT REVIEW

ISSUE REGISTER

No.	REFERENCE DRAWING

No.	DATE	REVISION	MOD.	VER.	APP.
01	06–JAN–2016	ADDED COORDINATES. UPDATED DWG NAME.			
00	09–DEC–2015	FINAL AS–BUILT			

REVISION REGISTER

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LEAD REVIEWER: Date (dd-mmm-yyyy):
NE-LCP MANAGEMENT: Date (dd-mmm-yyyy):
PROJECT MANAGER: Date (dd-mmm-yyyy):

PROFESSIONAL STAMP

H.J. O'CONNELL CONSTRUCTION LTD.
80 O'LEARY AVENUE, 1ST FLOOR
ST. JOHN'S, NEWFOUNDLAND & LABRADOR
A1B 3C7
PHONE (709) 726-8095 FAX (709) 726-8106

CLIENT: nalcor energy

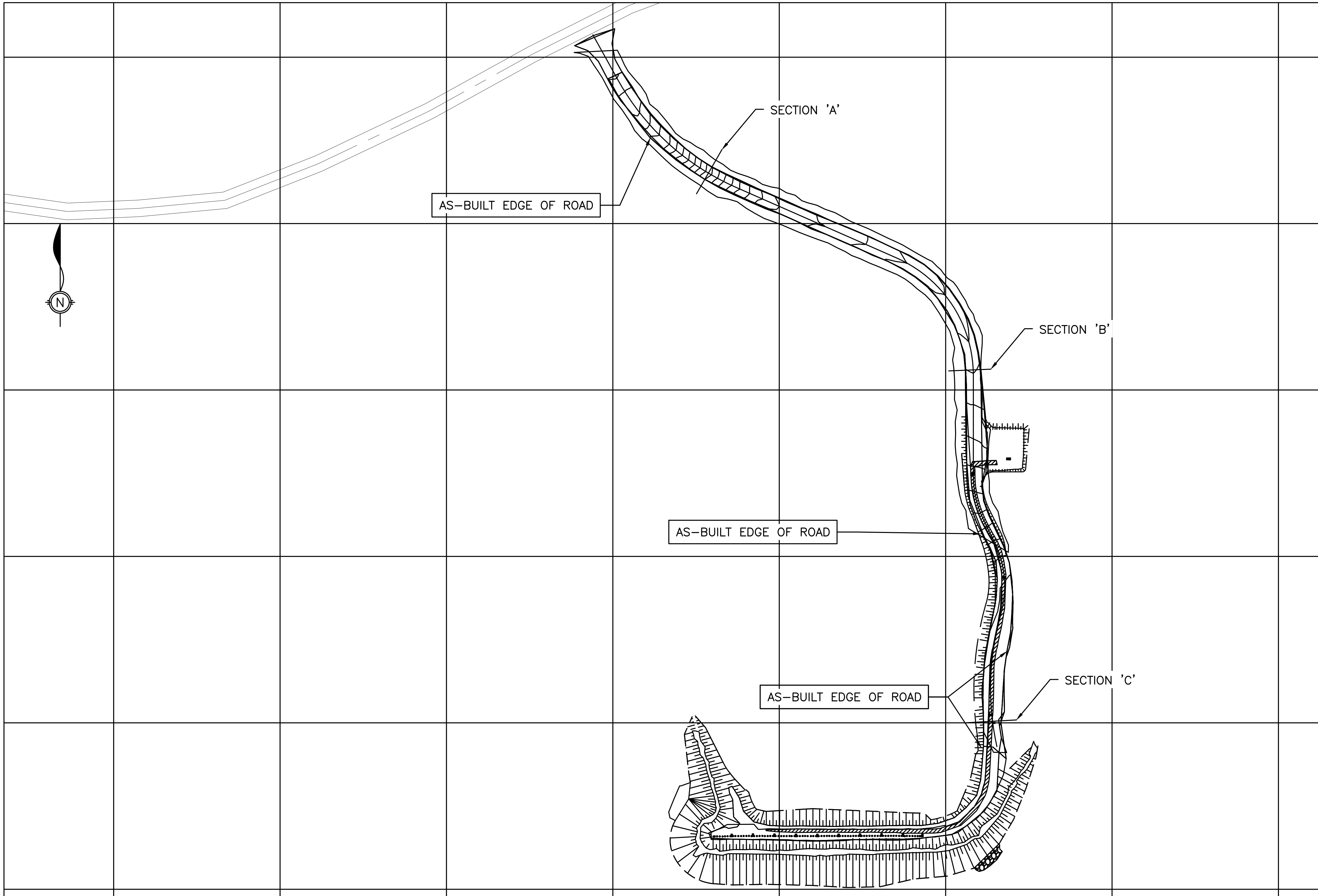
DESIGNED	--
APPROVED (Discipline Lead Engineer)	
DRAWN	LK
APPROVED (Engineering Manager)	
VERIFIED	GH
DATE	06–JAN–2016
SCALE	NTS

PROJECT: LOWER CHURCHILL PROJECT

TITLE: AS–BUILT L'ANSE AU DIABLE PULL BOXES & CONDUIT/CONCRETE LOCATIONS

SUPPLIER DOC No.: ES–CD0508001–01–AB–0005–001_01
NE DOC No.: ILK–HJ–SD–8610–CV–B02–0006–01
Rev.: L2

2021.11.10/11:03am



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ISSUE	REV.	DATE	DISTRIBUTION & STATUS
L2	01	08-JAN-2016	CLIENT REVIEW
L1	00	09-DEC-2015	CLIENT REVIEW

ISSUE REGISTER

No.	REFERENCE DRAWING

No.	DATE	REVISION	MOD.	VER.	APP.
01	08-JAN-2016	SECTIONS ADDED			
00	09-DEC-2015	FINAL AS-BUILT			

REVISION REGISTER

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LEAD REVIEWER: Date (dd-mmm-yyyy):

NE-LCP MANAGEMENT: Date (dd-mmm-yyyy):

PROJECT MANAGER: Date (dd-mmm-yyyy):

PROFESSIONAL STAMP

H.J. O'CONNELL CONSTRUCTION LTD.
80 O'LEARY AVENUE, 1ST FLOOR
ST. JOHN'S, NEWFOUNDLAND & LABRADOR
A1B 3C7
PHONE (709) 726-9095 FAX (709) 726-8106

DESIGNED		APPROVED (Discipline Lead Engineer)
DRAWN	SJ	APPROVED (Engineering Manager)
VERIFIED	GH	
DATE	09-DEC-2015	SCALE NTS

CLIENT: nalcor energy

PROJECT: LOWER CHURCHILL PROJECT

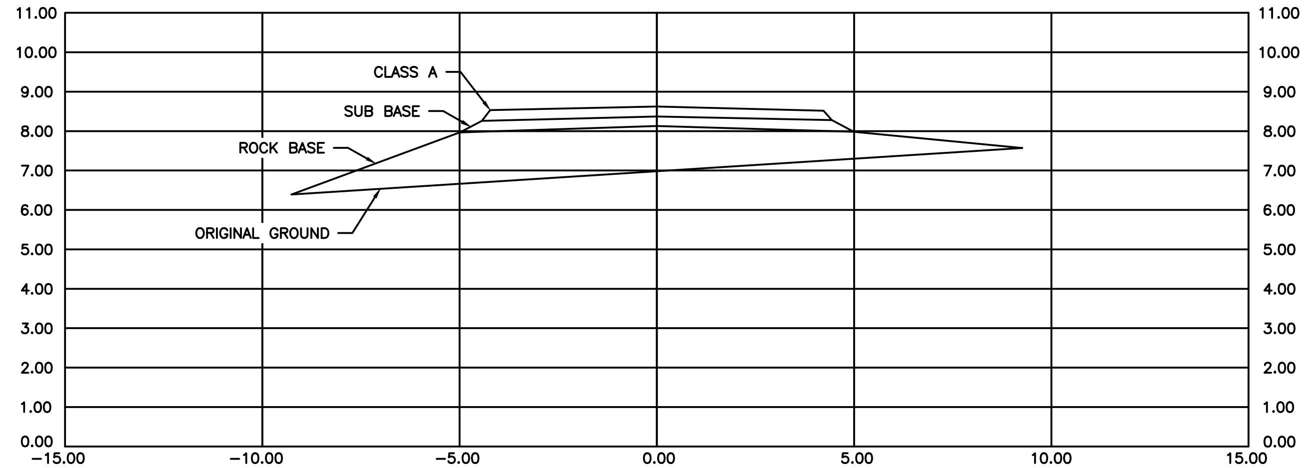
TITLE: AS-BUILT L'ANSE AU DIABLE ACCESS ROAD SHT 1 OF 4

SUPPLIER DOC No. ES-CD0508001-01-AB-0006-001_01

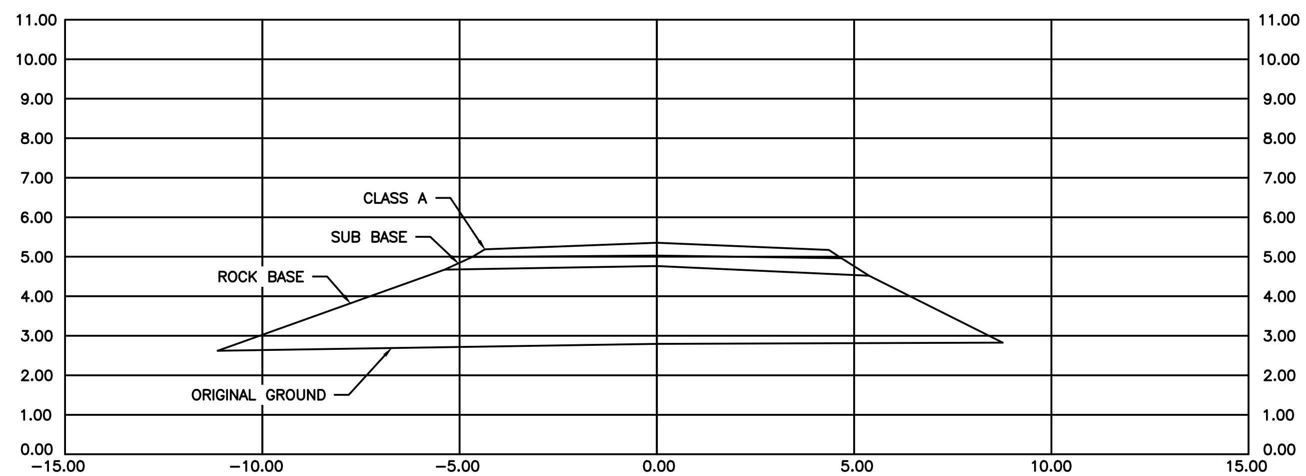
NE DOC No. ILK-HJ-SD-8610-CV-B02-0007-01

