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July 30, 2019

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: Application for Approval of Capital Expenditures to Complete a Level II Condition Assessment on Penstocks 1 and 2, and a Report on Penstocks 1, 2, and 3 at the Bay d'Espoir Hydroelectric Generating Station ("Bay d'Espoir") – Bay d'Espoir Condition Assessment and Refurbishment Options for Penstocks No. 1, 2, and 3, Report 3 of 3.

Following significant refurbishment works on Bay d'Espoir Penstocks 1 and 2 during 2016 and 2017, Newfoundland and Labrador Hydro ("Hydro") launched a comprehensive review of Bay d'Espoir Penstocks 1, 2, and 3. The objective of this review was to provide a thorough assessment of the current condition of all three penstocks, validate the condition of the penstocks for current operations, and review the need and options for life extension works.

This review was completed through three separate reports produced by an external engineering consultant, Hatch Ltd. ("Hatch"), in conjunction with Hydro:

1. Report 1: "Bay d'Espoir Level II Condition Assessment of Penstocks No. 1, 2, and 3," was filed with the Board of Commissioners of Public Utilities ("Board") on December 17, 2018;
2. Report 2: "Condition Assessment and Refurbishment Options for Penstocks No. 1, 2, and 3," was filed with the Board on March 29, 2019; and
3. Report 3: "Penstocks No. 1, 2, and 3 Life Extension Options," is attached to this letter. [1] The life extension alternatives reviewed in Report 3 are the three most viable options selected by Hydro from the alternatives presented in Report 2. Each conceptual review is accompanied by an Association for Advancement of Cost Engineering Class 4 capital cost estimate. Information regarding recommended maintenance activities is provided and can be used by Hydro to determine total life cycle costs for each alternative.

The three refurbishment alternatives presented in Report 2, and selected by Hydro for further development in the attached Report 3, are:

- Option 1:
    - Full refurbishment of all deteriorated longitudinal and circumferential weld seams over the length of Penstocks 1, 2, and 3;

[1] The redactions in Appendix A of Report 3 were applied by Hatch prior to providing the report to Hydro.

- Application of an interior protective coating along the full length of all three penstocks to protect against corrosion;

- Option 2B:
  - Replacement of the existing 17' diameter sections of Penstocks 1, 2, and 3 with new 17' diameter penstock sections, designed in accordance with current design standards;
  - Refurbishment of all deteriorated longitudinal and circumferential welds for the remainder of Penstocks 1, 2, and 3;
  - Application of an interior protective coating along the full length of all three penstocks to protect against corrosion; and
- Option 4:[2]
  - Full refurbishment of all deteriorated longitudinal and circumferential weld seams over the length of Penstocks 1, 2, and 3;
  - Installation of welded steel plates along the interior of the longitudinal weld seams in the 17' diameter portions of Penstocks 1, 2, and 3 to reinforce these regions; and
  - Application of an interior protective coating along the full length of all three penstocks to protect against corrosion.

The major findings contained in Report 3 are as follows:

- The currently conservative estimated capital costs of the selected alternatives are:
  - $79.7 million for Option 1;
  - $150.0 million for Option 2B;
  - $105.3 million for Option 4; and
- Option 1 was recommended by the consultant as the preferred refurbishment approach following a review of the three selected alternatives.

The refurbishment costs outlined in Report 3, Option 1 were higher than the refurbishment costs estimated in Report 2. Although the Report 3 costs were Association for Advancement of Cost Engineering Class 4 estimates, a number of assumptions were required, most notably an estimate of the length of the circumferential welds that must be refurbished. The assumed refurbishment length is based on the findings of the condition assessment; however, the circumferential weld refurbishment constitutes a significant portion of the work to be completed and variation in the estimated weld refurbishment length can have a material impact on the overall project cost. As the estimated percentage of circumferential weld refurbishment is consistent between the three reviewed refurbishment alternatives, this assumption would not alter the recommended refurbishment alternative. Additional engineering is required to validate the scope and estimate as well as explore various execution strategies to determine an appropriate capital investment strategy. For this reason the Report 2 estimate has been included in the 2020 Capital Budget Application.

During 2017 and 2018 the engineering consultant made a number of recommendations for the future of the Bay d'Espoir penstocks, namely:

[2] This alternative was modified by Hydro from the one presented in Report 2. The modification is to install the reinforcing steel plates within the 17' diameter sections of the penstocks, rather than along the full length of all three penstocks. This modification was endorsed by the consultant.

- A thorough condition assessment should be performed on Penstocks 1, 2, and 3 in 2018;
- Critical life extension work is recommended within the next three to five years; and
- Annual internal inspections should be performed on the penstocks to monitor for any change in the penstock condition until such time as the life extension work is completed.

Hydro has acted upon these recommendations as follows:

- A thorough condition assessment was performed on Penstocks 1, 2, and 3 in 2018;
- With the capital cost and maintenance information provided within Report 3, Hydro will develop total life-cycle costs for the three alternatives to determine the preferred approach for ensuring the continued delivery of least-cost, reliable power from Bay d'Espoir. These life extension works for the penstocks will be incorporated into Hydro's five-year and 20-year capital plan, as necessary; and
- Annual penstock inspections are scheduled in Hydro's 2019 work plan and will be included in future work plans until the life extension work is complete. The timing is incorporated in Hydro's annual planned generation outage schedule.

The condition assessments and reports on Bay d'Espoir Penstocks 1, 2, and 3, as approved in Board Order No. P.U. 23(2018) are now complete. Based on this recommendation, Hydro is developing updated plans for this refurbishment work, which will be proposed in Hydro's 2021 Capital Budget Application. Hydro intends to carefully review the proposed refurbishment project to investigate cost efficiencies and ensure work is completed in the most cost effective manner.

Should you have any questions, please contact the undersigned.

Yours truly,

NEWFOUNDLAND & LABRADOR HYDRO

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Senior Legal Counsel, Regulatory
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Encl.

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Newfoundland and Labrador Hydro

Final Report

For

Penstock No.'s 1, 2 and 3 Life Extension Options

H357395-00000-240-066-0003
Rev. 0
July 26, 2019

Newfoundland and Labrador Hydro

Final Report

For

Penstock No.'s 1, 2 and 3 Life Extension Options

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Penstock No.'s 1, 2 and 3 Life Extension Options

H357395-00000-240-066-0003

PROVINCE OF NEWFOUNDLAND AND LABRADOR
PEG Newfoundland and Labrador
PERMIT HOLDER
This Permit Allows
HATCH LTD
MIRC #: 01626
To practice Professional Engineering
in Newfoundland and Labrador.
Permit No. as issued by PEG D0090
which is valid for the year 2019

REGISTERED PROFESSIONAL ENGINEER
ANTHONY CHISLETT
SIGNATURE
26-07-2019
DATE
NEWFOUNDLAND & LABRADOR

2019-07-26	0	Approved for Use	K. O'Grady	Z. Kenneally, T. Chislett	G. Saunders
DATE	REV.	STATUS	PREPARED BY	CHECKED BY	APPROVED BY

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Executive Summary

Newfoundland and Labrador Hydro (NL Hydro) engaged Hatch to conduct a condition assessment of Penstock No.'s 1, 2, and 3 at the Bay d'Espoir Hydroelectric Generating Facility during the 2018 operating season. Due to the nature of the 2018 outage schedule and NL Hydro's reporting requirements for items such as winter readiness and capital budget applications, the Condition Assessment report was developed in three phases, as shown below.

Report 1 – Bay d'Espoir Level II Condition Assessment of Penstock No.'s 1, 2 and 3.

Report 2 – Condition Assessment and Refurbishment Options for Penstock No.'s 1, 2 and 3.

Report 3 – Penstock No.'s 1, 2 and 3 Life Extension Options.

All three penstocks were inspected as part of a Level II Condition Assessment. Inspections and data collection included: detailed weld inspection, material testing, 3D scanning and water pressure monitoring.

The weld inspections consisted of, at a minimum, pressure washing, buffing, visually inspecting and magnetic particle inspection of the longitudinal welds at a frequency of 1 in every 10 cans for the total penstock length. The overview of the inspections consists of the following:

- Penstock No. 1 was inspected from August 13 to 24, 2018. Refurbished welds completed in 2016 and 2017 show no sign of additional degradation.
- Penstock No. 2 was inspected from September 17 to 28, 2018. Refurbished welds completed in 2017 show no sign of degradation.
- Penstock No. 3 was inspected from May 14 to June 21, 2018. This was the first detailed inspection carried out and extensive weld metal corrosion and cracking was discovered, similar to what was found during the earlier inspections of Penstocks No. 1 and No. 2 in 2016 and 2017. Approximately 1027 m (3369 ft) of internal weld refurbishment was completed on Penstock No. 3 in 2018.

Material samples were removed from Penstock No. 3 to determine the grade of steel and compare with samples removed from Penstock No. 1.

Laser scans were completed to create a more accurate 3D model of the penstock geometry. The data showed similar peaking in all three penstocks and consequently the FEA model results for Penstock No. 1 can be extrapolated to the similarly constructed Penstock No. 2 and No. 3. This geometric data is also valuable for future use should NL Hydro wish to review the penstocks for geometric changes, such as settlement.

In conjunction with the laser scans, pressure transducers were installed at key locations on all three penstocks and connected to a data logging device to assess any internal pressure transients. Data collection is currently on-going, and this data will be analyzed and compared to data obtained in 2017 on Penstock No. 1. To provide meaningful analysis, data collection needs to take place over a longer period of time, so trends can be observed. This data collection should continue until a life extension option is implemented for Penstock No.'s 1, 2, and 3. Hatch will provide a preliminary commentary based on the ongoing data collection. This data and analysis will be presented in a standalone document at a later date, however, this information is not expected to impact any of the findings or recommendations contained in this report.

The penstocks have been in service for approximately 50 years. These are aging assets and as such require regular inspection and maintenance. To ensure the reliable long-term operation of these assets, refurbishment is required. This report details the refurbishment options that were chosen by NL Hydro for further analysis by Hatch.

Three life extension options were reviewed in this report for the purpose of further analysis and comparison of life extension options for the penstocks' refurbishment. A more detailed consideration of cost estimates suggest full weld refurbishment and application of a corrosion resistant coating is the suggested option for the rehabilitation of the penstocks.

The cost estimates for the weld refurbishment option (Option 1) are in the range of $25M to $30M per penstock.

The estimated costs are heavily influenced by the total length of the circumferential seams. To be conservative Hatch estimated 50 percent of all remaining seams require refurbishment. For example, the 17 foot section has a circumferential length of approximately 53 feet of which about of a third of the inspection, gouging and welding would be in the most difficult, overhead, position. NL Hydro could improve the accuracy of the estimates and possible reliability of the system with more detailed inspection of the circumferential seams.