Rev. L2

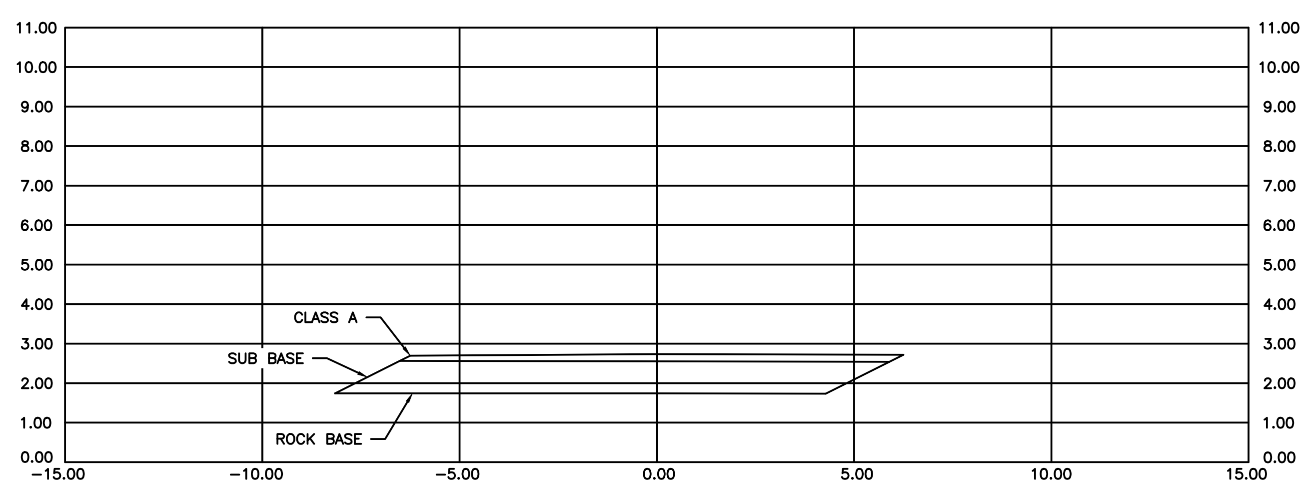
2021.11.10/11:06am



SECTION 'A'



SECTION 'B'



SECTION 'C'

SITE/SURVEY NOTES:

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ISSUE	REV.	DATE	DISTRIBUTION & STATUS
L1	00	08-JAN-2016	CLIENT REVIEW

ISSUE REGISTER

No.	REFERENCE DRAWING

No.	DATE	REVISION	MOD.	VER.	APP.
00	08-JAN-2016	SECTIONS ADDED			

REVISION REGISTER

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LEAD REVIEWER: Date (dd-mmm-yyyy):

NE-LCP MANAGEMENT: Date (dd-mmm-yyyy):

PROJECT MANAGER: Date (dd-mmm-yyyy):

PROFESSIONAL STAMP

H.J. O'CONNELL CONSTRUCTION LTD.

DESIGNED | APPROVED (Discipline Lead Engineer)

DRAWN SJ | APPROVED (Engineering Manager)

VERIFIED GH

DATE 07-JAN-2016 | SCALE NTS

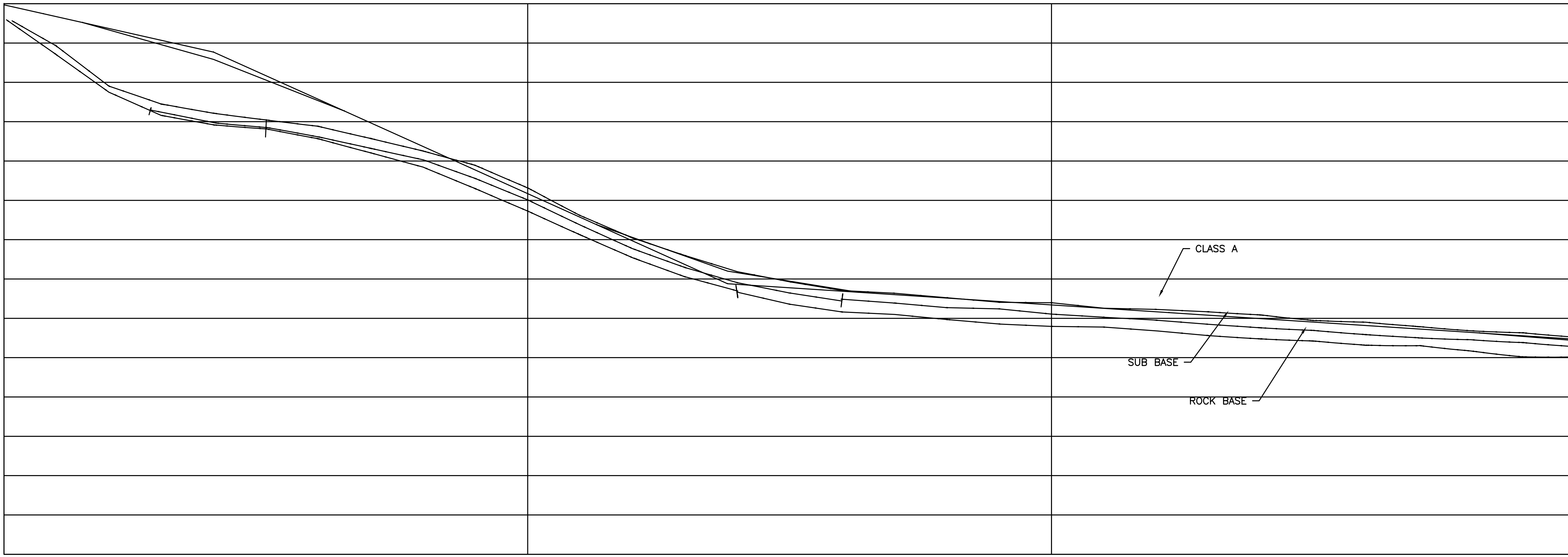
CLIENT nalcor energy

PROJECT LOWER CHURCHILL PROJECT

TITLE AS-BUILT L'ANSE AU DIABLE ACCESS ROAD – SECTIONS SHT 2 OF 4

SUPPLIER DOC No. ES-CD0508001-01-AB-0006-002_00 | NE DOC No. ILK-HJ-SD-8610-CV-B02-0007-02 | Rev. L1

2021.11.10/11:06am



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ISSUE	REV.	DATE	DISTRIBUTION & STATUS
L1	00	07-JAN-2016	CLIENT REVIEW

ISSUE REGISTER

No.	REFERENCE DRAWING

No.	DATE	REVISION	MOD.	VER.	APP.
00	07-JAN-2016	SECTIONS ADDED			

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LEAD REVIEWER: Date (dd-mmm-yyyy):

NE-LCP MANAGEMENT: Date (dd-mmm-yyyy):

PROJECT MANAGER: Date (dd-mmm-yyyy):

PROFESSIONAL STAMP

H.J. O'CONNELL CONSTRUCTION LTD.
80 O'LEARY AVENUE, 1ST FLOOR
ST. JOHN'S, NEWFOUNDLAND & LABRADOR
A1B 2C7
PHONE (709) 726-8085 FAX (709) 726-8106

DESIGNED		APPROVED (Discipline Lead Engineer)	
DRAWN	SJ	APPROVED (Engineering Manager)	
VERIFIED	GH		
DATE	07-JAN-2016	SCALE	NTS

CLIENT: nalcor energy

PROJECT: LOWER CHURCHILL PROJECT

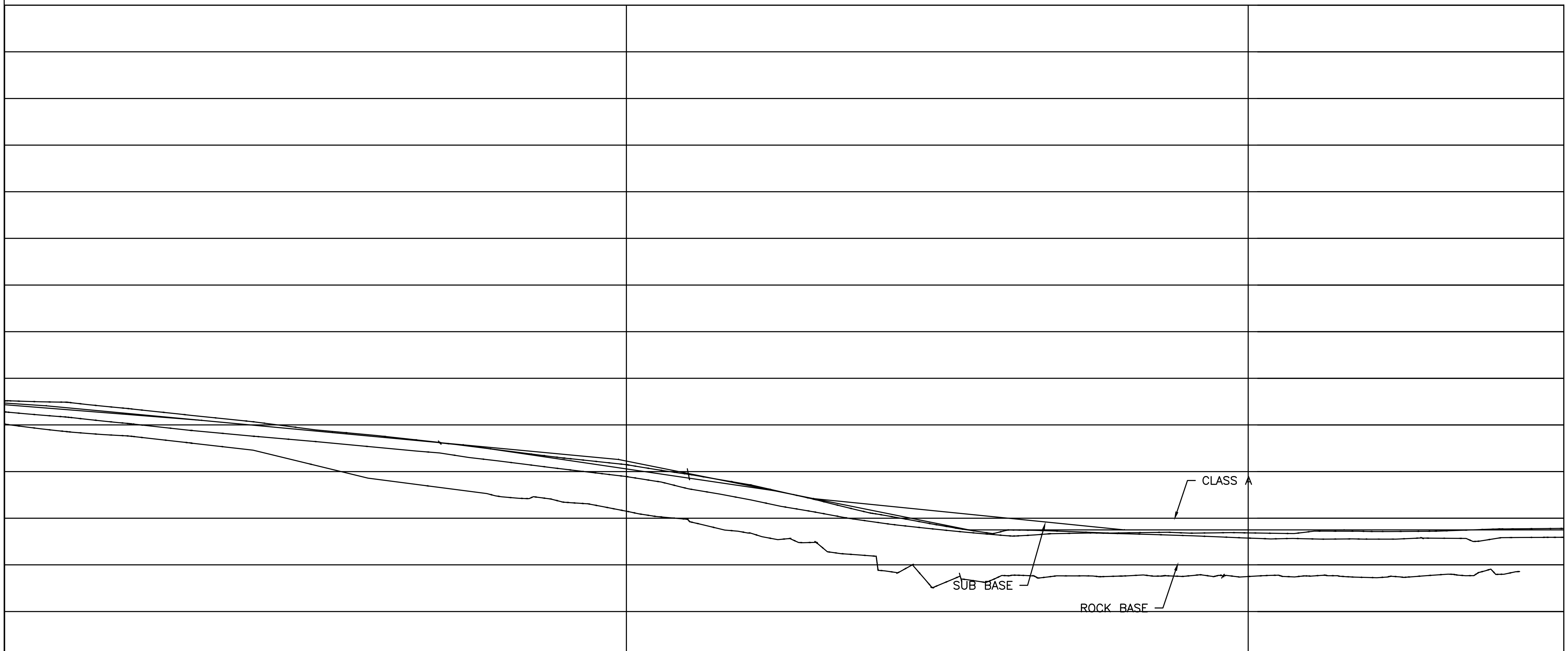
TITLE: AS-BUILT L'ANSE AU DIABLE ACCESS ROAD - PROFILE SHT 3 OF 4

SUPPLIER DOC No. ES-CD0508001-01-AB-0006-003_00

NE DOC No. ILK-HJ-SD-8610-CV-B02-0007-03

Rev. L1

2021.11.10/11:06am



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L1	00	07-JAN-2016	CLIENT REVIEW