With adequate maintenance of the coating systems, full replacement and installation of a new penstock can have an estimated design life of approximately 80 years. Hatch estimates the refurbishment options that include replacement of the interior coating will provide an additional life extension of at least 40 years provided there is no breakdown of the internal or external coating system.

Based on the current operational history, refurbishments and current operating procedures, it was Hatch's opinion the penstock's current condition will provide uninterrupted service through the 2019 winter season. This proved to be correct as no service interruptions occurred during the 2018-2019 winter season. Hatch recommends annual inspection of the penstocks should continue until a life extension program is implemented within the next 3- 5 years, as detailed elsewhere within this report.

1. Introduction

NL Hydro engaged Hatch to conduct a Level II Condition Assessment of Penstocks No.'s 1, 2, and 3 at the Bay d'Espoir Hydroelectric Generating Facility during the 2018 operating season. The findings from the condition assessment will ensure the penstocks are in reliable operating condition for the 2019 production season and will assist in verifying penstock life extension refurbishment options.

The contents of this report builds on the initial refurbishment/replacement analysis provided in the previous report; providing more detail into the three selected refurbishment/replacement options NL Hydro selected for further analysis. Due to the time intensive nature of inspection, data collection, analysis and refurbishment option evaluations, this work was completed in three phases each of which has had a report issued upon its completion. This third report completes the third phase of the work and provides further details on three refurbishment options chosen by NL Hydro for further analysis by Hatch. The following are the three report titles.

- Report 1 – Bay d'Espoir Level II Condition Assessment of Penstock No.'s 1, 2 and 3.
- Report 2 – Condition Assessment and Refurbishment Options for Penstock No.'s 1, 2 and 3.
- Report 3 – Penstock No.'s 1, 2 and 3 Life Extension Options.

The Bay d'Espoir Hydroelectric Generating Facility is comprised of four buried penstocks, three of which are connected to the main powerhouse containing six generating units. Each penstock bifurcates near the powerhouse to feed each unit through separate spherical valves. Units No.1 and No. 2 along with Penstock No. 1 were built in 1967. Units No. 3 and No. 4 along with Penstock No. 2 were built shortly after in 1968. The final addition to Powerhouse No.1 was completed in 1969 and consisted of the installation of generation Units No. 5 and No. 6 as well as Penstock No. 3. The penstocks run approximately 1,200 m (3,900 ft) in length and are constructed from a series of carbon steel cans[1] that vary in length, diameter and thickness.

The purpose of this report is to provide a more thorough review of the life extension options recommended for the penstock repair/refurbishment that were provided in Report 2 "Condition Assessment and Refurbishment Options for Penstock No.'s 1, 2 and 3" issued in the first quarter of 2019. The AACE Class 4 cost estimates included in this report are based on recent pricing information received from local construction companies, some of whom were involved with the refurbishment work on Penstock No.'s 1, 2, and 3.

[1] Lengths of penstock that are approximately 2.74 m (9 ft) long and constructed of two hemispheres of rolled plates longitudinally welded together to form a circumference.

To make this report more concise, the following sections that were included in Report 2 – Condition Assessment and Refurbishment Options for Penstock No. 1, 2 and 3, have not been included in this report:

- Condition Assessment Methodology
- Penstock Inspections and Refurbishments
- Finite Element and Fatigue Analysis
- Current Condition and Life Expectancy

2. Refurbishment or Replacement Options

Refurbishment or replacement options were investigated for each penstock. The options that NL Hydro has selected for Hatch's further review are as follows:

1. Refurbishment of deteriorated weld seams, both longitudinally and circumferentially, and re-coating the interior of the penstock (previously labelled Option 1 in Report 2 - H357395-00000-240-066-0002).
2. Replacement of penstock 17' ID section, weld refurbishment and recoating of the full penstock (previously labelled Option 2B in Report 2 - H357395-00000-240-066-0002).
3. Refurbishment of deteriorated weld seams, recoating of the entire penstock and installation of reinforcing plates over the longitudinal and circumferential weld seams of the 17 ft. section (previously labelled Option 4 in Report 2 - H357395-00000-240-066-0002).

The following options present varying degrees of life extension. Referencing published material from the American Society of Civil Engineers (ASCE), the design life of a steel penstock is normally in the range of 40-80 years with proper maintenance (ASCE, Guidelines for Evaluating Aging Penstocks). Since corrosion has been a major contributing factor relating to metal loss and in particular the welds, maintenance of a coating system is extremely important to the longevity.

Refurbishment options include replacement of the internal coating but not the external coating. Inspection of the external coating on Penstock No.'s 1, 2, and 3 from the brief sections that have been excavated during the penstock refurbishments and condition assessment have shown the coating is still intact. Additionally, wall thickness measurements were taken along the length of the penstock and showed no signs of metal loss due to external corrosion.

With adequate maintenance of the coating systems, full replacement and installation of a new penstock can have an estimated design life of approximately 80 years. Hatch estimates the refurbishment options that include replacement of the interior coating will provide an additional life extension of at least 40 years provided there is no breakdown of the internal or external coating system.

The AACE Class 4 cost estimates included in this report are based on recent pricing information received from a local construction companies, some of whom were involved with the refurbishment work on Penstock No.'s 1, 2 and 3. Additionally, information provided by local painting and fabrication companies were used to assist in the development of these cost estimates for the given options (supporting information can be found in Appendix A).

2.1 Refurbishment and Re-coating of Existing Penstocks

The first refurbishment option investigated for life extension of the penstocks includes completion of the weld refurbishment that started in 2016. This will include full inspection of all seams, both longitudinal and circumferential, and refurbishment of all deteriorated seams (Note: all options with weld refurbishment used a 50 percent refurbishment rate of non-refurbished longitudinal seams, as well as a 50 percent refurbishment rate of all circumferential seams).

As identified in previous reports, the circumferential seams have not yet been refurbished for multiple reasons. The stress in the penstock due to internal pressure is twice that in the longitudinal seams versus the circumferential seams. Past refurbishments concentrated on the longitudinal seams due to the higher probability of failure resulting from the increased stress (as all failures were on longitudinal seams). Longitudinal seam refurbishment was the target to ensure timely return of service and safe operation given the planned condition assessment and monitoring of the penstocks. Preliminary inspection indicated the circumferential seams were not in as bad condition as that of the longitudinal seams. Hence, due to the lower risk and lower priority of the circumferential welds, thorough inspection of circumferential seams was not conducted at this time. Therefore, due to outage time available, location of failures, higher stress, and condition of longitudinal seams, only longitudinal seams were refurbished. However, life extension of the penstocks must remediate all areas that could produce a negative effect on the penstocks long term operation.

Refurbishment of all cracked or severely corroded welds is required to ensure that a newly applied coating is not compromised from poor weld seam condition. If cracks are present, it could lead to premature coating failure in those areas. If weld imperfections do not run deeper than 2mm, they can be eliminated by grinding out the defect with no additional welding required. However, if the weld defects are deeper than 2mm it is recommended the defect be removed and the weld be repaired to bring it to original condition.

Each circumferential seam in the 17-foot ID section is approximately 53.4 feet versus that of 18 feet of longitudinal seams for the one can. Since the circumference results in a much longer seam length, the overall resulting cost of refurbishment is suspected to be greater for the circumferential seams. Based on the corrosion and cracking investigated thus far, a value of 50 percent refurbishment was selected to represent a conservative number for the circumferential seams. This number is an estimate as there has been limited inspection of the circumferential welds to date.

Following the completion of weld refurbishment, the penstock internals will have abrasive blasting to bare metal and a new internal coating installed. The following blasting and coating methodology were considered for all three refurbishment options mentioned within this report. The current coating option priced is for three coat paint system by the Wasser Corporation (Table 2-1).

Table 2-1: Proposed Coating System

Coat Number	Product	DFT
First	MC-Zinc 100	3.0 to 5.0 mils DFT
Second	MC-Tar 100	5.0 to 7.0 mils DFT
Third	MC-Tar 100	5.0 to 7.0 mils DFT
Total	**N/A**	**13.0 to 19.0 mils DFT**

The first coat would consist of MC-Zinc primer and be followed by two coats of MC-Tar moisture cure urethane that has similar performance to the coal tar epoxy that was originally installed, having a life span of approximately 15-20 years (recoating should be planned for every 15 years). The benefit of using the moisture cure product is that there will be significantly less environmental control and equipment required in the penstock during application. Other products can be assessed for this service; however, a large emphasis should be placed on the environmental application requirements (i.e., the internal penstock temperature, humidity, dew point, etc.). Hatch considers this important as NL Hydro and other companies such as Newfoundland Transshipment Limited have experienced difficulties in the past with trying to apply other coatings in high humidity environments.

The penstocks should have regular interior inspections following refurbishment work. Hatch recommends performing internal inspection after the first year of operation, with the system applied, to assess if any installation issues caused delamination of the coating and have repairs completed if required. After the initial warranty inspection, the frequency would be reduced to one interior inspection every 6 years. The interior inspection would be largely focused on coating condition and would include visual inspection and adhesion testing.

The total circumferential weld length was determined based on the number of cans (and associated seams) in each section of the penstocks multiplied by the circumference of that section. The penstock was broken up into three sections (17ft., 15.3ft.and 13.5ft.), the approximate number of cans for the 17ft. section was determined and multiplied by the circumference of the 17ft. section, the same process was used for the other two sections. Since no circumferential seams have been previously refurbished, half of the total circumferential length has been assumed for the estimated refurbished length as presented in Tables 2-2, 2-3, and 2-4.

Table 2-2: Circumferential Weld Lengths - Penstock No. 1

Section	Cans	# of Cans	50% Refurbished	Diameter ft	Circumferential Length (ft)
17 ft dia.	1-121	121	60.5	17	3231
15.3 ft dia.	121-230	109	54.5	15.3	2619
13.5 ft dia.	230-400	170	85	13.5	3605
			Total Circumferential Length (ft.)		9455

Table 2-3: Circumferential Weld Lengths – Penstock No. 2

Section	Cans	# of Cans	50% Refurbished	Diameter ft	Circumferential Length (ft)
17 ft dia.	1-128	128	64	17	3418
15.3 ft dia.	128-237	109	54.5	15.3	2620
13.5 ft dia.	237-400	163	81.5	13.5	3457
			Total Circumferential Length (ft.)		9495

Table 2-4: Circumferential Weld Lengths – Penstock No. 3

Section	Cans	# of Cans	50% Refurbished	Diameter ft	Circumferential Length (ft)
17 ft dia.	1-136	136	68	17	3,632
15.3 ft dia.	136-291	155	77.5	15.3	3,725
13.5 ft dia.	291-400	109	54.5	13.5	2,311
			Total Circumferential Length (ft.)		9,668

The total longitudinal weld seam length of the non-refurbished welds was estimated using the weld refurbished trackers, which were prepared during the various refurbishment projects. A summary is provided in Tables 2-5, 2-6, and 2-7.

Table 2-5: Longitudinal Weld Length - Penstock No. 1

Location	Length Previously Refurbished (ft)	Total Length of Penstock (ft)	Length not Refurbished (ft)	Both North/South Side (ft)	50% of Welds Assumed to be Refurbished (ft)
Can 1-173 Can 215 only South side	1,520	3,883	2,363	4,726	2,363

Table 2-6: Longitudinal Weld Length - Penstock No. 2

Location	Length Previously Refurbished (ft)	Total Length of Penstock (ft)	Length not Refurbished (ft)	Both North/South Side (ft)	50% of Welds Assumed to be Refurbished (ft)
Can 1-91 Can 230 and 270 only North side	752	3,896	3,144	6,288	3,144

Table 2-7: Longitudinal Weld Length - Penstock No. 3

Location	Length Previously Refurbished (total) (ft)	Total Length of Penstock (North and south) (ft)	Length not Refurbished (ft)	50% of Welds Assumed to be Refurbished (ft)
Approximation based on CAN 1-132; 132-175; 205-225; 302-342	3,500	7,420	3,920	1,960

Table 2-8 provides a summary of both the circumferential and longitudinal repair lengths for each penstock.

Table 2-8: Total Weld Refurbishment Lengths

	Penstock No. 1	Penstock No. 2	Penstock No. 3
Total Circumferential Repair Length (ft)	9,455	9,495	9,668
Total Longitudinal Repair Length (ft)	2,363	3,144	1,960
Total Repair Length (ft)	11,818	12,639	11,628

Table 2-9 presents the AACE Class 4 cost estimate for Option1. Appendix B provides additional cost breakdown.

Table 2-9: Refurbishment and Re-coating Cost Estimate

	Penstock No. 1	Penstock No. 2	Penstock No. 3
Contractor Mob/Demob	$1,670,000	$1,740,000	$1,600,000
Backfill Removal and Reinstatement	$50,000	$50,000	$50,000
Longitudinal Weld Refurbishment	$2,480,000	$3,260,000	$2,060,000
Circumferential Weld Refurbishment	$9,920,000	$9,850,000	$10,180,000
Doorsheet Removal and Re-installation	$110,000	$110,000	$110,000
Blasting/Coating	$3,700,000	$3,700,000	$3,560,000
Contractor Living out Allowance (LOA)	$700,000	$700,000	$700,000
Rescue / Safety	$480,000	$480,000	$480,000
TOTAL DIRECT COST	**$19,110,000**	**$19,890,000**	**$18,740,000**
EPCM(12% of direct)	$2,290,000	$2,390,000	$2,250,000
Temp site facilities and services (3% of direct)	$570,000	$600,000	$560,000
Owner's costs (5%)	$960,000	$990,000	$940,000
TOTAL INDIRECT COST	**$3,820,000**	**$3,980,000**	**$3,750,000**
Contingency (15% of direct + indirect)	$3,440,000	$3,580,000	$3,370,000
TOTAL COST	**$26,370,000**	**$27,450,000**	**$25,860,000**

2.2 Replacement of 17 ft. Diameter Section and Weld Refurbishment

Based on the recent refurbishment history and the results of the stress analysis, the part of the penstock which has required the most refurbishment is the 17 ft section which is located upstream of the Surge Tank. The cost estimate for this option (Option 2) considers replacing this section with materials designed to current standards, fully refurbishing all existing deteriorated welds and coating the penstock (refer to Section 2.1 for painting/coating methodology and refer to Table 2-15 for cost estimate). The 17 foot section will be coated in the shop with the exception of the field joints which will be coated on site along with the remainder of the unreplaced portion of the penstock.

The cost for replacing the 17 ft diameter section will be impacted by the constructability of a large diameter penstock, and the remote location of the site. The most significant constructability concern is the delivery of cans to the site. Shop manufacturing the cans will be far cheaper and produce a higher quality product. New penstock sections can be fabricated in St. John’s in 10 ft widths and 17 ft in diameter. Once fabricated, inspected, and painted, they can be shipped. Local transportation companies have provided budgetary estimates and indicated that two can sections can be shipped to the site on a low bed transport. Note, 17 ft is the upper limit set by the Department of Transportation for transport without escorts. Escort costs could increase transportation by up to 60 percent. This increase in cost was not considered in the cost estimate developed for this option.

Plate for fabrication of new can sections would need to be purchased requiring a two to three-month lead time due to the large tonnage quantity. Purchasing the plate as a free issue item would save the contractor markup on the material.

Shop fabrication is the most efficient and best way to control quality. The longitudinal seams would be welded using Submerged Arc automatic welding method and inspected using radiographic or ultrasonic inspection. Hatch recommends using ultrasonic inspection as it is more efficient and does not cause a shutdown of production during the inspection period.

Additional constructability considerations include:

1. Available site laydown area for equipment and penstock cans.
2. Access around operating penstocks, especially Penstock No. 2.
3. Access road condition.
4. Earthworks, backfill removal and bedding material supply installation for the new penstock section. Sand for bedding would likely need to be supplied from a significant distance.
5. Drainage under the penstock would need to be addressed.
6. Room and Board availability for the construction crew.
7. Length of available outage for demolition and construction.
8. Some contractors have used automatic or semiautomatic welding equipment for circumferential welds in the field. This possibility could be further investigated with contractors. Automatic welding requires significant hoarding around the welded joints and may not be practical for a thin shelled (approximately 5/8 inch) penstock.
9. There will be significantly higher costs for the NDE in the field plus availability of UT technicians on an as required basis could be a problem. Hatch recommends spot checking the circumferential joints due to the lower stress in these joints. Cost could be as high as four times the cost of shop inspection depending on the number of site visits.

The same methodology for determining weld refurbishment lengths for Option 1 was used, where the weld seam refurbishment lengths associated for the 17 ft. section was not included. The weld repair lengths for Option 2 are presented in Tables 2-10, 2-11, 2-12, 2-13, and 2-14.

Table 2-10: Circumferential Weld Lengths - Penstock No. 1

Section	Cans	# of Cans	50% Refurbished	Diameter	Circumferential Length (ft)
15.3 ft dia.	121-230	109	54.5	15.3	2620
13.5 ft dia.	230-400	170	85	13.5	3605
				Total Circumferential Length (ft)	6225

Table 2-11: Circumferential Weld Lengths - Penstock No. 2

Section	Cans	# of Cans	50% Refurbished	Diameter	Circumferential Length (ft)
15.3 ft dia.	128-237	109	54.5	15.3	2620
13.5 ft dia.	237-400	163	81.5	13.5	3457
				Total Circumferential Length (ft.)	6077

Table 2-12: Circumferential Weld Lengths - Penstock No. 3

Section	Cans	# of Cans	50% Refurbished	Diameter	Circumferential Length (ft)
15.3 ft dia.	136-291	155	77.5	15.3	3725
13.5 ft dia.	291-400	109	54.5	13.5	2311
				Total Circumferential Length (ft.)	6036

Table 2-13: Longitudinal Weld Lengths - Penstocks No. 1, 2 and 3

	Penstock No. 1	Penstock No. 2	Penstock No. 3
Total Longitudinal Repair Length (ft.)	2363	2829	1924

Table 2-14: Total Weld Refurbishment Lengths

	Penstock No. 1	Penstock No. 2	Penstock No. 3
Total Circumferential Repair Length (ft)	6225	6077	6036
Total Longitudinal Repair Length (ft)	2363	2829	1924
Total Repair Length (ft)	8588	8906	7960

Table 2-15 presents the AACE Class 4 cost estimate for Option 2.

Table 2-15: Partial Replacement and Refurbishment Cost Estimate

	Penstock No. 1	Penstock No. 2	Penstock No. 3
Contractor Mob/Demob	$2,790,000	$2,890,000	$2,580,000
Backfill Removal, Reinstatement and Bedding	$830,000	$830,000	$830,000
Longitudinal Weld Refurbishment	$1,760,000	$2,330,000	$1,380,000
Circumferential Weld Refurbishment	$7,060,000	$7,050,000	$6,800,000
Doorsheet Removal and Re-installation	$70,000	$70,000	$70,000
Blasting/Coating	$3,700,000	$3,700,000	$3,560,000
Purchasing of steel -17' ID	$1,420,000	$1,460,000	$1,270,000
Installation Penstock 1 - 17' ID	$3,450,000	$3,550,000	$3,090,000
Shipping	$340,000	$350,000	$370,000
Cranes (rate plus Mob/Demob)	$770,000	$770,000	$770,000
Site Fabrication	$8,820,000	$9,130,000	$7,940,000
Demo of Existing Penstock	$880,000	$880,000	$880,000
Contractor Living out Allowance (LOA)	$1,130,000	$1,130,000	$1,130,000
Rescue / Safety	$720,000	$720,000	$720,000
TOTAL DIRECT COSTS	**$33,740,000**	**$34,860,000**	**$31,390,000**
EPCM(12% of direct)	$4,050,000	$4,180,000	$3,770,000
Temp site facilities and services (3% of direct)	$1,010,000	$1,050,000	$940,000
Owner's costs (5%)	$1,690,000	$1,740,000	$1,570,000
TOTAL INDIRECT COSTS	**$6,750,000**	**$6,970,000**	**$6,280,000**
Contingency (25% of direct + indirect)	$10,120,000	$10,460,000	$9,420,000
TOTAL COST	**$50,610,000**	**$52,290,000**	**$47,090,000**

2.3 Refurbishment with Reinforcing Plates

Building on the requirements of Option 1, reinforcing plates could be installed internally over all longitudinal and circumferential weld seams of the 17 ft. diameter section; noting that all deteriorated welds would need to be refurbished first before reinforcing plates could be welded on. Following the weld refurbishment of the penstock, plates similar to those installed in Penstock No. 1 (November 2017) would be installed in the 17ft. section, to stiffen the existing penstock (at the peaked seams) and provide additional protection to the weld seams. The reinforcing plates will need to be cut, rolled (to the same radius as the penstock), inserted into the penstock, fit to place, and then welded (refer to Appendix C for details). Following the completion of welding the reinforcing plates, Magnetic Particle testing (MT) and Visual testing (VT) is required on the fillet welds, as well as corrosion protection. Abrasive blasting to bare metal and installation of a coating system would still be required to prevent further corrosion of the steel penstock and to protect the welds (refer to section 2.1, for blasting/coating methodology).

The same weld lengths (both circumferential and longitudinal) from Option 1 was used in determining the weld refurbishment portion of the cost for this option. Table 2-16 presents the AACE Class 4 cost estimate for Option 3.