ISSUE REGISTER

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A1B 2C7
PHONE (709) 726-9095 FAX (709) 726-8106

DESIGNED	APPROVED (Discipline Lead Engineer)
DRAWN SJ	APPROVED (Engineering Manager)
VERIFIED GH	
DATE 07-JAN-2016	SCALE NTS

CLIENT nalcor energy

PROJECT LOWER CHURCHILL PROJECT

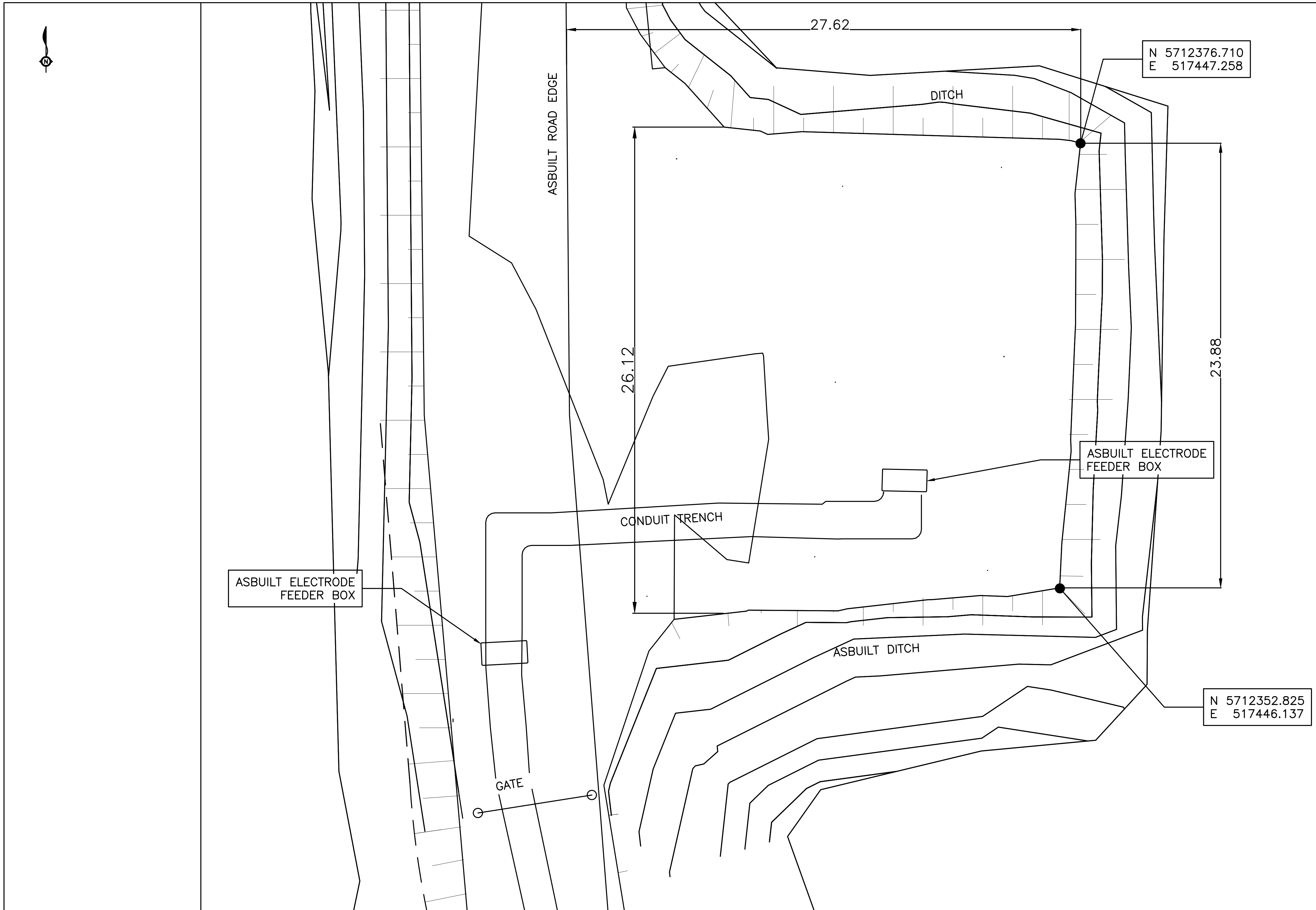
TITLE AS-BUILT L'ANSE AU DIABLE ACCESS ROAD – PROFILE SHT 4 OF 4

SUPPLIER DOC No. ES-CD0508001-01-AB-0006-004_00

NE DOC No. ILK-HJ-SD-8610-CV-B02-0007-04

Rev. L1

2021.11.10/11:06am



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ISSUE	REV.	DATE	DISTRIBUTION & STATUS
L2	01	06-JAN-2016	CLIENT REVIEW
L1	00	09-DEC-2015	CLIENT REVIEW

ISSUE REGISTER

No.	REFERENCE DRAWING

No.	DATE	REVISION	MOD.	VER.	APP.
01	06-JAN-2016	UPDATED DIMENSIONS			
00	03-DEC-2015	FINAL AS-BUILT			

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PROJECT MANAGER: Date (dd-mmm-yyyy):

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A1B 3C7
PHONE (709) 726-9095 FAX (709) 726-9106

DESIGNED --
APPROVED (Discipline Lead Engineer)
DRAWN KJM
APPROVED (Engineering Manager)
VERIFIED GH
DATE 06-JAN-2016
SCALE NTS

CLIENT nalcor energy LOWER CHURCHILL PROJECT

PROJECT LOWER CHURCHILL PROJECT

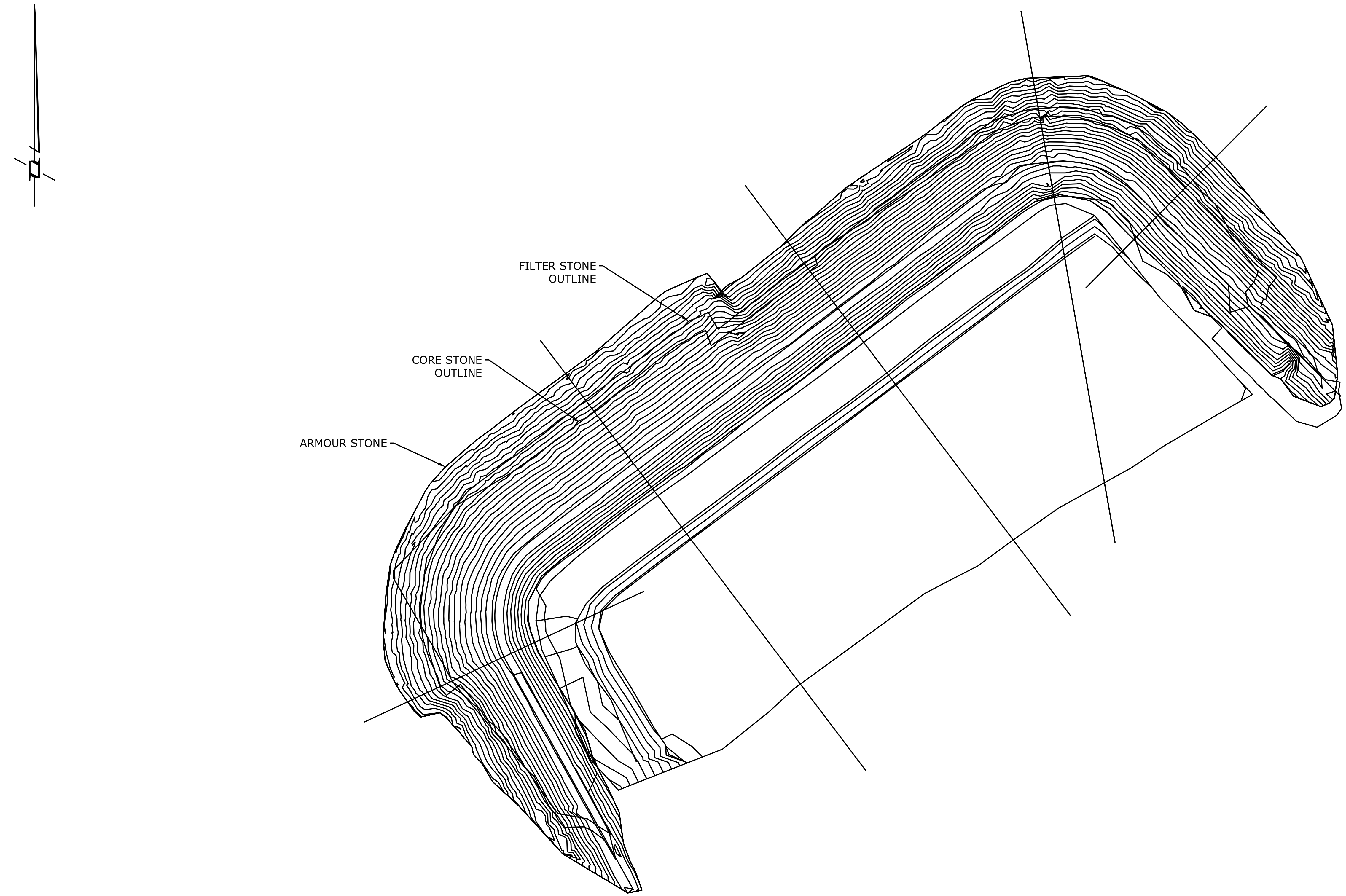
TITLE AS-BUILT L'ANSE AU DIABLE ELECTRODE YARD

SUPPLIER DOC No. ES-CD0508001-01-AB-0007-001_01

NE DOC No. ILK-HJ-SD-8610-CV-B02-0008-01

Rev. L2

2021.11.10/11:11am



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ISSUE	REV.	DATE	DISTRIBUTION & STATUS
L2	01	06-JAN-2016	CLIENT REVIEW
L1	00	27-NOV-2015	CLIENT REVIEW

ISSUE REGISTER

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01	06-JAN-2016	SECTIONS REMOVED			
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90 O'LEARY AVENUE, 1ST FLOOR
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A1B 2C7
PHONE: (709) 726-9095 FAX: (709) 726-9106

DESIGNED	APPROVED (Discipline Lead Engineer)
DRAWN SJ	APPROVED (Engineering Manager)
VERIFIED GH	
DATE 27-NOV-2015	SCALE NTS
SUPPLIER DOC No. ES-CD0508001-01-AB-0010-001_01	NE DOC No. ILK-HJ-SD-8620-CV-B02-0003-01

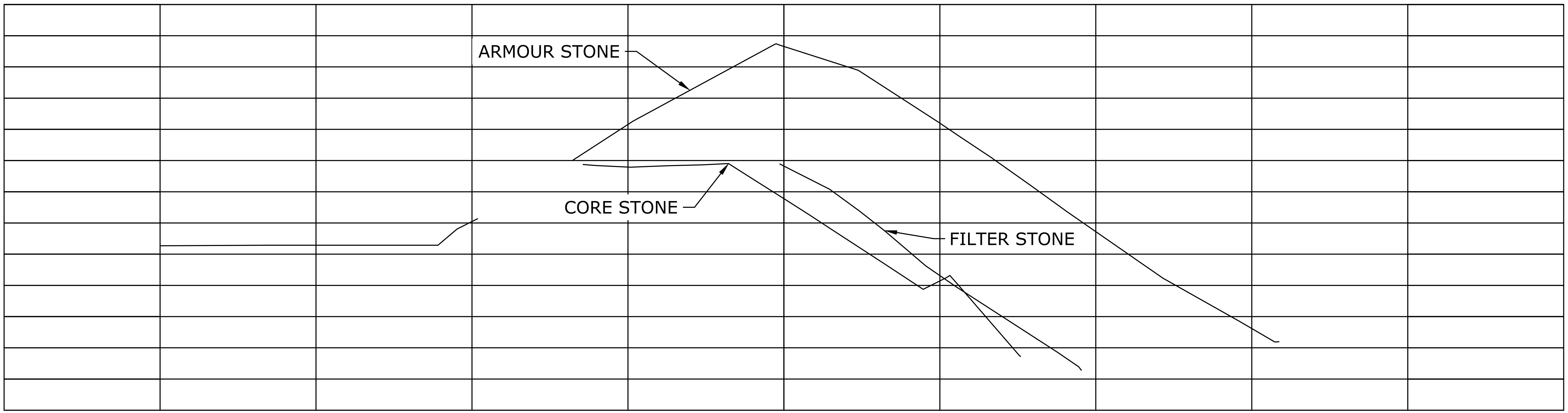
CLIENT: nalcor energy LOWER CHURCHILL PROJECT

PROJECT: LOWER CHURCHILL PROJECT

TITLE: AS-BUILT DOWDEN'S POINT BREAKWATER SHT 1 OF 6

Rev. L2

2021.11.10/11:16am



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L2	01	06-JAN-2016	CLIENT REVIEW
L1	00	27-NOV-2015	CLIENT REVIEW

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01	06-JAN-2016	SECTIONS REMOVED			
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A1B 2C7
PHONE: (709) 726-9095 FAX: (709) 726-9106

DESIGNED	APPROVED (Discipline Lead Engineer)
DRAWN SJ	APPROVED (Engineering Manager)
VERIFIED GH	
DATE 27-NOV-2015	SCALE NTS

CLIENT: nalcor energy LOWER CHURCHILL PROJECT

PROJECT: LOWER CHURCHILL PROJECT

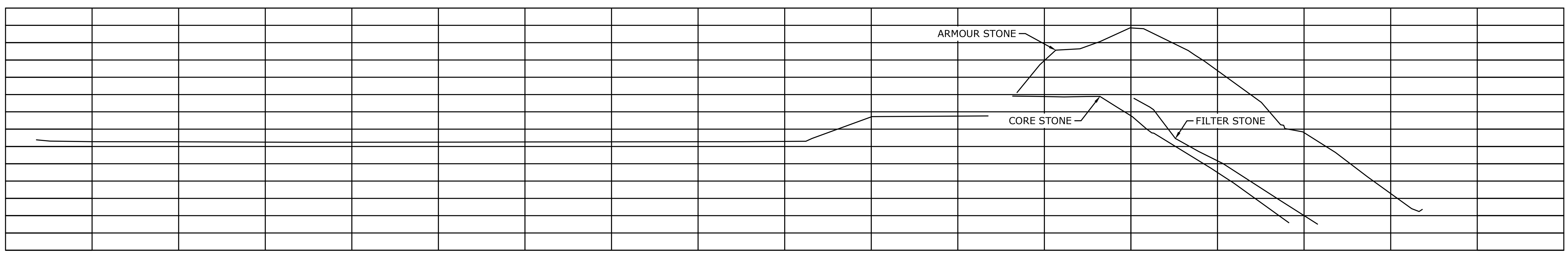
TITLE: AS-BUILT DOWDEN'S POINT BREAKWATER SHT 2 OF 6

SUPPLIER DOC No. ES-CD0508001-01-AB-0010-002_01

NE DOC No. ILK-HJ-SD-8620-CV-B02-0003-02

Rev. L2

2021.11.10/11:16am



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ISSUE	REV.	DATE	DISTRIBUTION & STATUS
L2	01	06-JAN-2016	CLIENT REVIEW
L1	00	27-NOV-2015	CLIENT REVIEW

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A1B 2C7
PHONE: (709) 726-9095 FAX: (709) 726-9106

DESIGNED | APPROVED (Discipline Lead Engineer)

DRAWN SJ | APPROVED (Engineering Manager)

VERIFIED GH

DATE 27-NOV-2015 | SCALE NTS

CLIENT: nalcor energy

PROJECT: LOWER CHURCHILL PROJECT

TITLE: AS-BUILT DOWDEN'S POINT BREAKWATER SHT 3 OF 6

SUPPLIER DOC No. ES-CD0508001-01-AB-0010-003_01 | NE DOC No. ILK-HJ-SD-8620-CV-B02-0003-03 | Rev. L2

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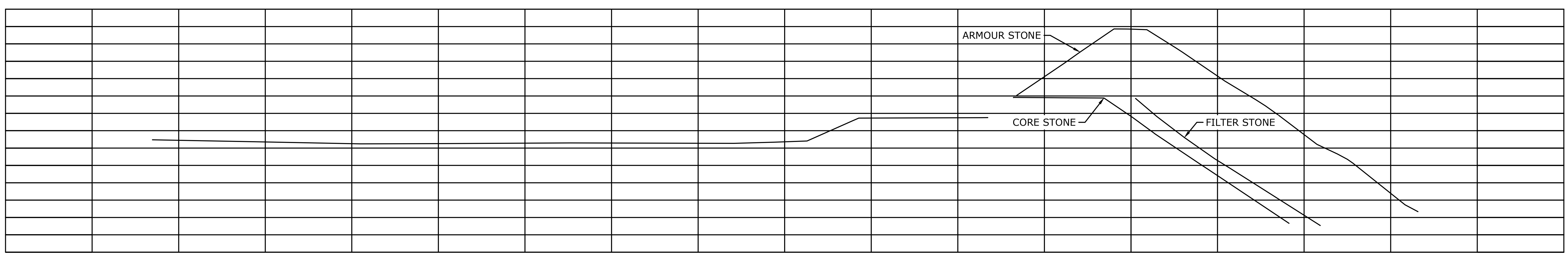

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L2	01	06-JAN-2016	CLIENT REVIEW
L1	00	27-NOV-2015	CLIENT REVIEW

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DESIGNED | APPROVED (Discipline Lead Engineer)

DRAWN SJ | APPROVED (Engineering Manager)

VERIFIED GH

DATE 27-NOV-2015 | SCALE NTS

CLIENT nalcor energy

PROJECT LOWER CHURCHILL PROJECT

TITLE AS-BUILT DOWDEN'S POINT BREAKWATER SHT 4 OF 6

SUPPLIER DOC No. ES-CD0508001-01-AB-0010-004_01

NE DOC No. ILK-HJ-SD-8620-CV-B02-0003-04

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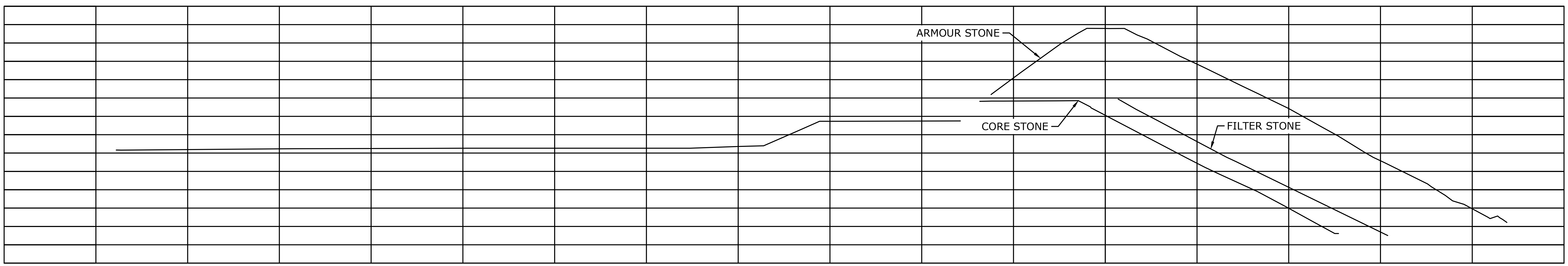

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ISSUE	REV.	DATE	DISTRIBUTION & STATUS
L2	01	06-JAN-2016	CLIENT REVIEW
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A1B 2C7
PHONE: (709) 726-9095 FAX: (709) 726-9106

DESIGNED | APPROVED (Discipline Lead Engineer)

DRAWN SJ | APPROVED (Engineering Manager)