Table 2-16: Refurbishment with Reinforcing Plates Cost Estimate

	Penstock No. 1	Penstock No. 2	Penstock No. 3
Mob/Demob (10%)	$2,230,000	$2,300,000	$2,200,000
Backfill Removal and Reinstatement	$50,000	$50,000	$50,000
Longitudinal Weld Refurbishment	$2,480,000	$3,260,000	$2,060,000
Circumferential Weld Refurbishment	$9,920,000	$9,850,000	$10,180,000
Doorsheet Removal and Re-installation	$100,000	$100,000	$100,000
Site Labour For Repad Installations	$5,450,000	$5,450,000	$5,450,000
Shipping	$20,000	$20,000	$20,000
Blasting/Coating	$3,700,000	$3,700,000	$3,560,000
Contractor Living out Allowance (LOA)	$920,000	$920,000	$920,000
Rescue / Safety	$600,000	$600,000	$600,000
TOTAL DIRECT COST	**$24,870,000**	**$26,250,000**	**$25,140,000**
EPCM(12%)	$2,980,000	$3,150,000	$3,020,000
Temp site facilities and services (3% of direct)	$750,000	$790,000	$750,000
Owner's costs (5%)	$1,240,000	$1,310,000	$1,260,000
TOTAL INDIRECT COST	**$4,970,000**	**$5,250,000**	**$5,030,000**
Contingency (15% of direct + indirect)	$4,480,000	$4,730,000	$4,530,000
TOTAL COST	**$34,320,000**	**$36,230,000**	**$34,700,000**

3. Option Comparison

Due to the complexity of the various options, it was decided to include a brief comparison matrix ranking the options based on four key factors as presented in Table 3-2. The factors used for the comparison were reliability, cost, schedule/phasing and risk.

Reliability- considers the long-term reliable operation of the penstocks unimpeded by outages.

All the options scored high on reliability.

Cost – based on the estimated capital cost of the various options. Costing was provided in the previous sections of this report.

The estimates were based on industry norms and contractor consultations and do not consider inflation and cost adders associated with phasing the project over multiple outages. Potential cost savings would be possible if NL Hydro purchased materials in advance and free issued these items to a contractor.

Schedule/Phasing – all options allow for implementation in a phased manner.

Implementing the life extension program in a phased approach decreases the length of outages and allows for more cash flow flexibility. Option 2 would be the most difficult to phase due to existing irreplaceable infrastructure. It could be phased by section to make it more attractive; however, the outages would be substantial.

Risk – risk during construction were considered.

Risk scores are similar based on the majority of the options being largely interior work. However, the partial replacement option (Option 2) would be subject to weather delays, risk to bedding wash out, and would require lifting and other logistical construction related issues due to working around and over operating penstocks.

Prior to completing the ranking matrix, the life extension options were first analyzed with listed advantages and disadvantages as shown in Table 3-1. This table complements the ranking matrix and lists some of the reasoning for decided scoring for this ranking matrix.

Table 3-1: Option Comparison Table

Option Number	Description	Advantages	Disadvantages
1	Refurbish circumferential and non-refurbished longitudinal welds of penstock followed by water blasting to bare metal and internal re-coating of penstock	1. Lower risk of failure. 2. Lowest cost of the three options. 3. Work is internal and weather delays would be minimal. 4. Reduction in surface roughness via new coating system. 5. Smaller labor force required and can be staged over multiple outages. 6. No large civil works required, minimal risk to existing infrastructure. 7. Minimal lifts over operational penstocks.	1. Multiple outages required. 2. Flexible 17’ diameter section remains. 3. Poor fabrication alignment issues remain. 4. Interior is repaired but exterior coating from original construction remains. Life extension is limited by external coating condition. 5. No inclusion of corrosion allowance on existing wall thickness. Therefore, coating needs to remain intact over the lifespan of the penstock. Essentially the coating system should be budgeted for replacement every 15-20 years. 6. Existing bedding and drainage system cannot be upgraded. Bedding remains in contact with the penstock in areas checked. However, some sections of the bedding were saturated during inspection.
2	Replacement of the 17ft. Section	1. Low risk of failure. 2. New sections can be constructed to meet current standards. 3. Reduction of surface roughness. 4. Existing flexible 17’ diameter section is removed. 5. Inclusion of corrosion allowance would be included in wall thickness. Reduces risk of corrosion effect on the penstock shell. This would allow initial recoating interval to be greater (approximately 25-30 years). After the first recoating the interval would revert back to 15-20 years. 6. Life extension up to 80 years depending on maintenance schedule. 7. Bedding and drainage could be upgraded during replacements.	1. Highest cost of the three options. 2. Long outage required. 3. High likelihood of weather delays. 4. Lifts over operational penstocks. 5. Heavy civil works required that could cause damage to existing infrastructure. 6. Demo of existing penstock sections would leave bedding system exposed to elements which could lead to compromised bedding and/or washouts. 7. Road transport of steel will require special permits for transport due to size and most likely be shipped in sections. This requires at least 2 longitudinal joints in the field per can. 8. Barge transport could be expensive due to the volume of steel cans. 9. Supply of required steel would have to be ordered one year in advance (long procurement period).
3	Refurbishment with reinforcing plates	1. Lower risk of failure. 2. Construction can be phased. 3. Work is all internal and weather delays would be minimal. 4. Increased reinforcement over welded areas.	1. Multiple outages required. 2. Possible flow disturbances caused by plates protruding into flow contributing to head loss. 3. Reduced flow through penstock do to repetitive pressure disturbances. 4. Refurbishment of existing welds is required prior to installation, thus there is no cost saving by a reduction in refurbishment cost by installing reinforcement plates over the welds. 5. Contractors stated very difficult to undertake due to handling large plates inside a confined space with no crane access. This poses a significant logistical challenge. Deemed by contractors as not a practical option.

Table 3-2: Refurbishment Option Matrix

Option Number	Option Description	Ranking Factors (out of 5)				
		Reliability	Cost	Schedule / Phasing	Risk	Total Score
1	Refurbishment and Re-coating	4	5	5	4	90%
2	Partial Replacement and Refurbishment	5	3	3	3	70%
3	Refurbishment with Reinforcing Plates	4	4	5	3	80%

4. Conclusions

Based on the current condition of the penstocks and the lack of corrosion protection, Hatch cannot guarantee that further leakages or micro cracks (if not already present) will not occur for each of the three penstocks. Hatch believes the probability of a major rupture or failure is relatively low within the next 5 years; however, a pin hole leak or micro crack could eventually lead to a rupture or failure.

Penstocks No. 1 and No. 2 have been in service 50 years and the internal coating in these penstocks has failed. There is a possibility that Penstock No. 3 was never internally coated.

The non-refurbished sections of the three penstocks, including circumferential seams, are showing signs of weld metal loss and preferential pitting corrosion of the HAZ. In the future these areas will need to be protected by application of a coating to avoid further deterioration.

Based on completed inspections, refurbishments, and current operating procedures as recommended by Hatch in previous reports, there have been no ruptures or recurring indications in the longitudinal seams. As a result, Hatch believes the refurbishment methodology has been successful in stabilizing the penstocks and the penstock's current condition as it provided uninterrupted service through the 2019 winter season. Hatch recommends that annual inspection of the penstocks should continue until a life extension program is completed. Hatch also believes that the refurbishment of backfill around Penstock No. 1, as outlined in Report H356043-00000-240-230-0003, may be deferred until the execution of the selected life extension work is completed.

Hatch noted the following constructability concerns related to the 17ft. section replacement option (Option 2); access around the operating penstocks (especially Penstock No. 2), site access due to road conditions and available laydown area for equipment and penstock cans. Additionally, concerns were noted regarding the local availability of suitable bedding material, drainage under the penstock would require refurbishment and the fact that this option would require a long outage for demolition and construction. These constructability concerns make this option less desirable. It should be noted, that similar work required for the other two options has been completed successfully in the past and any constructability concerns related to either of these options are well understood and are manageable. Other than the amount of time it will take to refurbish and or reinforce the circumferential seams, Hatch does not see any major constructability concerns with Options 1 or 3.

AACE Class 4 cost estimates for three options have been presented as part of this Report 3 and a comparison of these costs is shown in Table 4-1. The least cost option is Option 1 - Refurbishment of weld seams and application of a new protective coating.

After carefully reviewing the data collected, the yearly inspection of the completed refurbishments, and cost estimates, it is Hatch's opinion at this time that Refurbishment Option 1 is the recommended life extension strategy. With refurbishment of the remaining seams (removal of surface cracks, deposition of new weld metal where required) and the

application of a new protective coating, the service life of the penstocks could be extended for an additional 20 years. Further life extension could be accomplished depending on maintenance of the new coating, maintenance of existing backfill and maintaining the current reduction in rough zone operation. It is in Hatch's opinion that the reinforcing plate option does not provide any significant additional life extension benefits in relation to the high costs involved in the installation of reinforcing plates.

One of the biggest contributing factors to the overall cost of each option is the extent of the weld refurbishment of the circumferential seams. The current cost estimates have assumed 50 percent will need refurbishment. This assumption is based upon the findings of the Condition Assessment, however, a maximum of 10 percent to 15 percent of the circumferential welds were inspected. Additional inspection of these seams would likely increase the accuracy of the estimate by providing a larger sample size. The previous refurbishment of the three penstocks concentrated on the longitudinal seams as these are subject to twice the internal pressure stress as are the circumferential seams and the ruptures occurred in the longitudinal seams.

Based on inspections of the circumferential seams we know there is pitting corrosion in these seams. To understand the condition of these seams in the various sections of the penstock a more detailed scale removal and magnetic particle inspection could be performed, as noted above. It is possible that further inspection could reduce the requirements for significant weld refurbishment and increase the recommended refurbished period from three to five years to five to ten years. As most of the weld pitting corrosion occurred in the 17 ft section it is Hatch's opinion these portions of all three penstocks should be inspected, refurbished as needed, in particular the circumferential seams, and protected with a suitable coating system. This work should be completed in the next 5 years. Depending on the findings of the potential circumferential seam inspections and regular yearly penstock inspections the weld refurbishment and protective coating application for the remaining penstock sections could be completed in 10 years.

In addition, coating manufactures could potentially provide a system to coat the currently non-refurbished circumferential seams with minimal preparation and provide an expected coating service life of up to fifteen to twenty years.