VERIFIED GH

DATE 06-JAN-2016 | SCALE NTS

CLIENT nalcor energy

PROJECT LOWER CHURCHILL PROJECT

TITLE AS-BUILT DOWDEN'S POINT BREAKWATER SHT 5 OF 6

SUPPLIER DOC No. ES-CD0508001-01-AB-0010-005_00

NE DOC No. ILK-HJ-SD-8620-CV-B02-0003-05

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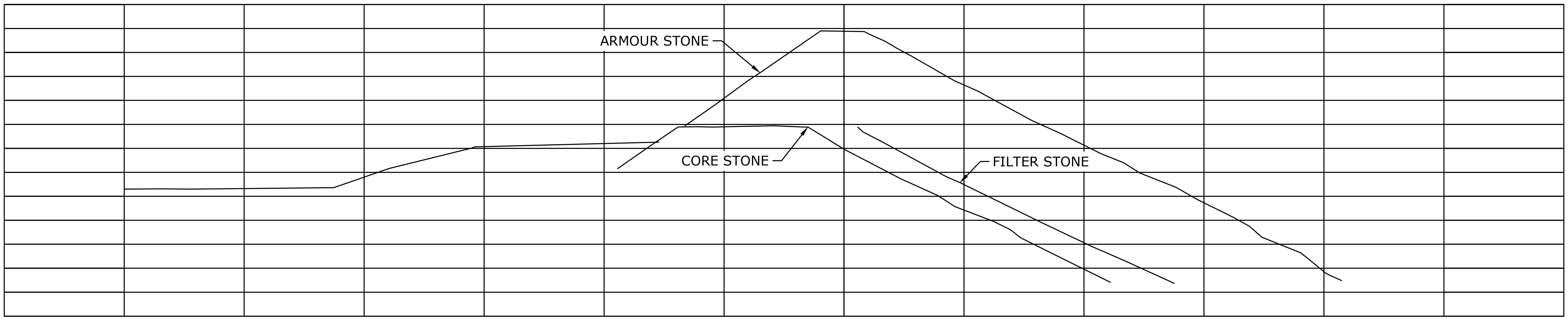

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L1	00	06-JAN-2016	CLIENT REVIEW

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PHONE: (709) 726-9095 FAX: (709) 726-9106

DESIGNED

APPROVED (Discipline Lead Engineer)

DRAWN SJ

APPROVED (Engineering Manager)

VERIFIED GH

DATE 06-JAN-2016

SCALE NTS

CLIENT nalcor energy

PROJECT LOWER CHURCHILL PROJECT

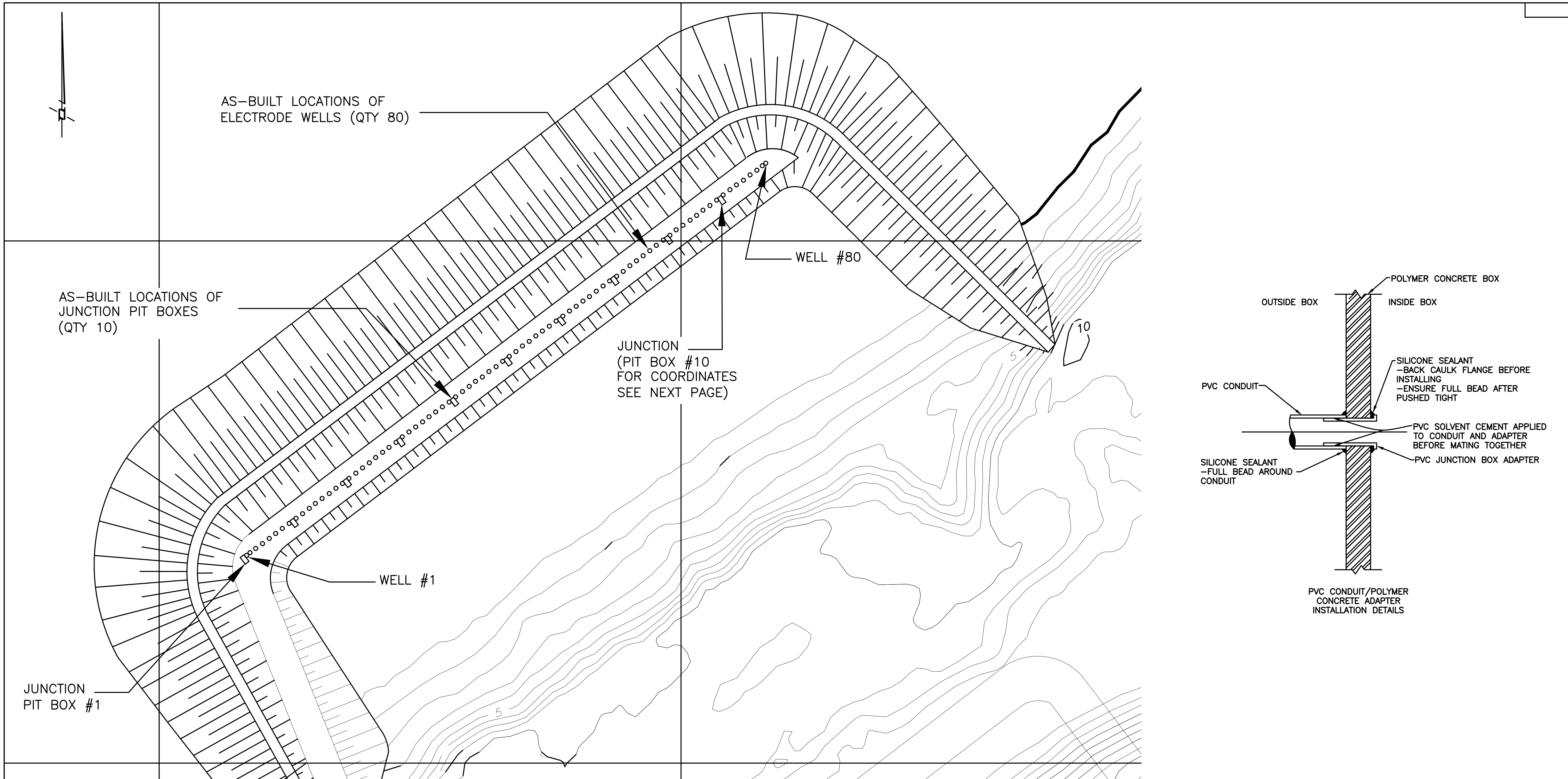
TITLE AS-BUILT DOWDEN'S POINT BREAKWATER SHT 6 OF 6

SUPPLIER DOC No. ES-CD0508001-01-AB-0010-006_00

NE DOC No. ILK-HJ-SD-8620-CV-B02-0003-06

Rev. L2

2021.11.10/11:17am



SITE/SURVEY NOTES:
1. SITEPLAN WAS COMPLETED ON: 2015/09/23.
2. ALL DISTANCES ARE SHOWN IN METRES AND DECIMAL PLACES THEREOF, UNLESS SPECIFIED OTHERWISE ON PLAN.
3. SURVEY BASED ON CONTROL PROVIDED BY NALCOR. BENCHMARKS 13DP001, 13DP002 AND 83G3230. COORDINATES ARE REFERENCED TO NAD 83 UTM ZONE 22. ALL ELEVATIONS ARE GEODECTIC UNLESS NOTED OTHERWISE.
4. SEE SHEET 2 FOR AS–BUILT INFORMATION FOR EACH ELECTRODE WELL AND JUNCTION PIT BOX LOCATION.

***** DATUM REFERENCE: *ALL ELEVATIONS ARE IN METRES REFERENCED TO GEODETIC.* COORDINATE REFERENCE: *UTM 6° (UNIVERSAL TRANSVERSE MERCATOR) PROJECTION, NAD83, ZONE 22 CENTRAL MERIDIAN 57° 00' W LONGITUDE.* *****

ISSUE	REV.	DATE	DISTRIBUTION & STATUS
L2	01	06–DEC–2016	CLIENT REVIEW
L1	00	30–NOV–2015	CLIENT REVIEW

ISSUE REGISTER

No.	REFERENCE DRAWING

No.	DATE	REVISION	MOD.	VER.	APP.
01	06–DEC–2016	ADD NOTES			
00	30–NOV–2015	FINAL AS–BUILT			

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LEAD REVIEWER: Date (dd-mmm-yyyy):

NE-LCP MANAGEMENT: Date (dd-mmm-yyyy):

PROJECT MANAGER: Date (dd-mmm-yyyy):

PROFESSIONAL STAMP

H.J. O'CONNELL CONSTRUCTION LTD.
90 O'LEARY AVENUE, 1ST FLOOR
ST. JOHN'S, NEWFOUNDLAND & LABRADOR
A1B 2C7
PHONE: (709) 726-6086 FAX: (709) 726-8109

CLIENT: nalcor energy

DESIGNED | APPROVED (Discipline Lead Engineer)

PROJECT: LOWER CHURCHILL PROJECT

DRAWN: GH

APPROVED (Engineering Manager)

VERIFIED: GH

TITLE: AS–BUILT – DOWDEN'S POINT ELECTRODE WELLS & JUNCTION BOX LOCATIONS SHT 1 OF 2

DATE: 06–JAN–2016 | SCALE: NTS

SUPPLIER DOC No.: ES–CD0508001–01–AB–0011–001_01

NE DOC No.: ILK–HJ–SD–8620–CV–B02–0004–01

Rev.: L2

2021.11.10/11:19am

POINT TABLE - ELECTRODE WELLS

Point Number	Northing	Easting	Elevation
1	5259939.779	343416.778	2.438
2	5259940.293	343417.414	2.463
3	5259941.099	343418.517	2.453
4	5259942.026	343419.81	2.43
5	5259943.023	343421.109	2.376
6	5259943.961	343422.33	2.39
7	5259944.948	343423.599	2.359
8	5259945.9	343424.906	2.386
9	5259946.876	343426.234	2.613
10	5259947.757	343427.498	2.298
11	5259948.781	343428.782	2.386
12	5259949.713	343429.951	2.371
13	5259950.675	343431.238	2.37
14	5259951.633	343432.6	2.408
15	5259952.639	343433.88	2.355
16	5259953.534	343435.145	2.376
17	5259954.536	343436.383	2.381
18	5259955.532	343437.7	2.387
19	5259956.539	343438.972	2.377
20	5259957.508	343440.284	2.398

POINT TABLE - ELECTRODE WELLS

Point Number	Northing	Easting	Elevation
21	5259958.513	343441.5	2.392
22	5259959.517	343442.837	2.361
23	5259960.459	343444.053	2.396
24	5259961.403	343445.392	2.385
25	5259962.473	343446.594	2.374
26	5259963.425	343447.88	2.378
27	5259964.359	343449.164	2.477
28	5259965.349	343450.488	2.357
29	5259966.328	343451.725	2.4
30	5259967.253	343452.988	2.305
31	5259968.218	343454.277	2.389
32	5259969.129	343455.576	2.357
33	5259970.123	343456.806	2.41
34	5259971.168	343458.135	2.414
35	5259972.134	343459.42	2.398
36	5259973.104	343460.615	2.413
37	5259973.933	343461.946	2.379
38	5259974.982	343463.199	2.396
39	5259975.905	343464.581	2.394
40	5259976.946	343465.833	2.416

POINT TABLE - JUNCTION PIT BOXES

Point Number	Northing	Easting	Elevation
1	5259938.376	343416.851	2.62
2	5259945.385	343426.3459	2.633
3	5259953.05	343436.5222	2.632
4	5259960.826	343446.7672	2.604
5	5259968.555	343457.031	2.617
6	5259976.278	343467.3051	2.649
7	5259984.028	343477.5665	2.632
8	5259991.737	343487.7593	2.627
9	5259999.578	343498.0912	2.607
10	5260007.122	343508.1764	2.607

POINT TABLE - ELECTRODE WELLS

Point Number	Northing	Easting	Elevation
41	5259977.887	343467.099	2.405
42	5259978.803	343468.362	2.4
43	5259979.887	343469.621	2.397
44	5259980.763	343470.922	2.396
45	5259981.812	343472.184	2.387
46	5259982.735	343473.44	2.392
47	5259983.678	343474.762	2.356
48	5259984.645	343476.067	2.364
49	5259985.606	343477.365	2.388
50	5259986.581	343478.631	2.395
51	5259987.475	343479.924	2.379
52	5259988.482	343481.21	2.38
53	5259989.347	343482.465	2.368
54	5259990.366	343483.758	2.416
55	5259991.377	343485.07	2.41
56	5259992.332	343486.33	2.366
57	5259993.226	343487.668	2.419
58	5259994.163	343488.934	2.45
59	5259995.25	343490.199	2.38
60	5259996.191	343491.46	2.396

POINT TABLE - ELECTRODE WELLS

Point Number	Northing	Easting	Elevation
61	5259997.159	343492.745	2.396
62	5259998.127	343494.023	2.361
63	5259999.163	343495.271	2.369
64	5260000.167	343496.61	2.375
65	5260001.076	343497.872	2.359
66	5260002.123	343499.065	2.375
67	5260002.994	343500.378	2.402
68	5260003.981	343501.754	2.381
69	5260004.885	343502.998	2.379
70	5260005.882	343504.211	2.378
71	5260006.781	343505.537	2.349
72	5260007.823	343506.831	2.385
73	5260008.805	343508.066	2.452
74	5260009.806	343509.384	2.392
75	5260010.738	343510.625	2.346
76	5260011.624	343511.975	2.401
77	5260012.643	343513.239	2.393
78	5260013.552	343514.536	2.54
79	5260014.398	343515.59	2.407
80	5260014.891	343516.244	2.347

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4. SEE SHEET 2 FOR AS-BUILT INFORMATION FOR EACH ELECTRODE WELL AND JUNCTION PIT BOX LOCATION.

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ISSUE	REV.	DATE	DISTRIBUTION & STATUS
L2	01	06-JAN-2016	CLIENT REVIEW
L1	00	30-NOV-2015	CLIENT REVIEW

ISSUE REGISTER | No. | REFERENCE DRAWING

No.	DATE	REVISION	MOD.	VER.	APP.
01	06-JAN-2016	UPDATE TABLES			
00	30-NOV-2015	FINAL AS-BUILT			

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PROFESSIONAL STAMP

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90 O'LEARY AVENUE, 1ST FLOOR
ST. JOHN'S, NEWFOUNDLAND & LABRADOR
A1B 2C7
PHONE (709) 726-8055 FAX (709) 726-8106

DESIGNED | APPROVED (Discipline Lead Engineer)
DRAWN GH | APPROVED (Engineering Manager)
VERIFIED GH
DATE 06-JAN-2016 | SCALE NTS
SUPPLIER DOC No. ES-CD0508001-01-AB-0011-002_01

CLIENT nalcor energy LOWER CHURCHILL PROJECT
PROJECT LOWER CHURCHILL PROJECT
TITLE AS-BUILT – DOWDEN'S POINT ELECTRODE WELLS & JUNCTION BOX LOCATIONS SHT 2 OF 2
NE DOC No. ILK-HJ-SD-8620-CV-B02-0004-02 | Rev. L2

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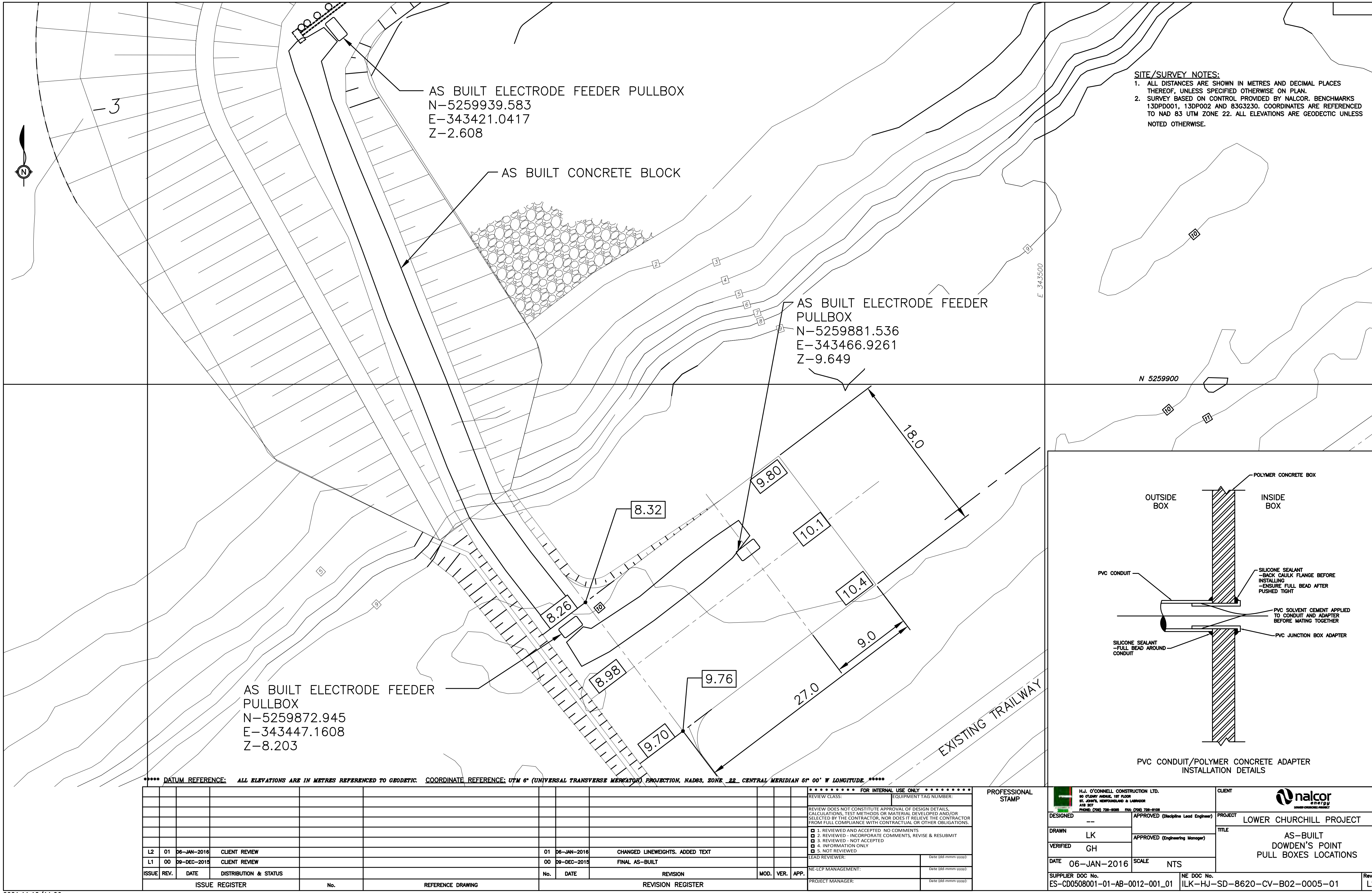