Table 4-1: Cost Estimate Comparison

	Penstock No. 1	Penstock No. 2	Penstock No. 3	Total
Option 1: Refurbishment and Re-coating	$26,370,000	$27,450,000	$25,860,000	**$79,680,000**
Option 2: Partial Replacement and Refurbishment	$50,610,000	$52,290,000	$47,090,000	**$149,990,000**
Option 3: Refurbishment with Reinforcing Plates	$34,320,000	$36,230,000	$34,700,000	**$105,250,000**

Appendix A
Construction, Fabrication and Painting Supporting Documents

List of Supporting Documents

#	Supporting Document
1	[redacted] Pricing for Weld Refurbishment and 17ft. Section Replacement Option
2	[redacted] Pricing for Weld Refurbishment and 17ft. Section Replacement Option - Comments
3	[redacted] – Budgetary Quote for Painting/Blasting
4	[redacted] – Painting/Blasting Cost Estimate
5	[redacted] – Penstock Demolition and Removal Estimate
6	Shipment of Penstock Cans – Estimate and Comments
7	Penstock Plate Costs

From: Saunders, Greg
To: O"Grady, Kathleen
Cc: Drake, Dylan
Subject: FW: BDE Penstock #1,2 and 3 - Weld Refurbishment Pricing
Date: Friday, June 14, 2019 2:36:04 PM
Attachments: image003.png
image004.png
image007.png
image008.png

Regards,

Greg Saunders P.Eng.
Hatch St. John's, General Manager
Hatch Limited
Suite 100
80 Hebron Way, St. John's, NL
A1A 0L9
Ph: (709) 701-0081
Fax: (709) 754-2717
Cell: (709) 690 1932
e-mail: greg.saunders@hatch.com web : www.hatch.ca

From: [redacted]
Sent: Friday, June 14, 2019 2:35 PM
To: Saunders, Greg <greg.saunders@hatch.com>
Subject: Fwd: BDE Penstock #1,2 and 3 - Weld Refurbishment Pricing

Sent from my iPhone

Begin forwarded message:

[redacted]

Subject: RE: BDE Penstock #1,2 and 3 - Weld Refurbishment Pricing

[redacted]

Option 7 with no Civil or Coating.

17' Diameter Replacement			
	Penstock #1	Penstock #2	Penstock #3
Total	23,227,564.42	23,920,523.33	21,148,687.73
Weld Refurbishment			
15.3 ft dia. Section	2619.6	2619.6	3725.1
13.5 ft dia. Section	3605	3456.5	2311.4
Total Circumferential Repair Length (ft)	6224.6	6076.1	6036.5
Total Longitudinal Repair Length (ft)	1800.4	2581.7	1337.1
Total Repair Length (ft)	8025	8657.8	7373.6
Sub Total	$ 13,448,655.95	$ 14,300,114.91	$ 12,472,085.64
Total	$ 33,254,797.40	$ 35,174,999.09	$ 32,038,456.53

Subject: RE: BDE Penstock #1,2 and 3 - Weld Refurbishment Pricing

The information below aligns with cost per liner M which we have submitted previously excluding coating.

Greg

Weld Refurbishment only:

	Penstock #1	Penstock #2	Penstock #3
Circumferential Repair Length (ft)			
17ft dia. Section	3231.1	3418.1	3631.7
15.3 ft dia. Section	2619.6	2619.6	3725.1
13.5 ft dia. Section	3605	3456.5	2311.4
Total Circumferential Repair Length (ft)	9455.7	9494.2	9668.3
Total Longitudinal Repair Length (ft)	2362.9	3144.2	1899.6
Total Repair Length (ft)	11818.6	12638.4	11567.8

Total	$ 19,806,141.45	$ 20,874,884.18	$ 19,566,370.88

Greg

From: Saunders, Greg
To: O"Grady, Kathleen; Kenneally, Zachary
Cc: DylanDrake@nlh.nl.ca
Subject: FW: NL Hydro BDE Penstock Replacement Option 17 ft Section
Date: Friday, June 28, 2019 1:33:10 PM
Attachments: image001.png
image003.png

Hi Guys

See the comments from [redacted] next to the questions.

Regards,

Greg Saunders P.Eng.
Hatch St. John's, General Manager
Hatch Limited
Suite 100
80 Hebron Way, St. John's, NL
A1A 0L9
Ph: (709) 701-0081
Fax: (709) 754-2717
Cell: (709) 690 1932
e-mail: greg.saunders@hatch.com web : www.hatch.ca

From: Saunders, Greg
Sent: Thursday, June 27, 2019 5:04 PM
To: [redacted]
Cc: [redacted]
Subject: RE: NL Hydro BDE Penstock Replacement Option 17 ft Section

Thanks

Regards,

Greg Saunders P.Eng.
Hatch St. John's, General Manager
Hatch Limited
Suite 100
80 Hebron Way, St. John's, NL
A1A 0L9
Ph: (709) 701-0081
Fax: (709) 754-2717
Cell: (709) 690 1932
e-mail: greg.saunders@hatch.com web : www.hatch.ca

From: [redacted]
Sent: Thursday, June 27, 2019 5:01 PM
To: Saunders, Greg <greg.saunders@hatch.com>
Cc: [redacted]
Subject: RE: NL Hydro BDE Penstock Replacement Option 17 ft Section

Greg,

I will get back to you first thing tomorrow morning.

[redacted]

From: Saunders, Greg [mailto:greg.saunders@hatch.com]
Sent: Thursday, June 27, 2019 9:31 AM
To: [redacted]
Cc:
Subject: RE: NL Hydro BDE Penstock Replacement Option 17 ft Section

Hi Greg

Hydro reviewed our cost estimates and had some questions for us.

I would like to ask you a couple of questions to make sure we understand what you included or didn't include in your estimate. Also roughly how much contingency you used as we have also included some contingency in our final numbers.

For example:

1. Transportation to BDE full cans or partial needing longitudinal seams welded on site - [redacted] did not include any cost.
2. Site fabrication - [redacted] included fabrication of two half sections into a can on site and included welding 2 to 3 cans into an assembly to drop into the trench.
3. Demolition and disposal of existing penstock - [redacted] did not include demolition costs
4. Civil works, backfill removal, bedding reinstatement, backfill – [redacted] did not include any Civil Works costs
5. Craneage on site - [redacted] did include cranage (250ton at $180/hr + operator at $75/hr regular time OD is after 40hrs) , Mob and demob is around $5000 each so my estimate was good.
6. Housing of workforce in the area – rough idea of the number of workers and duration – [redacted] said the local area will probably max out at 40 people, LOA in the area costs around $180 to $200 per day.
7. Any indirect costs as a percentage of the total – [redacted] included an indirect cost which is around 25%
8. Any constructability concerns you see, in particular access to the middle penstock No. 2. - [redacted] stated there will be issues around Penstock No. 2 but didn't see anything insurmountable

Other notes.

[redacted] assumed a 5 to 6 month schedule for the work. They would work all day shift 10hrs per day 7 days a week and have a rotating crew. The total labour rate for the 70 hrs per week would be $100 per hour.
They included a 10% contingency on the top of their estimate.

Regards,

Greg Saunders P.Eng.
Hatch St. John's, General Manager
Hatch Limited
Suite 100
80 Hebron Way, St. John's, NL

[redacted]

QUOTE

Quote No: 1576

Date: Jun 28, 2019

Sold To:

Hatch

NL

Business No.: [redacted]

Description	Amount
Re: Penstocks in Bay D'Espoir Our budgetary quote for sandblasting and applying specified coating as per your request is $15-$18 / sq ft.	
HST NOT INCLUDED IN QUOTE. QUOTE VALID FOR 30 DAYS — **Total**	

From: Saunders, Greg
To: O"Grady, Kathleen; Kenneally, Zachary
Subject: FW: Bay D"Espoir - Penstock Painting
Date: Friday, June 28, 2019 10:55:08 AM
Attachments: image004.png

Hi

See cost per square foot below.

Regards,

Greg Saunders P.Eng.
Hatch St. John's, General Manager
Hatch Limited
Suite 100
80 Hebron Way, St. John's, NL
A1A 0L9
Ph: (709) 701-0081
Fax: (709) 754-2717
Cell: (709) 690 1932
e-mail: greg.saunders@hatch.com web : www.hatch.ca

From: [redacted]
Sent: Friday, June 28, 2019 10:03 AM
To: Saunders, Greg <greg.saunders@hatch.com>
Subject: FW: Bay D'Espoir - Penstock

Greg,

See below.

[redacted]

From: [redacted]
Sent: Friday, June 28, 2019 10:00 AM
To: [redacted]
Subject: RE: Bay D'Espoir - Penstock

Hi [redacted]

I would use $18.00 - $22.00 sf. It really depends on the lining they want to use.

Note: Our hose bundle for spraying out the linings is 250' long, we would need access (manways?) 200' from each end of the penstock and then at approx. every 400'.

Regards,

From: [redacted]
Sent: Thursday, June 27, 2019 12:39 PM
To: [redacted]
Subject: RE: Bay D'Espoir - Penstock

Welded.

From: [redacted]
Sent: Thursday, June 27, 2019 12:01 PM
To: [redacted]
Subject: RE: Bay D'Espoir - Penstock

Hi [redacted]
Is it riveted or welded ?

From [redacted]
Sent: Thursday, June 27, 2019 10:45 AM
To: [redacted]
Subject: Bay D'Espoir - Penstock

[redacted]

I was just speaking with an Engineering Company here, Hatch, who is working with Hydro NL on options for repairs on the Bay D'Espoir Penstock. They were asking us some questions on welding and replacing sections of Penstock, etc.

They also asked me if I had any kind of norm and approx. budget method we could give them for their high level analysis of painting the inside of the penstock. If there anything off the cuff you can provide me for this. They say they would wan to apply a Polyurethane product, good for damp atmospheres where it is insite the penstock.

The penstock is almost 3800 ft long and 17 ft in diameter. Area Approx: 200,000 sq ft.

Would you be able to throw a number at this or even an approximate allowance per sq – ft?

Regards,

[redacted]

From: [redacted]
To: O"Grady, Kathleen
Cc: Saunders, Greg; Kenneally, Zachary
Subject: RE: Budgetary Pricing on Penstock Removal
Date: Thursday, June 27, 2019 10:33:18 PM
Attachments: image001.png

Morning all;

I've done up a budget number on the removal of the Penstocks as requested.

I've made a couple assumptions:

1. All fill to remain onsite
2. Concrete support for bottom of tank to remain.
3. Next's years work??

$875,000.00 + Hst

If got any questions give me a call.

[redacted]

[redacted]

From: O'Grady, Kathleen [mailto:kathleen.ogrady@hatch.com]
Sent: June 26, 2019 7:39 PM
To: [redacted]
Cc: Saunders, Greg <greg.saunders@hatch.com>; Kenneally, Zachary <zachary.kenneally@hatch.com>
Subject: Budgetary Pricing on Penstock Removal

Hi Jeff,

Following your discussion with Greg Saunders this morning, we are hoping to get a budgetary cost on the demolition/removal of 17ft. dia sections of penstocks located in Bay d'Espoir. The information is as followed:

	Penstock #1	Penstock #2	Penstock #3
Length	1087 ft.	1120 ft.	1125 ft.

Inside Diameter	17 ft.	17 ft.	17 ft.
Thickness	0.4375inch (11mm)	0.4375inch (11mm)	0.4375inch (11mm)
Approximate Imperial short Tons	521	537	540

The penstocks can be accessed by road. There is approximately 5000 m^3 of backfill that would need to be removed (this is total amount between all three penstocks). Please see attached drawings outlining the sections that require removal.

Thank you for your help!

Regards,
Kathleen

Kathleen O'Grady
Junior Mechancial EIT / Oil and Gas

Tel: +1 709 700 1391
Suite 100, 80 Hebron Way, St. John's
Newfoundland Canada A1A 0L9

HATCH

From: Saunders, Greg
To: O"Grady, Kathleen; Kenneally, Zachary
Subject: FW: Shipment of Penstock to Bay D"Espoir
Date: Thursday, June 27, 2019 10:33:22 AM
Attachments: image004.png

FYI

Regards,

Greg Saunders P.Eng.
Hatch St. John's, General Manager
Hatch Limited
Suite 100
80 Hebron Way, St. John's, NL
A1A 0L9
Ph: (709) 701-0081
Fax: (709) 754-2717
Cell: (709) 690 1932
e-mail: greg.saunders@hatch.com web : www.hatch.ca

From: [redacted]
Sent: Thursday, June 27, 2019 10:21 AM
To: Saunders, Greg <greg.saunders@hatch.com>
Subject: FW: Shipment of Penstock to Bay D'Espoir

From: [redacted]
Sent: Thursday, June 27, 2019 10:20 AM
To: [redacted]
Cc: [redacted]
Subject: RE: Shipment of Penstock to Bay D'Espoir

[redacted]

As a budget

$5500 per load – assuming 2 per truck
17 ft wide at the upper limit for DOT escort so price could go up 60+% if they have to get involved…
in case you get over 17 ft wide

[redacted]

From: [redacted]
Sent: June 27, 2019 9:51 AM
To: [redacted]
Cc: [redacted]
Subject: RE: Shipment of Penstock to Bay D'Espoir

[redacted]

I'm working with Hatch to pull together some high level budgets on this. They are looking at options to supply to Hydro.

What's high level estimate to ship a load to Bay D'espoir?

Regards,

[redacted]

[redacted]

From: [redacted]
Sent: Thursday, June 27, 2019 9:26 AM
To: [redacted]
Cc: [redacted]
Subject: RE: Shipment of Penstock to Bay D'Espoir

[redacted]

Yes this wouldn't be an issue for highway or public road transport

[redacted]

From: [redacted]
Sent: June 27, 2019 9:20 AM
To: [redacted]

Cc: [redacted]
Subject: Shipment of Penstock to Bay D'Espoir

Hi [redacted]

Do you know if we would be able to ship a piece penstock pipe 17’ in diameter x 10’ long to Bay D’Espoir? We can sit the piece of penstock on its end so the height would be 10’ and it would be 17’ wide.

Thanks,

[redacted]

From: Saunders, Greg
To: O"Grady, Kathleen; Kenneally, Zachary
Subject: FW: Penstock Plate
Date: Friday, June 28, 2019 10:57:21 AM

Hi Guys

See cost for the plate. This is $0.82 per pound or $1.81 per kg.

Regards,

Greg Saunders P.Eng.
Hatch St. John's, General Manager
Hatch Limited
Suite 100
80 Hebron Way, St. John's, NL
A1A 0L9
Ph: (709) 701-0081
Fax: (709) 754-2717
Cell: (709) 690 1932
e-mail: greg.saunders@hatch.com web : www.hatch.ca

From: [redacted]
Sent: Friday, June 28, 2019 10:08 AM
To: Saunders, Greg <greg.saunders@hatch.com>
Subject: RE: Penstock Plate

Hi Greg,
Based on current estimates and current lead time of approximately 2 months, $1,640.00 ton.
In reference to squaring material, our plasma table can handle maximum 40 FT lengths.
Thank you for your inquiry.
[redacted]

From: [redacted]
Sent: Thursday, June 27, 2019 3:10 PM
To: [redacted]
Subject: FW: Penstock Plate

From: Saunders, Greg <greg.saunders@hatch.com>
Sent: Thursday, June 27, 2019 1:44 PM
To: [redacted]
Cc: O'Grady, Kathleen <kathleen.ogrady@hatch.com>; Kenneally, Zachary <zachary.kenneally@hatch.com>
Subject: Penstock Plate

The plate we would be looking for is CSAW300WT or 350WT 27J at -20C

Plate thickness 0.625” and width 10 ft. Each can is 17 feet in diameter so 53.4 feet long. Probably need to be cut in 2 for shipping.

Total weight 850 tons.

Just looking for the mill run delivery time for the plate.

If you can give a rough budget price ($1.00/lb?) for the plate delivered to St. Johns cut and squared that would be great.

Regards,

Greg Saunders P.Eng.
Hatch St. John's, General Manager
Hatch Limited
Suite 100
80 Hebron Way, St. John's, NL
A1A 0L9
Ph: (709) 701-0081
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Cell: (709) 690 1932
e-mail: greg.saunders@hatch.com web : www.hatch.ca

Appendix B
Cost Estimate Breakdown

Option 1 - Weld Refurbishment and Coating

	Penstock No. 1	Penstock No. 2	Penstock No. 3	
Contractor Mob/Demob	$1,670,000	$1,740,000	$1,600,000	1.
Backfill Removal and Reinstatement	$50,000	$50,000	$50,000	2.
Longitudinal Weld Refurbishment	$2,480,000	$3,260,000	$2,060,000	3.
Circumferential Weld Refurbishment	$9,920,000	$9,850,000	$10,180,000	4.
Doorsheet Removal and Re-installation	$110,000	$110,000	$110,000	5.
Blasting/Coating	$3,700,000	$3,700,000	$3,560,000	6.
Contractor LOA	$700,000	$700,000	$700,000	7.
Rescue / Safety	$480,000	$480,000	$480,000	8.
TOTAL DIRECT COST	**$19,110,000**	**$19,890,000**	**$18,740,000**	
EPCM(12% of direct)	$2,290,000	$2,390,000	$2,250,000	
Temp site facilties and services (3% of direct)	$570,000	$600,000	$560,000	
Owner's costs 5%	$960,000	$990,000	$940,000	
TOTAL INDIRECT COST	**$3,820,000**	**$3,980,000**	**$3,750,000**	
Contingency (15% of direct + indirect)	$3,440,000	$3,580,000	$3,370,000	
TOTAL COST	**$26,370,000**	**$27,450,000**	**$25,860,000**	

1. factored 10% of the weld refurb direct cost provieded by [redacted] plus 10% each of all additional items, with the exception of Contractor LOA which was not inlcuded
2. 1000 m^3 per penstock, $50/m^3
3. Cost was based on [redacted] direct cost for weld refrub. In order to break out cost further, each item included in the overall unit pricing was factored based on how items were weighted in previous estimate
4. Cost was based on [redacted] direct cost for weld refrub. In order to break out cost further, each item included in the overall unit pricing was factored based on how items were weighted in previous estimate
5. Cost was based on [redacted] direct cost for weld refrub. In order to break out cost further, each item included in the overall unit pricing was factored based on how items were weighted in previous estimate
6. Assumed $20/sq.ft. ([redacted] estimate of $18/sq.ft. and [redacted] estimate of 18-22sq.ft. For purpose of estimate used a price in between $20/sq.ft.)
7. 40 worker; 90 days: $180 prediem per day + 10 painters; 30 days; $180 prediem per day
8. 120 days; 10hrs shifts; $100/hr; 2 workers; night and day shift

Option 2 - 17ft. Section Replacement

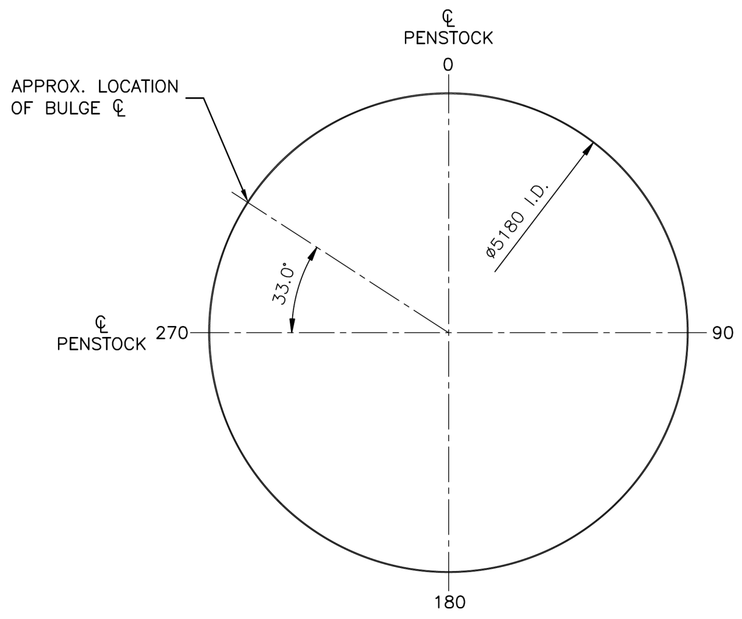
	Penstock No. 1	Penstock No. 2	Penstock No. 3	
Contractor Mob/Demob	$2,790,000	$2,890,000	$2,580,000	1.
Backfill Removal, Reinstatement and Bedding	$830,000	$830,000	$830,000	2.
Longitudinal Weld Refurbishment	$1,760,000	$2,330,000	$1,380,000	3.
Circumferential Weld Refurbishment	$7,060,000	$7,050,000	$6,800,000	4.
Doorsheet Removal and Re-installation	$70,000	$70,000	$70,000	5.
Blasting/Coating	$3,700,000	$3,700,000	$3,560,000	6.
Purchasing of steel -17' ID	$1,420,000	$1,460,000	$1,270,000	7.
Installation Penstock 1 - 17' ID	$3,450,000	$3,550,000	$3,090,000	8.
Shipping	$340,000	$350,000	$370,000	9.
Cranes (rate plus Mob/Demob)	$770,000	$770,000	$770,000	10.
Site Fabrication	$8,820,000	$9,130,000	$7,940,000	11.
Demo of Existing Penstock	$880,000	$880,000	$880,000	12.
Contractor LOA	$1,130,000	$1,130,000	$1,130,000	13.
Rescue / Safety	$720,000	$720,000	$720,000	14.
TOTAL DIRECT COSTS	**$33,740,000**	**$34,860,000**	**$31,390,000**	
EPCM(12% of direct)	$4,050,000	$4,180,000	$3,770,000	
Temp site facilties and services (3% of direct)	$1,010,000	$1,050,000	$940,000	
Owner's costs 5%	$1,690,000	$1,740,000	$1,570,000	
TOTAL INDIRECT COSTS	**$6,750,000**	**$6,970,000**	**$6,280,000**	
Contingency (25% of direct + indirect)	$10,120,000	$10,460,000	$9,420,000	
TOTAL COST	**$50,610,000**	**$52,290,000**	**$47,090,000**	