AS BUILT ELECTRODE FEEDER PULLBOX
N-5259939.583
E-343421.0417
Z-2.608
AS BUILT CONCRETE BLOCK
AS BUILT ELECTRODE FEEDER PULLBOX
N-5259881.536
E-343466.9261
Z-9.649
AS BUILT ELECTRODE FEEDER PULLBOX
N-5259872.945
E-343447.1608
Z-8.203
E 343500
N 5259900
18.0
9.80
10.1
10.4
9.0
27.0
8.32
8.26
8.98
9.76
9.70
EXISTING TRAILWAY
SITE/SURVEY NOTES:
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OUTSIDE BOX
INSIDE BOX
POLYMER CONCRETE BOX
PVC CONDUIT
SILICONE SEALANT -BACK CAULK FLANGE BEFORE INSTALLING -ENSURE FULL BEAD AFTER PUSHED TIGHT
PVC SOLVENT CEMENT APPLIED TO CONDUIT AND ADAPTER BEFORE MATING TOGETHER
PVC JUNCTION BOX ADAPTER
SILICONE SEALANT -FULL BEAD AROUND CONDUIT
PVC CONDUIT/POLYMER CONCRETE ADAPTER INSTALLATION DETAILS
***** DATUM REFERENCE: ALL ELEVATIONS ARE IN METRES REFERENCED TO GEODETIC. COORDINATE REFERENCE: UTM 6° (UNIVERSAL TRANSVERSE MERCATOR) PROJECTION, NAD83, ZONE 22, CENTRAL MERIDIAN 57° 00' W LONGITUDE. *****
L2 01 06-JAN-2016 CLIENT REVIEW
L1 00 09-DEC-2015 CLIENT REVIEW
ISSUE REV. DATE DISTRIBUTION & STATUS
ISSUE REGISTER
No. REFERENCE DRAWING
01 06-JAN-2016 CHANGED LINEWEIGHTS. ADDED TEXT
00 09-DEC-2015 FINAL AS-BUILT
No. DATE REVISION MOD. VER. APP.
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DESIGNED --
DRAWN LK
VERIFIED GH
DATE 06-JAN-2016
APPROVED (Discipline Lead Engineer)
APPROVED (Engineering Manager)
SCALE NTS
CLIENT nalcor energy
PROJECT LOWER CHURCHILL PROJECT
TITLE AS-BUILT DOWDEN'S POINT PULL BOXES LOCATIONS
SUPPLIER DOC No. ES-CD0508001-01-AB-0012-001_01
NE DOC No. ILK-HJ-SD-8620-CV-B02-0005-01
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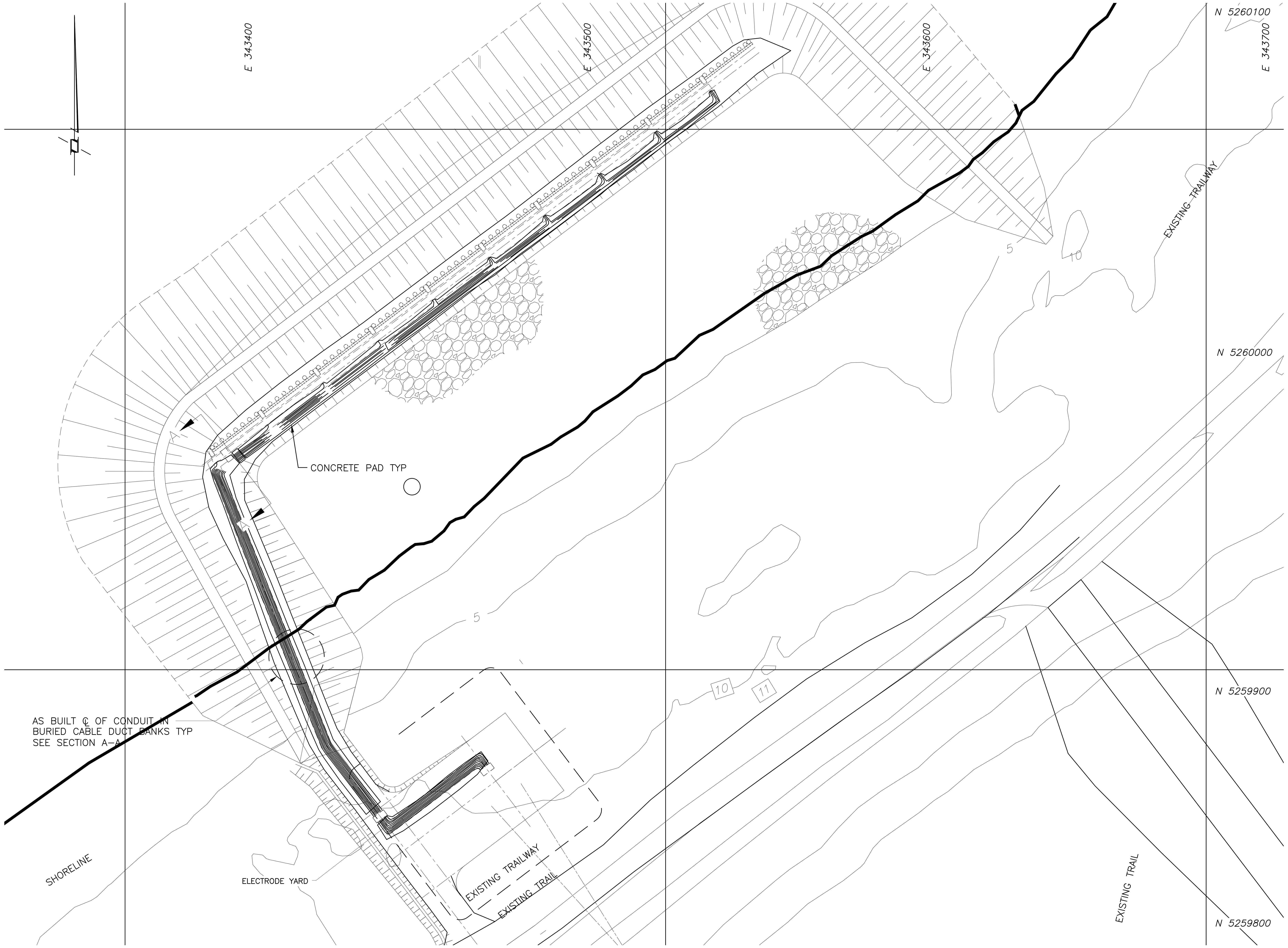

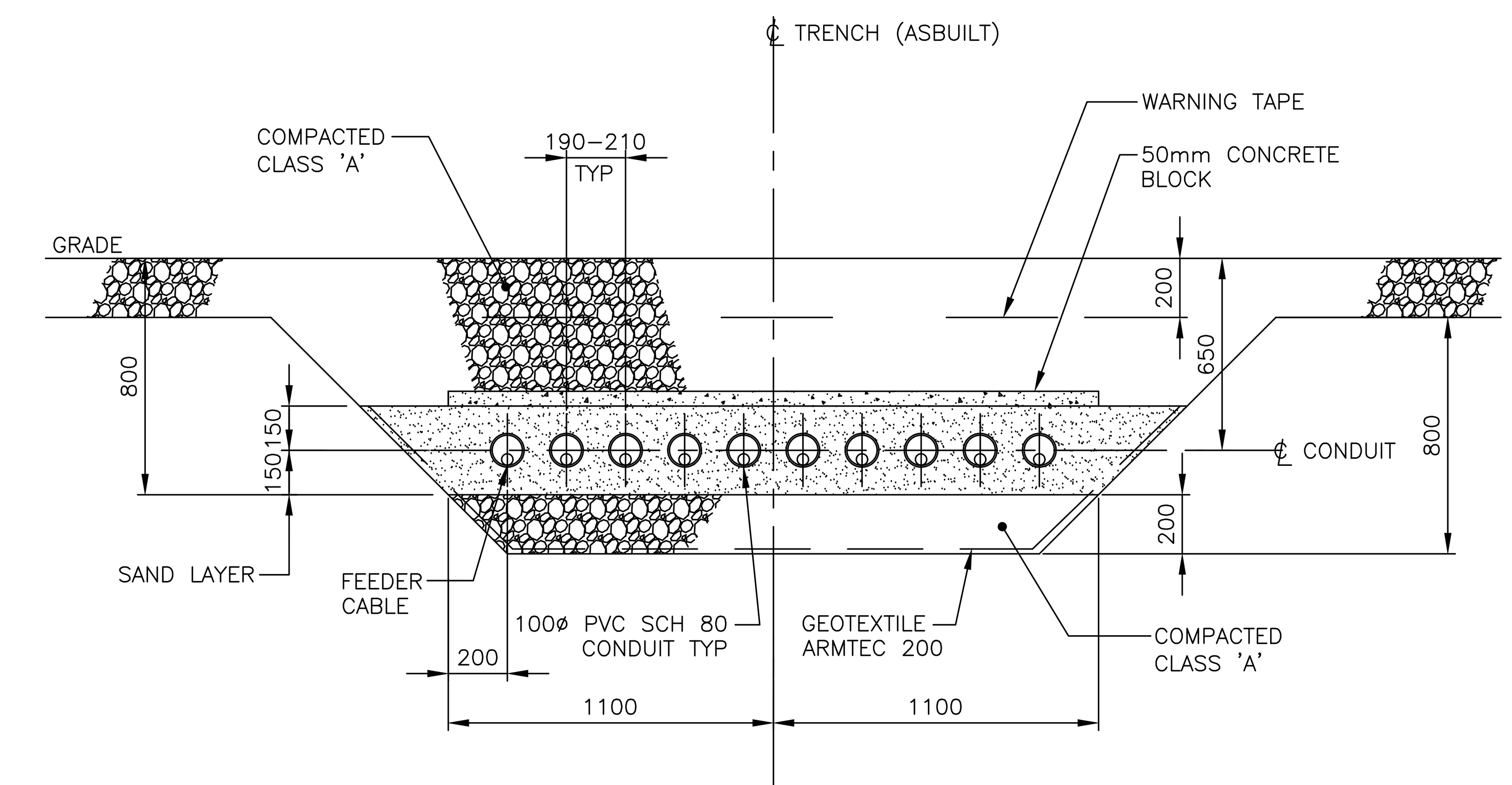

SECTION A-A

TYPICAL BURIED CABLE DUCTBANK

LEGEND:

- SHORELINE
- 6 — TOPOGRAPHIC CONTOUR (GEODETIC)
- -2 — BATHYMETRIC CONTOUR (CHART)
- EMBANKMENT SLOPE
- BURIED CABLE DUCT BANKS
- N 5712233.190 / E 517222.110 — ASBUILT COORDINATES SYSTEM (NORTHING & EASTING)

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4. SEE SHEET 2 FOR AS-BUILT INFORMATION FOR EACH ELECTRODE WELL AND JUNCTION PIT BOX LOCATION.
5. SHOTS TAKEN ON TOP OF CONDUIT.

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L2	01	06-DEC-2016	CLIENT REVIEW
L1	00	25-NOV-2015	CLIENT REVIEW

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No.	REFERENCE DRAWING

REVISION REGISTER

No.	DATE	REVISION	MOD.	VER.	APP.
01	06-DEC-2016	REMOVED SECTION, UPDATED NOTES			
00	25-NOV-2015	FINAL AS-BUILT			

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PROJECT MANAGER: Date (dd-mmm-yyyy):

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ST. JOHN'S, NEWFOUNDLAND & LABRADOR
A1B 2C7
PHONE: (709) 726-9095 FAX: (709) 726-9106

DESIGNED | APPROVED (Discipline Lead Engineer)

DRAWN LK | APPROVED (Engineering Manager)