1. Factor of the weld refurb was taken as well as the factor of replacement cost. 10% of each additional item was included in the price, with the expception of the crane mob/demob being $10,000 and the Contractor LOA, Shipping and Demo not being included for cost
2. $25,000 was included for 15.3 and 13.5 section backfill (to be confirm as 17ft. Section was estimated high)
3. Cost was based on [redacted] direct cost for weld refrub. In order to break out cost further, each item included in the overall unit pricing was factored based on how items were weighted in previous estimate
4. Cost was based on [redacted] direct cost for weld refrub. In order to break out cost further, each item included in the overall unit pricing was factored based on how items were weighted in previous estimate
5. Cost was based on [redacted] direct cost for weld refrub. In order to break out cost further, each item included in the overall unit pricing was factored based on how items were weighted in previous estimate
6. Assumed $20/sq.ft. ([redacted] estimate of $18/sq.ft. and [redacted] estimate of 18-22sq.ft. For purpose of estimate used a price in between $20/sq.ft.)
7. Based on direct cost of 17ft. replacement cost given by [redacted] and weighted each item based on previous estimate
8. Based on direct cost of 17ft. replacement cost given by [redacted] and weighted each item based on previous estimate
9. shipping per 2 cans
10. Based on $180/hr + operator at $75/hr regular time, 150 days + 10 hours + night and day shift
11. Based on direct cost of 17ft. replacement cost given by [redacted] and weighted each item based on previous estimate
12. Based on [redacted] Pricing
13. 40 worker; 150 days: $180 prediem per day + 10 painters; 30 days; $180 prediem per day
14. 180 days; 10hrs shifts; $100/hr; 2 workers; night and day shift

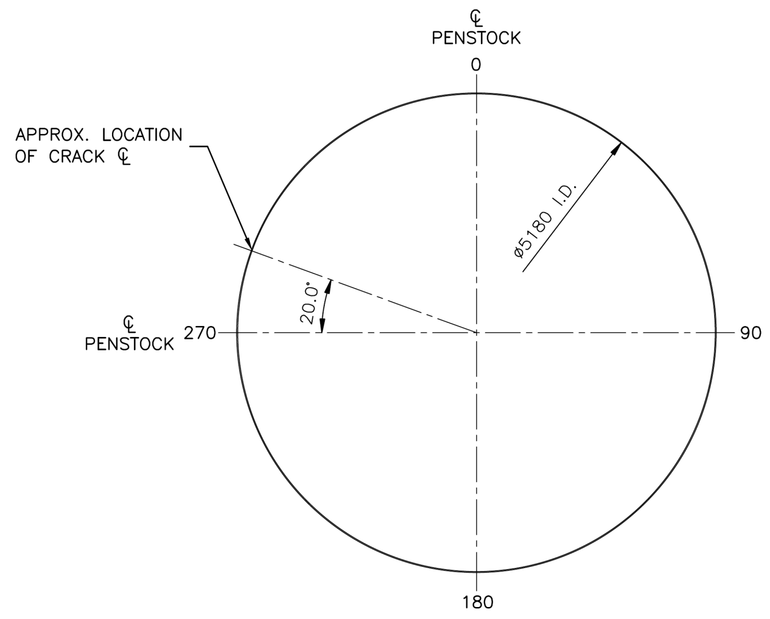
	Penstock No. 1	Penstock No. 2	Penstock No. 3	
Mob/Demob (10%)	$2,230,000	$2,300,000	$2,200,000	1.
Backfill Removal and Reinstatement	$50,000	$50,000	$50,000	2.
Longitudinal Weld Refurbishment	$2,480,000	$3,260,000	$2,060,000	3.
Circumferential Weld Refurbishment	$9,920,000	$9,850,000	$10,180,000	4.
Doorsheet Removal and Re-installation	$100,000	$100,000	$100,000	5.
Site Labour For Repad Installations	$5,450,000	$5,450,000	$5,450,000	6.
Shipping	$20,000	$20,000	$20,000	7'.
Blasting/Coating	$3,700,000	$3,700,000	$3,560,000	8.
Contractor LOA	$920,000	$920,000	$920,000	9.
Rescue / Safety	$600,000	$600,000	$600,000	10.
TOTAL DIRECT COST	**$24,870,000**	**$26,250,000**	**$25,140,000**	
EPCM(12%)	$2,980,000	$3,150,000	$3,020,000	
Temp site facilities and services (3% of direct)	$750,000	$790,000	$750,000	
Owner's costs (5%)	$1,240,000	$1,310,000	$1,260,000	
TOTAL INDIRECT COST	**$4,970,000**	**$5,250,000**	**$5,030,000**	
Contingency (15% of direct + indirect)	$4,480,000	$4,730,000	$4,530,000	
TOTAL COST	**$34,320,000**	**$36,230,000**	**$34,700,000**	

1. factored 10% of the weld refurb direct cost provieded by [redacted] plus 10% each of all additional items, with the exception of shipping and Contractor LOA which was not included
2. 1000 m^3 per penstock, $50/m^3
3. Cost was based on [redacted] direct cost for weld refrub. In order to break out cost further, each item included in the overall unit pricing was factored based on how items were weighted in previous estimate
4. Cost was based on [redacted] direct cost for weld refrub. In order to break out cost further, each item included in the overall unit pricing was factored based on how items were weighted in previous estimate
5. Cost was based on [redacted] direct cost for weld refrub. In order to break out cost further, each item included in the overall unit pricing was factored based on how items were weighted in previous estimate
6. 82.5 tonnes of normal welds; 82.5 tonnes of out of position welds; 88hr/tonne; $150/hr. Assumed half the welds were normal welds and half were out of position welds. Out of postiion welds were considered to cost 4 times as much as normal welds.
7. 36 tonnes/trip; 165 tonnes; approximately 5 trips; $3000/trip
8. Assumed $20/sq.ft. ([redacted] estimate of $18/sq.ft. and [redacted] estimate of 18-22sq.ft. For purpose of estimate used a price in between $20/sq.ft.)
9. 40 worker; 120 days: $180 prediem per day + 10 painters; 30 days; $180 prediem per day
10. 150 days; 10hrs shifts; $100/hr; 2 workers; night and day shift

Appendix C
Reinforcing Plate Detail



SECTION - CAN 34
SCALE: 1:50
A



SECTION - CAN 35
SCALE: 1:50
B

INSERT PLATE INSTALLATION SEQUENCE

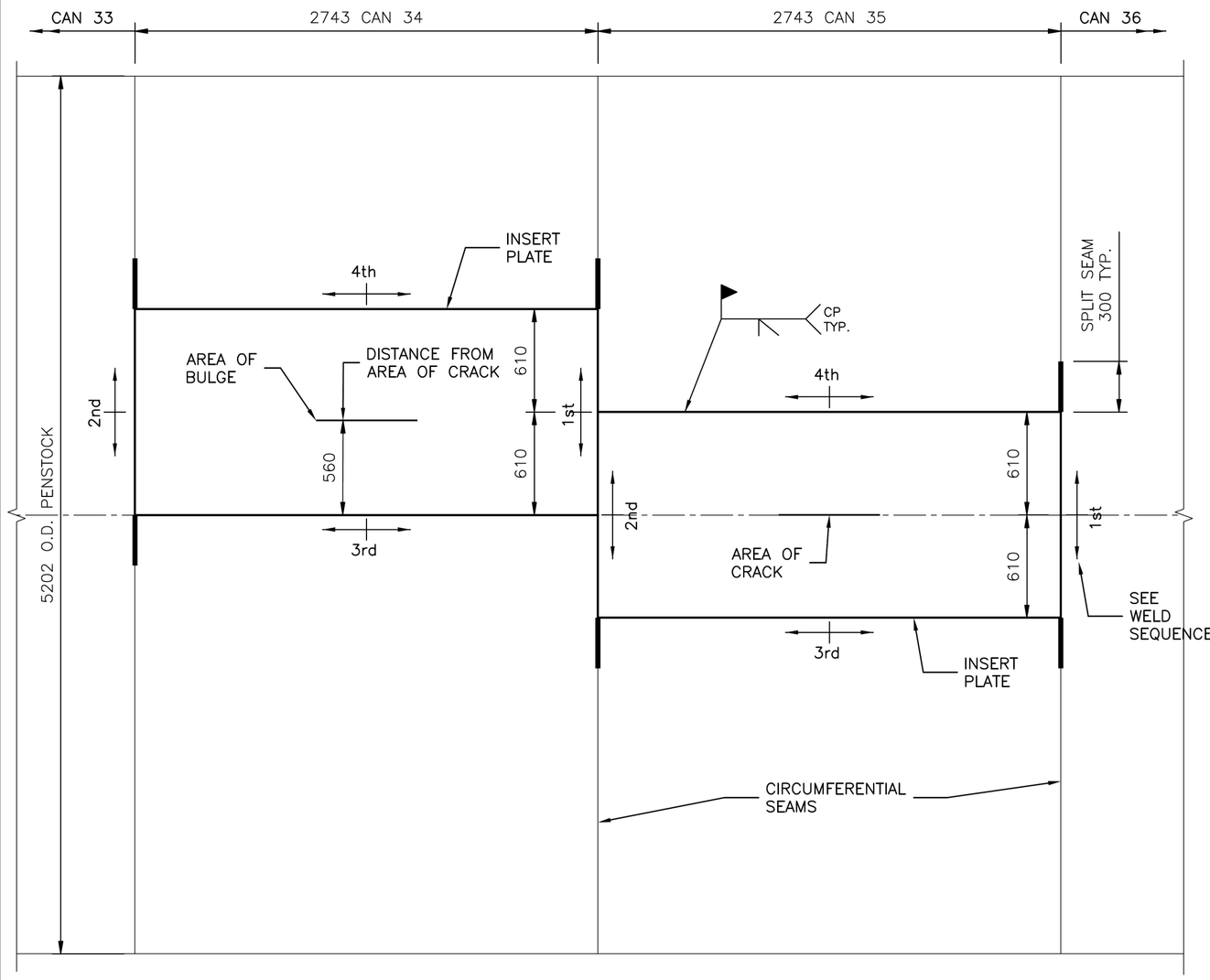
1. INSTALL THE INSERT PLATE FOR CAN 35 FIRST.
2. INSTALL THE INSERT PLATE FOR CAN 34 SECOND.
3. WHERE LONGITUDINAL JOINTS INTERSECT CIRCUMFERENTIAL JOINTS SPLIT THE CIRCUMFERENTIAL SEAM BACK 300mm PRIOR TO FITTING THE INSERT PLATE.
4. REINFORCING PLATES TO BE INSTALLED AS SHOWN ON DRAWING. BUTT WELDS TO BE INSPECTED AND FOUND ACCEPTABLE PRIOR TO THE INSTALLATION OF REINFORCING PLATES.

WELD SEQUENCE FOR DISTORTION CONTROL

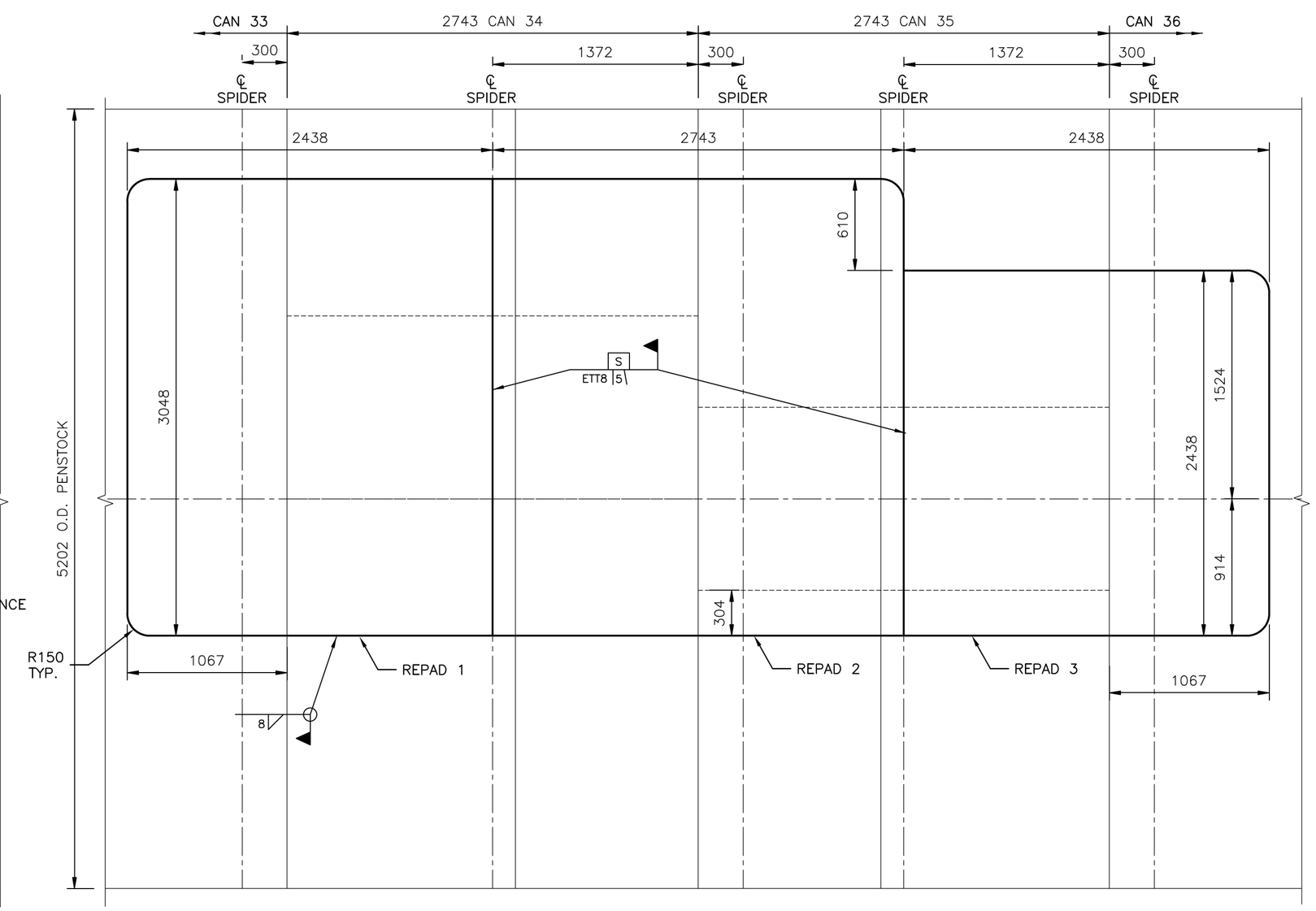
1. TACK WELD INSERT PLATE INTO OPENING AFTER AREA HAS BEEN GROUND AND CLEANED FOR WELDING. TACKS TO BE 50mm MIN. LENGTH AT 150mm c/c.
2. WELDING TO BE PERFORMED ON CIRCUMFERENTIAL SEAMS FIRST STARTING IN THE CENTER AND WORKING TO EDGES EQUALLY BOTH SIDES. SEE ELEVATION C.
3. AFTER TACK WELDING COMPLETE THE FIRST PASS USING THE SAME SEQUENCE AND BACK STEPPING THE WELDING.
4. COMPLETE THE SECOND PASS SAME AS THE FIRST PASS UNTIL THE JOINT IS APPROXIMATELY 50% FILLED.
5. BACK GOUGE TO SOUND METAL ON THE INSIDE AND FILL THE JOINT BY WELDING IN THE SAME SEQUENCE AS ABOVE.
6. COMPLETE THE WELD ON THE EXTERIOR IN THE SAME SEQUENCE AS ABOVE.
7. PERFORM A VT AND MT INSPECTION ON THE INTERIOR AND EXTERIOR SURFACES OF THE WELDS 12 HOURS AFTER WELDING.
8. GRIND THE INTERIOR AND EXTERIOR WELDS FLUSH WITH THE SURFACE.
9. PERFORM A VT AND MT INSPECTION ON THE SURFACE OF THE WELDS AT 48 HOURS AFTER WELDING.
10. COMPLETE RT AND UT INSPECTION OF THE WELDS.
11. THE COMMON CIRCUMFERENTIAL SEAM BETWEEN CAN 34 & CAN 35 SHALL ONLY BE WELDED 50%. THIS PORTION OF THE COMMON SEAM WILL BE COMPLETED WHEN THE INSERT FOR CAN 34 IS INSTALLED.

GENERAL NOTES:

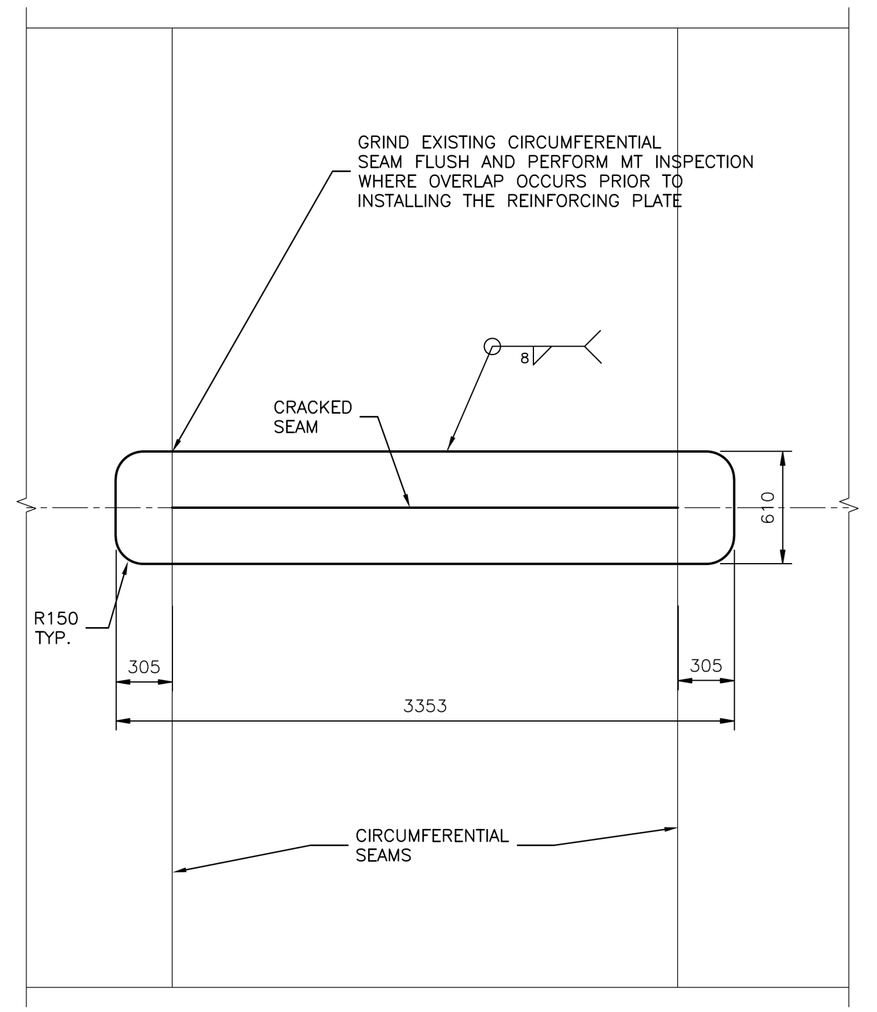
1. ALL DIMENSIONS IN MILLIMETERS.
2. DO NOT SCALE FROM DRAWING.
3. CONTRACTOR MUST VERIFY ALL DIMENSIONS & CONDITIONS ON SITE BEFORE PROCEEDING WITH ANY PORTION OF THIS WORK.
4. ALL STRUCTURAL STEEL IN ACCORDANCE WITH CAN/CSA–G40.20/G40.21. STEEL GRADE SHALL BE PLATE: 350WT U.N.O.
5. ALL STRUCTURAL STEEL WORK TO CAN/CSA S16.1 LATEST EDITION.
6. ALL WELDING IN ACCORDANCE WITH ASME IX BY WELDERS QUALIFIED TO ASME IX
7. ALL CP WELDS SHALL BE INSPECTED AS FOLLOWS:
   –100% VT
   –100% MT
   –100% RT
   –100% UT
   ALL FILLET WELDS TO BE INSPECTED 100% VT, MT
8. ALL FILLET WELDS SHALL BE 8mm ALL AROUND UNLESS NOTED OTHERWISE.
9. EXISTING PENSTOCK WALL THICKNESS: 11mm. ALL INSERT PLATES AND REPAD THICKNESS TO BE 13mm.



ELEVATION - INSERT PLATE
SCALE: 1:25
C



ELEVATION - EXTERIOR REPAD DETAIL
SCALE: 1:25
D



ELEVATION - INTERIOR REINFORCING PLATE DETAIL
SCALE: 1:25
E

DWG.NO.	TITLE
	REFERENCE DRAWINGS

NO.	DATE	DESCRIPTION	DWN.	DESIGN.	CHK.	APP'D
1	JAN.19,2018	ISSUED AS RECORD SET	TB	GS	GS	GS
0	NOV.27,2017	ISSUED FOR CONSTRUCTION	RG	GS	GS	GS

REVISIONS

HATCH

HATCH PROJECT NO. H352666
HATCH DRAWING NO. H352666–D–M–0001.1

newfoundland labrador hydro
a nalcor energy company

BAY D'ESPOIR HYDROELECTRIC GENERATING FACILITY

ELECT.	SCALE:	AS SHOWN
CIVIL	DESIGNED:	G. SAUNDERS
TRANS.	DRAWN:	R. GEORGE
MECH.	DATE:	NOV.10, 2017
P&C	CHECKED:	G. SAUNDERS
TELC.	APPROVED:	G. SAUNDERS

PENSTOCK No.1 MODIFICATIONS ELEVATIONS, SECTIONS AND DETAILS SHEET 1 OF 1

W.O. NO.

DWG. NO. H352666-D-M-0001-1

REV. 1

C.A.D.

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