VERIFIED GH

DATE 06-DEC-2015 | SCALE NTS

CLIENT: nalcor energy — LOWER CHURCHILL PROJECT

PROJECT: LOWER CHURCHILL PROJECT

TITLE: AS-BUILT DOWDEN'S POINT BURIED CONDUIT

SUPPLIER DOC No. ES-CD0508001-01-AB-0013-001_01

NE DOC No. ILK-HJ-SD-8620-CV-B02-0006-01

Rev. L2

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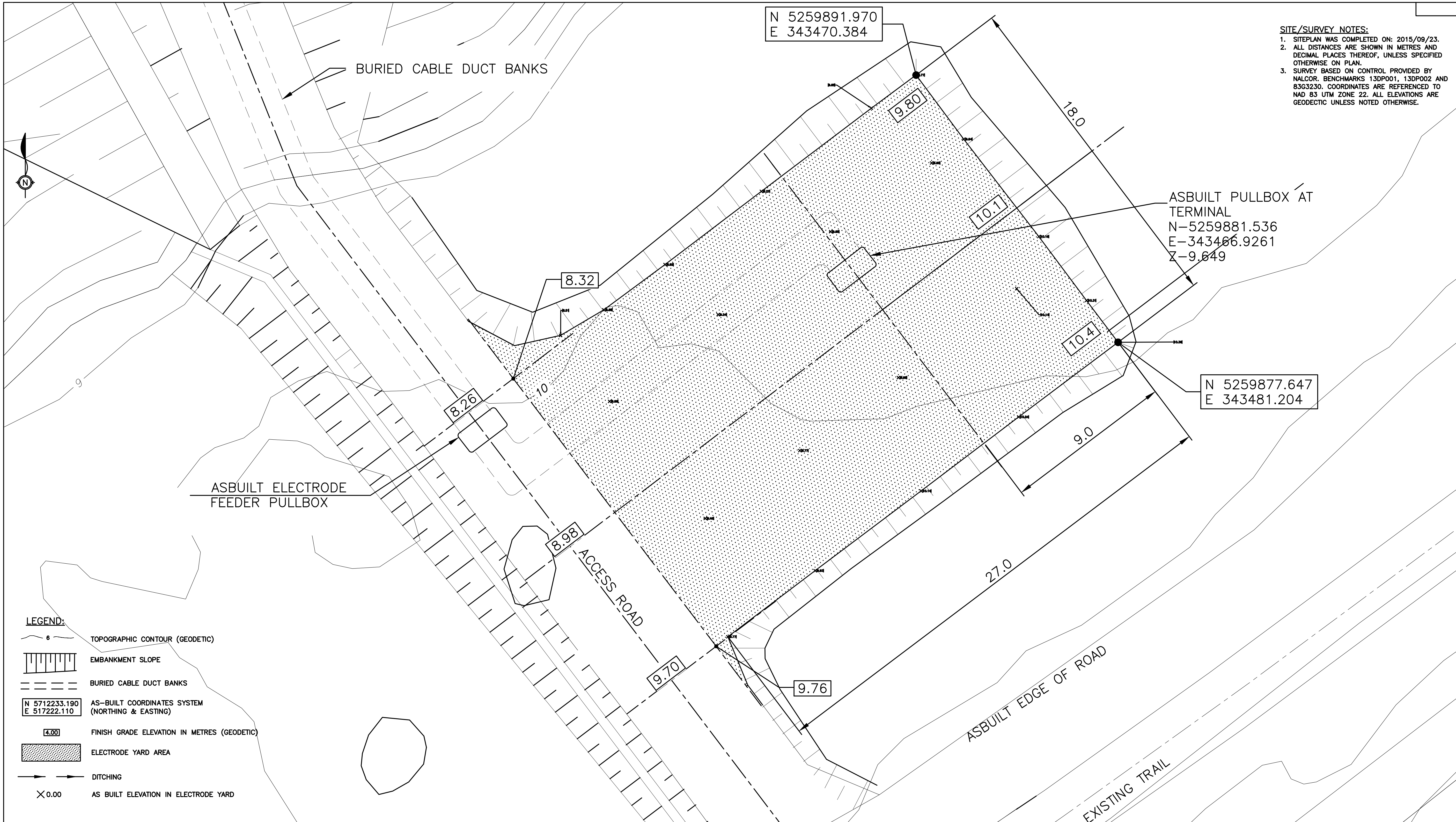

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LEGEND:

- 6 — TOPOGRAPHIC CONTOUR (GEODETIC)
- EMBANKMENT SLOPE
- BURIED CABLE DUCT BANKS
- N 5712233.190 E 517222.110 — AS-BUILT COORDINATES SYSTEM (NORTHING & EASTING)
- 4.00 — FINISH GRADE ELEVATION IN METRES (GEODETIC)
- ELECTRODE YARD AREA
- DITCHING
- X 0.00 — AS BUILT ELEVATION IN ELECTRODE YARD

***** DATUM REFERENCE: *ALL ELEVATIONS ARE IN METRES REFERENCED TO GEODETIC.* COORDINATE REFERENCE: *UTM 6° (UNIVERSAL TRANSVERSE MERCATOR) PROJECTION, NAD83, ZONE 22, CENTRAL MERIDIAN 51° 00' W LONGITUDE.* *****

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00	30-NOV-2015	FINAL AS-BUILT			

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NE-LCP MANAGEMENT: Date (dd-mmm-yyyy):

PROJECT MANAGER: Date (dd-mmm-yyyy):

PROFESSIONAL STAMP

H.J. O'CONNELL CONSTRUCTION LTD.

DESIGNED	--	APPROVED (Discipline Lead Engineer)
DRAWN	LK	APPROVED (Engineering Manager)
VERIFIED	GH	
DATE	06-DEC-2016	SCALE NTS

CLIENT: nalcor energy

PROJECT: LOWER CHURCHILL PROJECT

TITLE: AS-BUILT DOWDEN'S POINT ELECTRODE YARD

SUPPLIER DOC No.: ES-CD0508001-01-AB-0014-001_01

NE DOC No.: ILK-HJ-SD-8620-CV-B02-0007-01

Rev.: L2

2021.11.10/11:32am

Appendix D: Fill Placement Checklist

List of Documents:
ILK-HJ-SD-8610-CV-R02-0005-01
Pg. 356 & 357

O'CONNELL BIRD

CHECKLIST - FILL PLACEMENT

CONTRACTOR: HJOC	STRUCTURE: Breakwater	DATE: July 23rd/15 SHEET 1 OF 1
CLIENT: NALCOR	LOCATION: L'Anse A Diable	WEATHER: Cloudy, Cold
CONTRACT NO.: CD0508	ELEVATION: Init.: Varies Final: Varies	SHIFT: Night ☐ Day ☑

AREA: ☑ Breakwater ☐ ☐ ☐ ☐ ☐ ☐ ☐

REFERENCE DRAWINGS:

Footing ☐ Grade Wall ☐ Pier ☐ Slab ☐ Other ☑

DESCRIPTION: PLACEMENT OF ARMOUR IN Breakwater

NO.	ITEMS TO BE INSPECTED	TESTING AGENCY (As Req)	HJOC	CLIENT REP (As Req)
1	Placement on approved foundation or lift and alignment		NH	R.J.
2	Fill materials conforming to specification requirements		NH	R.J.
3	Sampling for gradation tests as per specification		N/A	N/A
4	Area free from snow, ice and debris. Frost protection measures in place if required		NH	R.J.
5	Lift thickness as per drawings and/or specification		NH	R.J.
6	Placement of material to lines and grades		NH	R.J.
7	Control of material segregation		NH	R.J.
8	Placement provided homogeneous embankment and structures		NH	R.J.
9	Compaction as per specification requirements		N/A	N/A
10	QC survey conducted and reviewed, as-built completed		N/A	N/A
11	Corrective measures as required		N/A	N/A

OBSERVATIONS

DEFICIENCIES

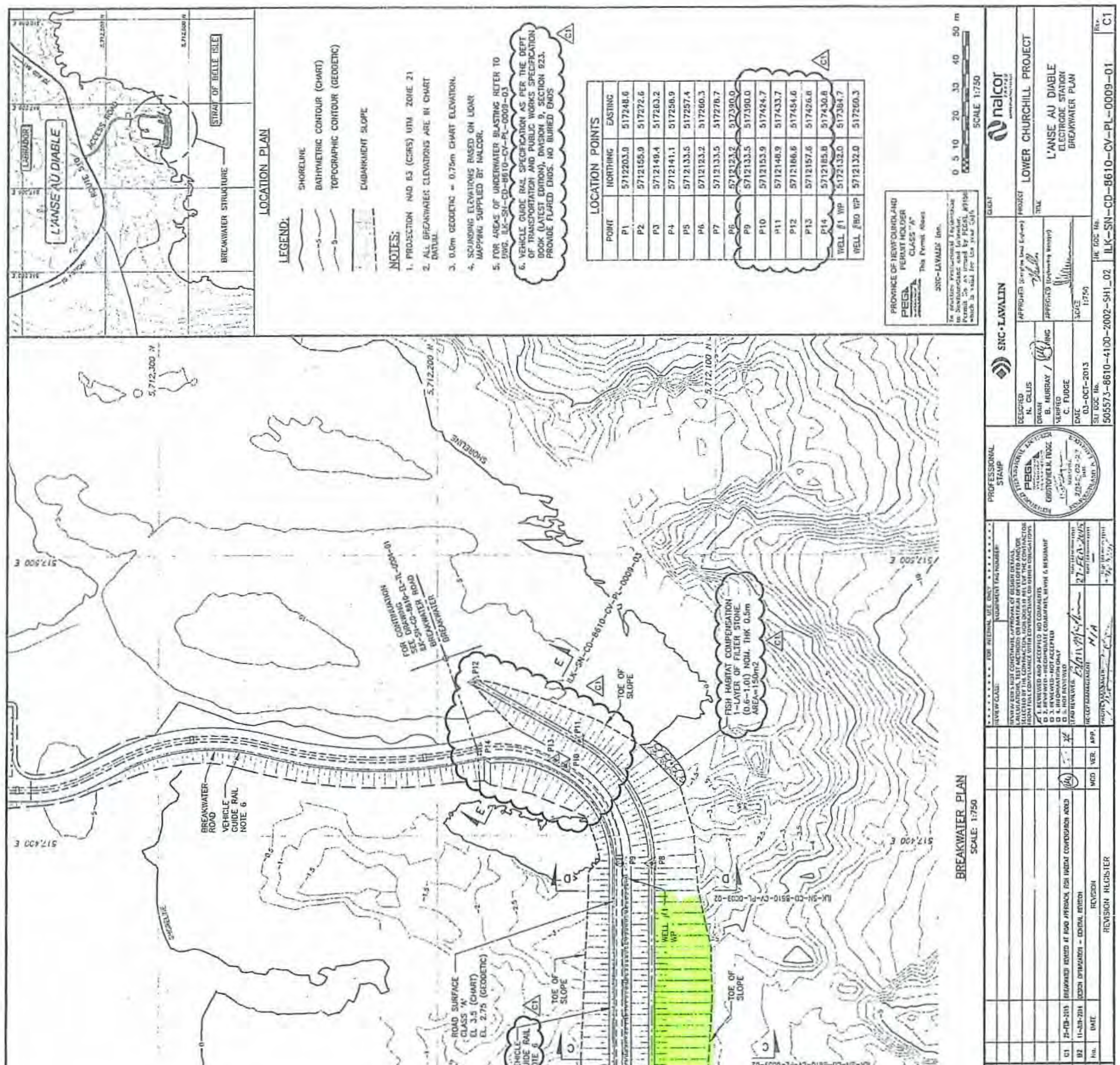
CORRECTED:

NAME: SIGNATURE: DATE:

EQUIPMENT USED: 2x 390, 2 or 3 x 769, 988

REMARKS: - As built w/ 390
- Be aware of Rock sizes.

HJOC FIELD REPRESENTATIVE	**CLIENT REPRESENTATIVE**
NAME: NATHAN HIGGINS	NAME: Bob Tobin
SIGNATURE: [signature]	SIGNATURE: Robert Tobin
DATE: July 23rd/15	DATE: JULY 23-2015


L'ANSE AU DIABLE
LOCATION PLAN
LEGEND:
NOTES:
LOCATION POINTS
BREAKWATER PLAN
SCALE: 1:750
WATERS OF STRAIT OF BELLE ISLE
SNC·LAVALIN
nalcor
LOWER CHURCHILL PROJECT
L'ANSE AU DIABLE
ELECTRODE STATION
BREAKWATER PLAN
REVISION REGISTER
REFERENCE DRAWING